6.2m Ka Limited-Motion Antenna Scheme Design Report

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C a t a l o g

Main Functions and Technical specifications

1.1 Main Functions

The main functions of 6.2m truss antennas are as follows

a) transmitting/receiving at Ka band, single pulse tracking
b) transmitting /receiving with left/right hand circular polarization
c) step tracking, manual control, program tracking, position setting mode were available in the antenna control unit

1.2 Main technical specifications and function requirements

1.2.1 Antenna electrical specification

Item	Description	
Frequency(GHz)	Tx:29.4-31.0	Rx:19.6-21.2
Gain (Mid-band, dBi)	≥62.8	≥59.5
Side Lobes	1st sidelobe not higher than -14dB Other sidelobes compliant with ITU-R S.580-6.	
Antenna Noise Temperature	150K (at 10° EL angel)	
Feed Type	Corrugated horn and TE_{21} mode coupler	
VSWR for Corrugated Horn	≤1.30	
AR (dB)	≤0.5	
Port and port Isolation (dB)	Tx to Rx >85, Rx to Rx >15, Tx to Tx >20	
Power Capability	1kW	/

1.2.2 Antenna mechanical specification

Item	Description
Antenna Type	Modified Ring-foucs Antenna, El over Az geometry
Antenna Diameter (m)	6.2
Main Reflector Accuracy (mm)	≤0.30rms
Subreflector Accuracy (mm)	≤0.15 rms
Mount Type	Az and EL for Limited-Motion (LMA)
Driving Chain Mode	Single-motor for azimuth axis Single-motor for elevation axis
Drive range	Azimuth drive: ±85°（Separating into two sections，Continuous in each section, screw jack drive.） Elevation drive: 5° - 90° continuous, screw jack drive.
Antenna Accessorial Parts and Interface	Hot Dip Galvanise
	Lightning Arresting Rods
	Lightning Arrestor down-conductors
	Foundation HW

1.2.3 Antenna servo control and tracking specifications

Item	Description
Travel maximum velocity	AZ / ELAxis Drive Rates up to 0.04°/s;
Autotrack method	Step Tracking
Tracking Accuracy	≤0.033°（rms）
Antenna Operation Mode	Step tracking, Programmed Tracking; Stand-by, Manual Driving; Position Preset

1.2.4 Antenna environmental conditions and other features

Item	Description	Remark
Ambient Temperature	-40°C～+55°C (Outdoor) 0°C～+30°C (indoor)	
Relative Humidity	0%～100%	
Anti-wind Capability	Steady wind: 45km/h, gust:72km/h	Normal Operation

Item	Description	Remark
	Steady wind: 72km/h, gust: 97km/h	Degraded Operation
	gust wind:180km/h	Survival in any position
	gust wind:200km/h	Survival in stow at peak
Others	Packing (sea freight)	
	Feed Rain Blower	
	Dehydrator	
	12 months warranty	

2 System design

2.1 System Composition

The 6.2m Ka-band antenna is mainly composed of antenna reflector, Ka-band feed network, antenna mount, servo control subsystem and monopulse tracking subsystem. The antenna reflector is composed of main reflector and its back bracket, subreflector and its support, hub, feed sleeve, etc. The Ka-band feed network is composed of Ka-band corrugated horn, Ka-band microwave network, etc. The antenna servo control subsystem is composed of antenna control unit (ACU), antenna driving unit (ADU), safeguard protection device, etc.

The composition block diagram of 6.2m Ka-band antenna is shown in Fig.1. The appearance structure of 6.2m antenna is shown in Fig.2

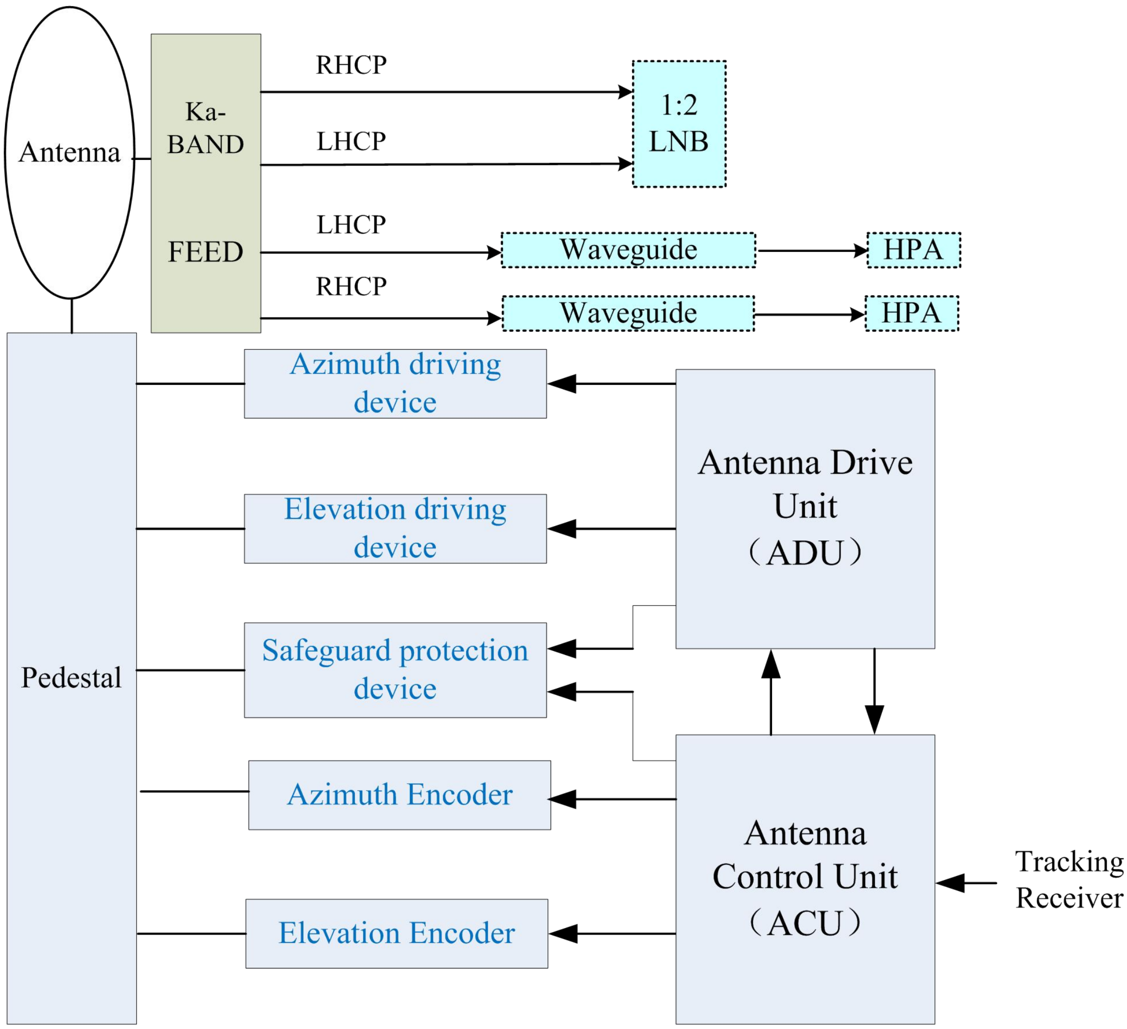

Fig.1 Composition and Principle Block Diagram of Antenna System

Fig.2 Appearance Structure Diagram of 6.2m Antenna

2.2 Operation principle

The feed of Ka-band dual-reflector antenna has six ports, two for Rx, two for Tx and two for tracking. The operation principles are described as follows.

Antenna receiving principle: the antenna aligns with the satellite, the satellite signals are reflected via main reflector and subreflector to the feed, then output from the corresponding port of feed.

Antenna transmitting principle: the transmitting signals are sent from the power amplifier to the feed via waveguide feeder and radiated by the feed, then reflected to the free space via main reflector and subreflector of antenna and propagated to the specific direction of space.

The antenna can simultaneously transmit and receive electromagnetic wave signals in Ka-band. The step tracking mode is used to make the antenna be able to align with the satellite all the time.

3 Design of sub system

3.1 Feed system

3.1.1 Main reflector and subreflector curve design

The shaped Ring-foucs antenna is used to realize such excellent performances such as high efficiency, low sidelobe and low reflection loss. The shaped optimum design is adopted for the main reflector and subreflector by using computer optimization design technique and low sidelobe technique and selecting the special aperture field distribution function and appropriate marginal irradiation level. The main reflector and subreflector curve schematic of 6.2m antenna is shown in Fig.3.

The main geometric parameters are as follows:

Main reflector diameter D_m=6200mm。

Subreflector diameter D_s=620mm。

Half flare angle of main reflector edge to main reflector focus ψ_m=76°。

Half flare angle of subreflector edge to feed phase center θ_m=17°。

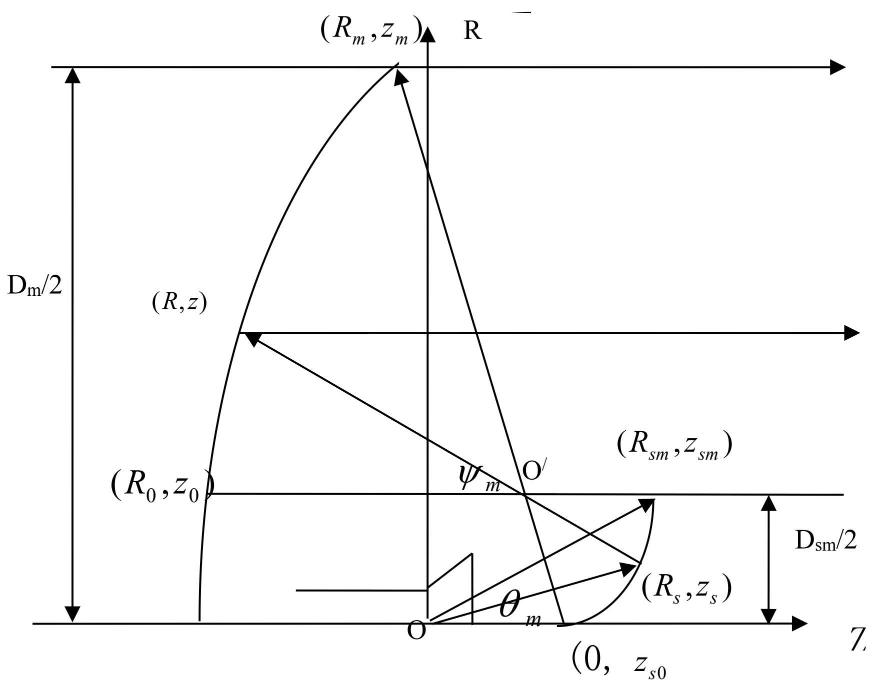

Fig.3. Schematic of Main Reflector and Subreflector Curve of 6.2m Antenna

3.1.2 Feed design scheme

3.1.2.1 General

The feed is the core of the whole antenna and its performances directly affect the RF performance of the antenna. So the optimization scheme and design should be performed more carefully. The feed is composed of corrugated horn, monopluse tracking network and MW communication network. The appearance structure of feed is shown in Fig.4

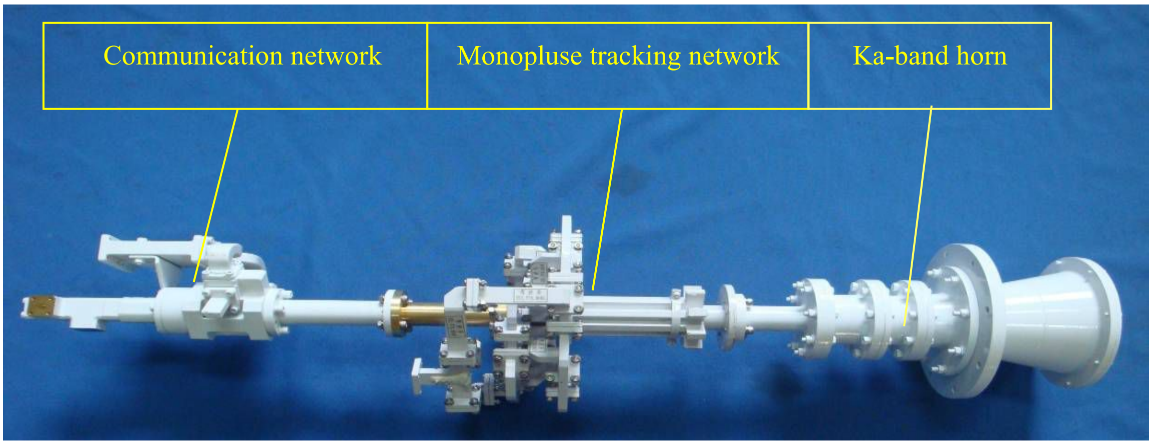

Fig.4 Appearance Structure Diagram of Feed

3.1.2.2 Corrugated horn

The antenna uses one horn for transmitting and receiving signals, which is required to implement ideal irradiation in Rx/Tx frequency bands and have such features as rotation symmetry, low cross polarization radiation directivity pattern and low voltage SWR.。

The corrugated horn is composed of input tapering segment, mode transformer segment, frequency variation segment, flare angle variation segment and horn radiation segment. The appearance of the whole horn is shown in Fig.5.

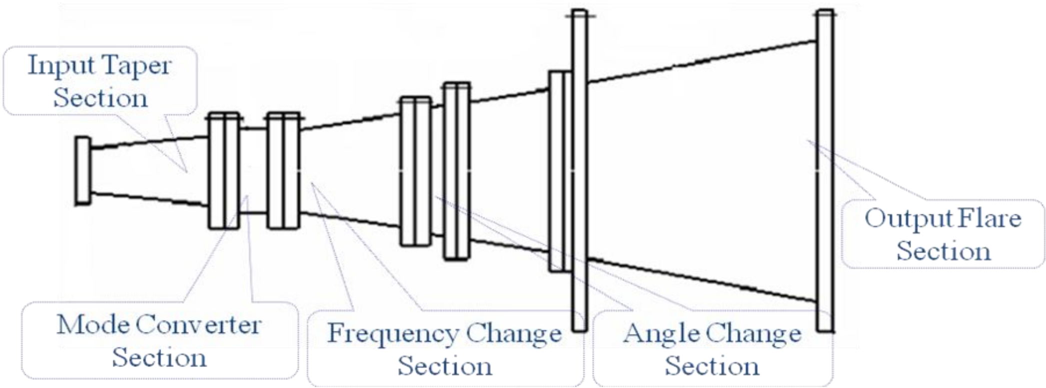

Fig.5 Appearance Structure Diagram of horn

3.1.2.3 Monopluse tracking network

The two polarization connects respectively a frequency duplexer to implement the Tx/Rx frequency segregation. The appearance of TE_{21} mode coupler is shown in Fig.6.There is one waveguide switch to choose the tracking port LHCP or RHCP.

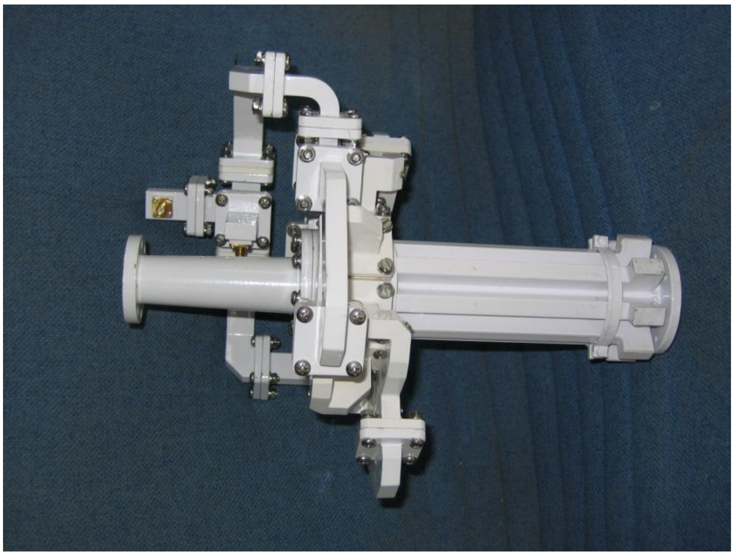

Fig.6 TE_{21} Mode Coupler

3.1.2.4 Communication network

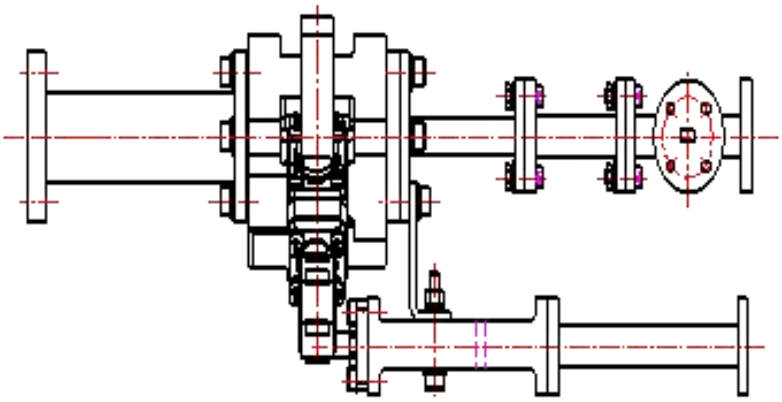

Fig.7 Communication network

3.2 Reflector

3.2.1 General

6.2m Ka band ring focus antenna adopt high accuracy reflector, high stiffness, light weight pedestal structure, it was composed of main reflector, reflector supporting structure, sub reflector and other support structures as shown in figure 8.

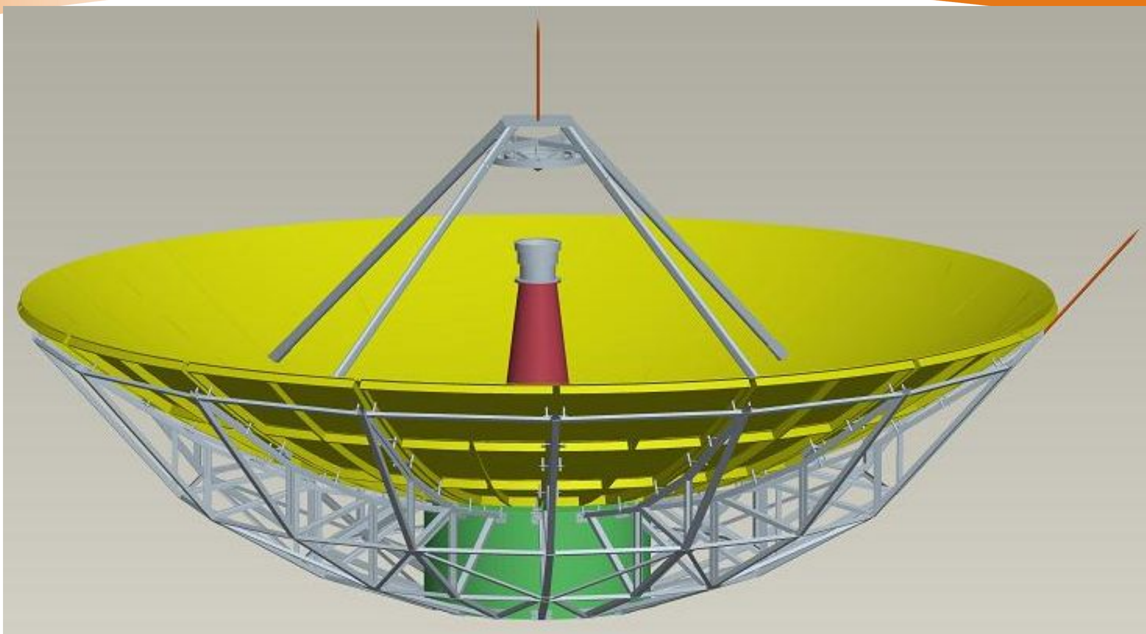

Fig8 Reflector structure

3.2.2 Main reflector

The main reflector are the key part of the antennas, it was composed of hub panels and outer ring panels

Hub panels was casted by aluminum alloy and machined to ring panels,fixed on the hub

single panel of the outer ring was shown in figure 10, it surface accuracy is σ ≤0.15, the total accuracy of the reflector is σ ≤0.2 and will be σ ≤0.3 after reassembled.

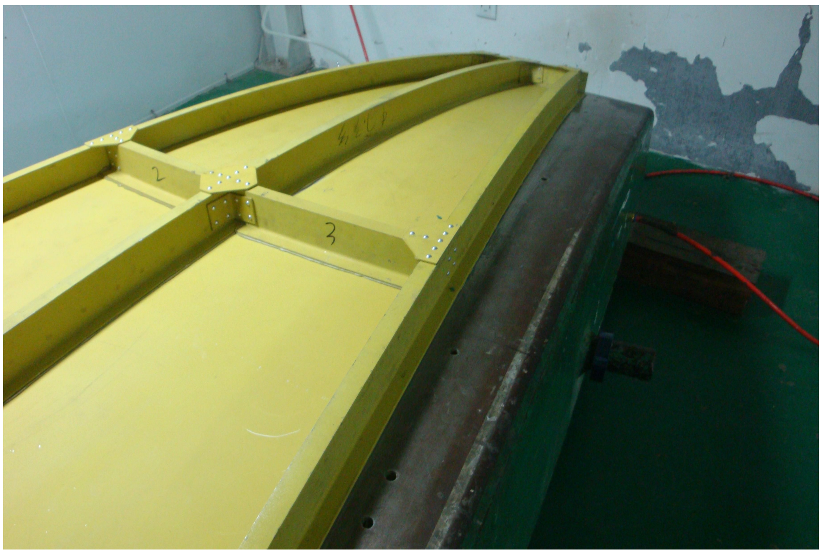

Fig 9Panel

3.2.3 Reflector supporting structure

3.2.3.1 General

The main reflector was support by beams,hub,and ring bars,which are all steel structure, as shown in figure 10

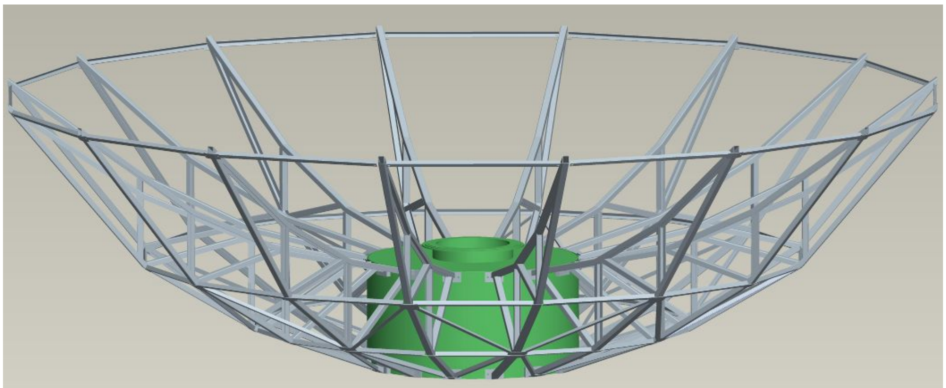

Fig 10 Reflector support structure

3.2.3.2 Hub

The hub is the base part of the whole reflector,wielded by steel panels,the hub panels and feed network were mounted on its top, beams were connected at its side. it was mounted on the top of pedestal, two input and output fans were mounted on the bottom; customer equipment could be mounted inside the hub,the window at the bottom could be open and close by push and pull, as shown in figure 11.

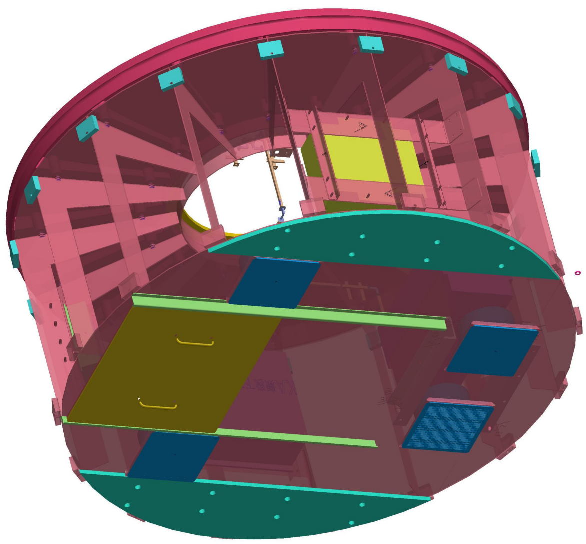

Fig 11 Hub

3.2.3.3 Beams

Beams are the main support parts of the reflector, connect 16 outer ring panels and the hub, it was wielded by rectangle steel tubes, its features are high stiffness and light weight as shown in figure 12.

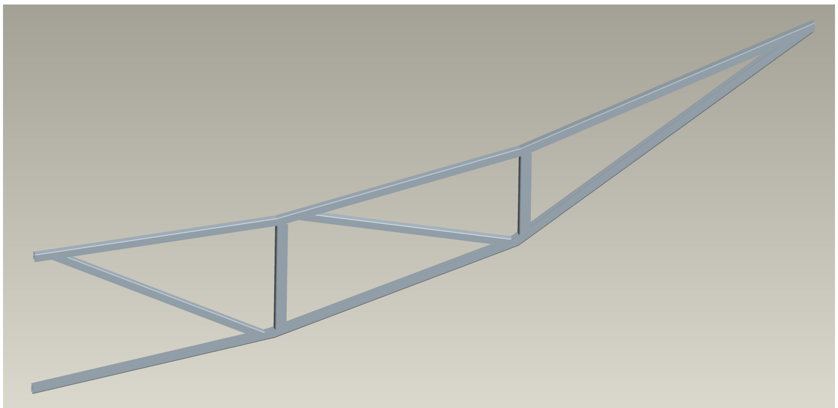

Fig 12 Beams

3.2.4 Sub reflector and quadrupod

The sub reflector as casted by aluminum and machined,its accuracy is ≤0.1mm（R.M.S.）and support by quadruped. The quadruped was made by ellipse steel tubes to minimize its shadow effect, one end of the quadruped was connect to the main reflector,the other end was connected to the sub reflector, as shown in figure 13

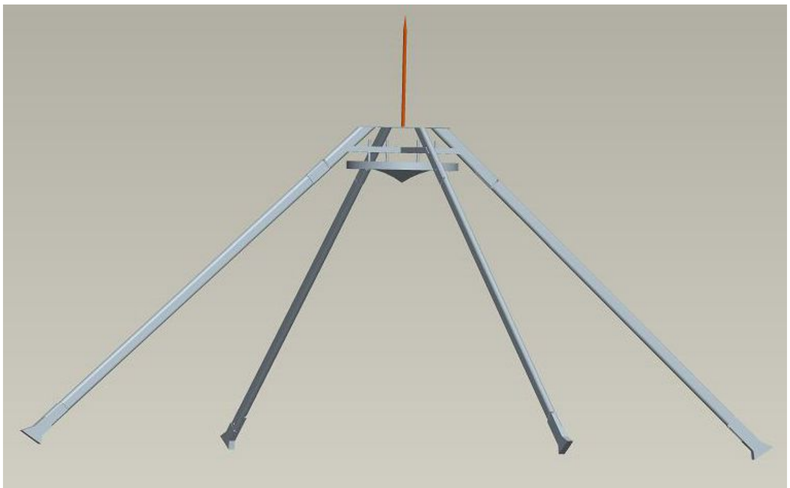

Fig 13 Sub reflector and quandrupod

3.2.5 Lightning protection

A lightning rod was design on the top of sub reflector, and lightning conductor was connected to the ground.

3.3 Pedestal

6.2m antennas adopt truss type pedestal, azimuth and elevation are drive by ball screw, the whole pedestal was mounted on the main pillaras shown in figurexx azimuth and elevation drive device, synchronization device, limitation assembly, safety protection device were include in the pedestal. The rotation range of azimuth is 0～±85° ,the range of elevation is 5～90° ,there are limitation device on both azimuth and elevation.

Fig 14 Pedestal

Both azimuth and elevation are drive by ball screw and gearbox, 750W AC motor was used for azimuth and 1.1kw motor used for elevation.

Manual drive wheels are available for both azimuth and elevation for adjustment and maintence,manual drive wheels should be taken off before turn on the power of motor.

Safety protection devices including limitation devices and emergency stops etc. limitation switches are installed on the end of each rotation range, power will be cut off when the antenna rotated close to the limitation angle to guarantee the safety of personnel and equipments, encoders were installed on each end of axis.

3.4 Servo and tracking system

3.4.1 General

The antenna control system composes of antenna control unit, antenna driving unit and tracking receivers, it controls the rotation of antenna and position of azimuth and elevation, controls the beam to track satellite with high accuracy and stability.

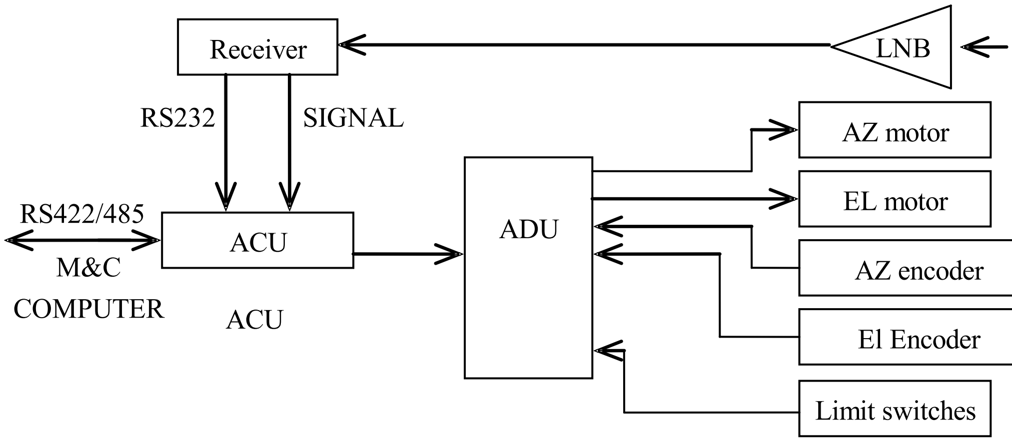

Fig 15 diagram of antenna control system

3.4.2 Antenna control unit (ACU)

Antenna control unit is standard 19 inch cabinet on rack, 3U high.The main function of antenna control unit to receive control input, display, data processing, local and remote control, satellite setting, polarization control, tracking the satellite by analogue or digital signal; monitor the receiver, LNA etc.It control the ADU and read the encoder and other informations via CAN bus.There are RS232/422/485 or Ethernet port to communicate with other devices.

3.4.3 Antenna Driving Unit (ADU)

Antenna control unit is standard 19 inch cabinet on rack, 5U high.

There is a internal processor in the ADU,it read the encoders and other information via CAN bus. Local and remote control mode are avaialbe, coustomer can maintain the antenna by local manual control,or control by the antenna control unit by remote control; it can change and adjust the porlarization as well. A Simens mother driver and protection circuit were adopted in the ADU, over voltage,over current,short circuit will be protected. There is a emergency stop to cut off all power of the antenna and stop the rorations

3.4.4 Tracking receiver

A L band tracking receiver was adopted, convert the satellite beacon RF or IF to DC signal and sent it to ACU to control the antenna.

3.5 Attached equipment

3.5.1 Dehydrator

The Dehydrator fill dry air into the feed network and wave guide to clear humid air. The ETI ADH-23437 dehydrator was used.。

3.6 Attached equipment

3.6.1 Deicing device on the feed aperture

The deicing device on the feed aperture is composed of air blower, filter, heater, pipe and nozzle. As shown in Fig.16, the heated air is blown toward the horn aperture to melt the ice and snow on the horn aperture and blows away the water beads on the horn aperture film to guarantee the normal operation of the communication.

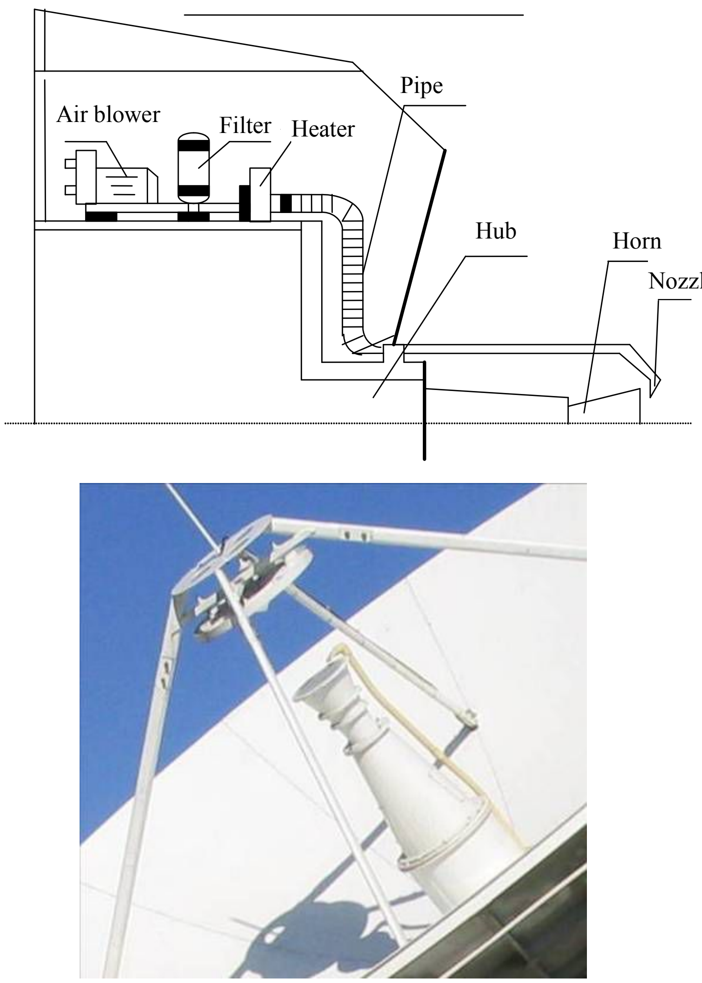

Fig.16 Schematic Diagram of Deicing Device on the Feed Aperture

4 Estimation of main technical indexes

4.1 Estimation of antenna gain

The computation formula of antenna gain is:

$$G = \frac{4\pi S}{\lambda^2}\eta 。$$

Where：

S——Area of main reflector aperture

λ ——Operating wavelength

η ——Overall efficiency of antenna， $\eta = \eta_1\eta_2\eta_3\eta_4\eta_5\eta_6\eta_7\eta_8\eta_9$ 。

η_1 ——Irradiation efficiency of main reflector aperture;

η_2 ——Spillover and diffraction efficiencies of sub-reflector;

η_3 ——Spillover and diffraction efficiencies of main reflector;

η_4 ——Surface tolerance efficiency;

η_5 ——Insertion loss efficiency of feed system

η_6 ——Cross polarization efficiency;

η_7 ——Feed and support rod sheltering efficiency;

η_8 ——Reflection loss efficiency;

η_9 ——Phase center loss efficiency;

The estimation of antenna efficiency is shown in table below

Estimation of Antenna Gain

f（GHz）	20.4	30.2
η_1	0.92	0.93
η_2	0.94	0.94
η_3	0.91	0.91
η_4	0.944	0.876
η_5	0.832	0.841
η_6	0.97	0.97

f（GHz）	20.4	30.2
η_7	0.96	0.96
η_8	0.95	0.95
η_9	0.983	0.983
η	0.532	0.510
G（estimated value ）dBi	59.70	62.92
G（desired value）dBi	59.5	62.8

According to the above estimated result, it meets the corresponding technical index requirement.

4.2 Antenna Noise Temperature

The antenna noise temperature in the position of LNA input port is:

$$T_A = \frac{T_a}{L_F} + (1 - \frac{1}{L_F})T_0$$

Where:

T_a ——is the antenna noise temperature in the position of horn aperture

T_a ——is the antenna noise temperature estimated to horn mouth surface.

L_F ——is the insertion loss of feed

T_0 ——is the ambient temperature, i.e. 300K.

The comparison between the estimated result of antenna noise temperature and the technical requirement is shown.

Noise Estimation of Antenna Feed System

Index name	f(GHz)	
	20.4	Remarks
T_a（K）	102	
L_F（dB）	1	Fine, breeze, 10° elevation
T_A（K）	142.72	
T_A（K）	150	Estimated value

5 Bill of material

All items are listed

Bill of material

No.	Name	Quantity	Remarks
1	Corrugated horn	1	
2	Feed network	1	Circular polarization
3	Feed network support device	1	
4	Main and sub reflector	1	
5	Pedestal	1	
6	ACU	1	
7	ADU	1	
8	Servo cables	1	
9	Uplink wave guide cable	1	
10	Dehydrator	1	
11	Rain blow/remove device on feed horn	1	
12	Limitation and safety assembly	1	
13	Foundation fitting	1	
14	Aviation alarm light	1	
15	Light of hub	1	
16	Lightning rod and conductor	1	
	Spare parts		
1	Horn film	1	
2	Limit switches	1	

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