

Exhibit

Antenna Registration Question 4: Directional Antenna Information

ANTENNA DESCRIPTION

Morehead State University 21 M Space Tracking Antenna

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The Morehead State University 21 m Space Tracking antenna is a full-motion, directional, parabolic antenna. The antenna system is located above the campus of Morehead State University in Morehead, KY, USA. The antenna is oriented with an azimuth axis of 0 degrees oriented due North. Basic performance parameters and RF performance characteristics are provided below.

FUNCTION	PERFORMANCE
Antenna Diameter	21 Meter
Receive Polarization	RHCP,LHCP,VERT,HORZ
Travel Range	AZ +/- 275 degrees from due South (180 deg) EL -1 to 91 degrees POL +/- 90 degrees
Velocity	AZ Axis = 3 deg/sec EL Axis = 3 deg/sec POL Axis = 1 deg/sec
Acceleration	AZ = 1.0 deg/sec/sec min EL = 0.5 deg/sec/sec min
Display Resolution	AZ/EL = 0.001 deg POL = 0.01 deg
Encoder Resolution	AZ/EL = 0.0003 deg (20 Bit)
Tracking Accuracy	<= 5% Received 3 dB Beamwidth (0.028 deg RMS L-band) (0.005 deg RMS Ku-Band)
Pointing Accuracy	<= 0.01 deg rms

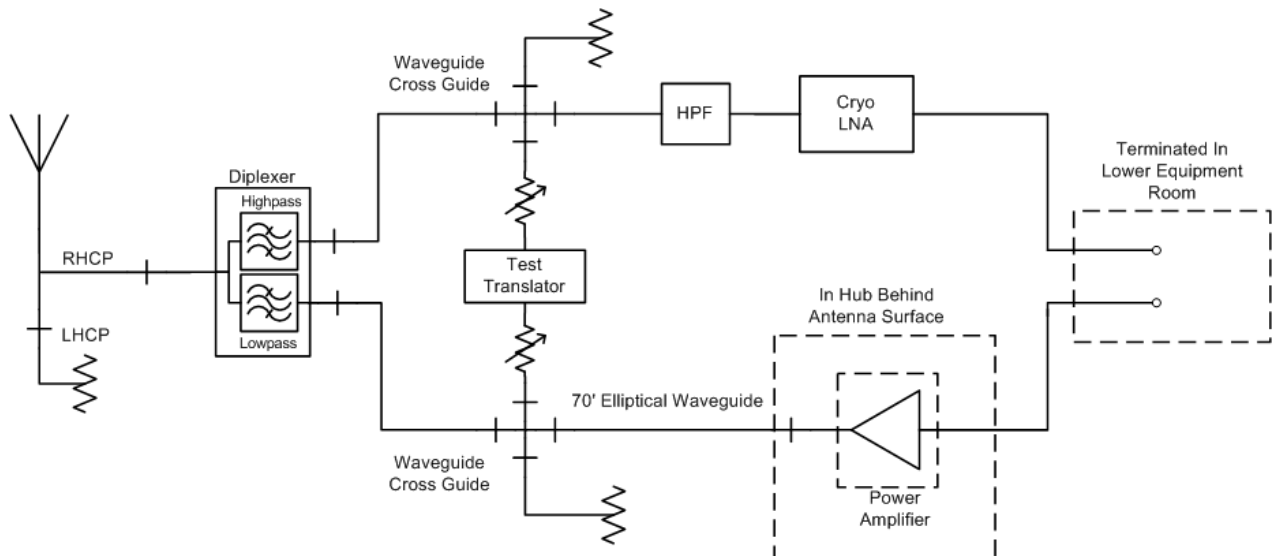
Performance Measure	Performance Value
X-Band Frequency Range*	7.0 – 8.5 GHz
X-band Uplink Range*	7.145 – 7.235 GHz
X-band Downlink Range*	8.400 – 8.500 GHz
LNA Temperature	< 20 K
System Temperature T _{sys}	<100 K
Antenna Gain	62.7 dBi (@8.4 GHz)
System Noise Spectral Density	<-178 dBm/Hz
G/T at 5° Elevation	40.4 dBi/K
Time Standard	H- MASER (1ns/day)
EIRP	93.7 dBW
HPBW	0.1150 deg
SLE Compliant	Yes
CCSDS Capable	Yes
Forward Error Coding	Reed Solomon/Convolutional, Turbo, Low Density Parity Check
Radiometric	Angle, Doppler, Sequential Tone and PN Ranging
Ranging Precision	+/-1 range unit (0.94 ns)



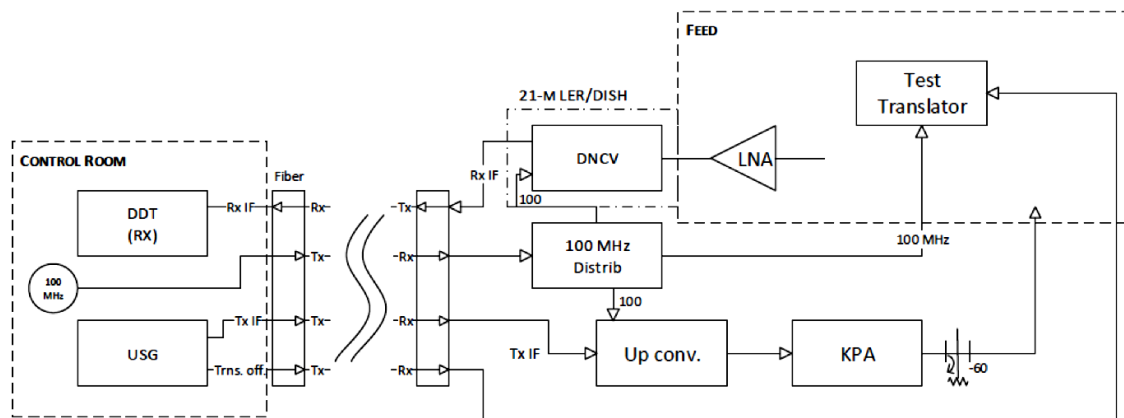
Photograph of the Morehead State University Space Science Center 21 Meter Space Tracking Antenna September, 2020

RECEIVER/TRANSMITTER DESCRIPTION:

The 21 m station's current S-band configuration supports operations as an independent station offering direct connection from the mission's operation center (MOC) to the 21 m Station Operations Center (SOC). The X-band system is primarily used for LEO mission support (uplink and downlink and ranging). A block diagram of the standard 21-m feed configuration is shown below, followed by the overall systems architecture. The X-band feed consists of a horn, coupler, orthomode transducer (OMT), low noise amplifier (LNA), and noise control source or test inject system. Down conversions are accomplished using frequency-specific, interchangeable tuners.

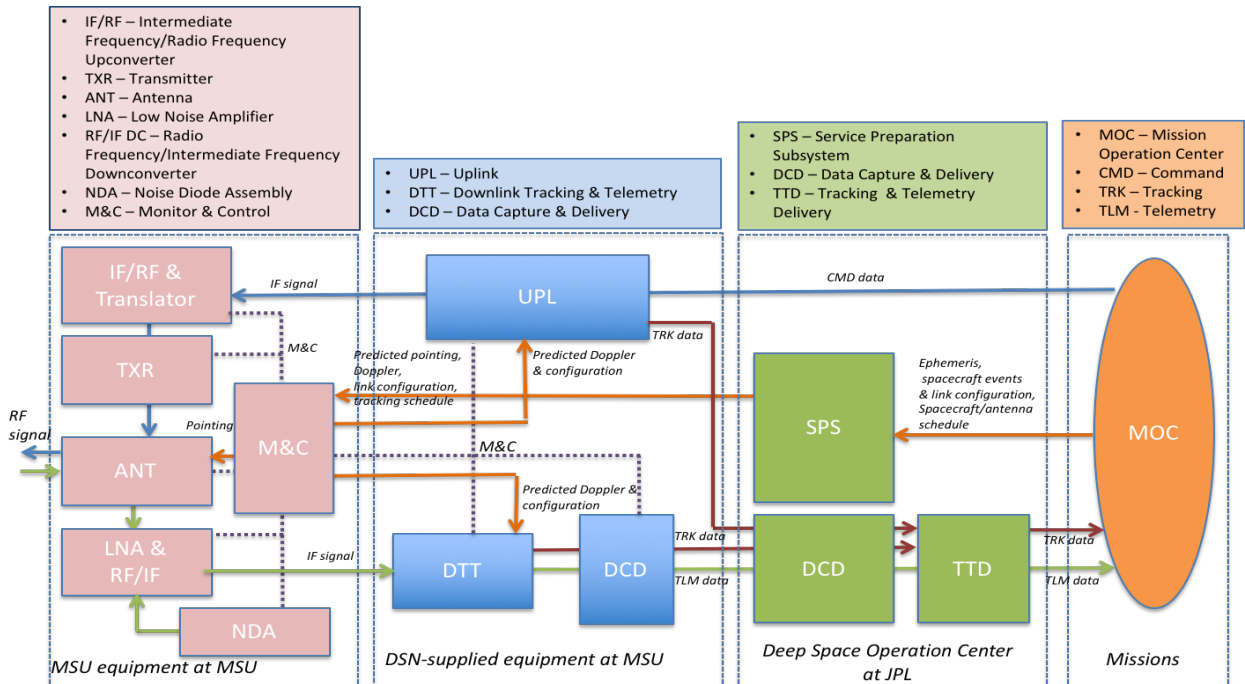


Block Diagram of the 21 m X-band Feed



RF System Block Diagram

The 21-m receiver system incorporates back-end (digital front-end) technologies that includes complete automation and control systems (for remote autonomous operation of the 21 m) and a NASA Deep Space Network Block 6 Receiver and signal generator (shown below).



Block Diagram of the 21 meter Antenna DSN Block 6 Receiver/Transmitter System

The 21 -m transmitter system incorporates a 3 KW CPI GEN IV Klystron Power Amplifier (KPA) is utilized for the uplink. Basic information describing the KPA system is shown below.

K4C75LBNZ0F00EF, 2.45KW, 6.7-7.3 GHz Gen IV Klystron High Power Amplifier Outdoor with a VKC2505D-M24 Klystron.

- CPI GEN IV Klystron PA
- Frequency Range 7.9 - 8.4 GHz
- Klystron Power Output 3.0 kW min. (64.77 dBm)
- Gain at 3 KW = 77 dB, min.
- Gain Stability vs. Time ± 0.25 dB/24 hr. max. at constant drive and temperature
- Noise and Spurious = -65 dBW/4 kHz, 4.2 - 12.0 GHz
- Bandwidth = 40 MHz