

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

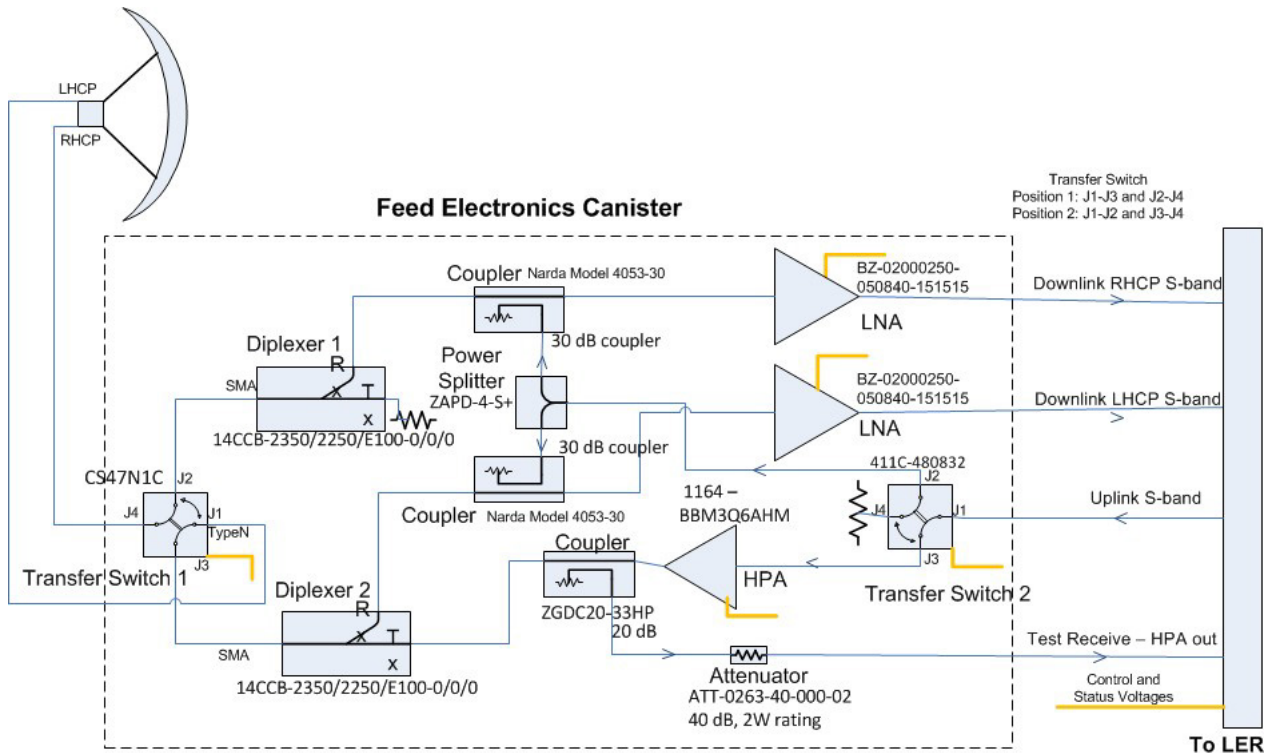
21 m Performance Characteristics (S-Band)*	
frequency band and performance values listed are ranges in which the 21 m system has capabilities, not for which the system is licensed.	
Performance Measure	Performance Value
S-Band Downlink Range*	2.2 – 2.3 GHz
S-band Uplink Range*	2.02 to 2.12 GHz
LNA Temperature	~35K
System Temperature T_{sys}	~135 K
Antenna Gain	51.6 dBi (@2.25 GHz)
G/T at 5° Elevation	30.8 dBi/K
Time Standard	H- MASER (1ns/day)
Transmitter Output Power	100 W
HPBW	0.37 deg
Data rates	100 bps to 20 Mbps
Line Coding	NRZ-L, NRZ-M, NRZ-S, Biphas-L, Biphas-M, Biphas-S, RZ
Modulation/ Demodulation	PM, BPSK, QPSK, SQPSK, DQPSK-Normal, DQPSK-Alternative, FSK, GFSK, GMSK, MSK
Decoding	Viterbi/ convolutional rate ½, Reed Solomon (255, 223)
Front end processing	CCSDS compatible, stores data on system, transmit data via TCP/ IP, FTP. Space Link Extension (SLE) modules



Photograph of the Morehead State University Space Science Center 21 Meter Space Tracking Antenna September, 2019

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 S-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. The S-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.



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), software-defined radio/ DSP front-end (including an Amergint SoftFEP 200 Telemetry receiver and an RT Logic T400 Modem).

The 21 -m transmitter system incorporates a 100 W Stealth Microwave Power Amplifier (Model SR31720-50L) is utilized for the uplink. A block diagram of the receiver/transmitter system is shown below.

