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Supplemental Statement
File 0116-EX-CN-2023

This application is for a 2 year research program on subterahertz communications technology at Oklahoma State University (OSU), a major public research university. This work will be directed by Prof. John Ohara[1] whose current research interests are focused on the use of novel terahertz and optical systems for the realization of 6G communications, optical and RF/optical hybrid sensing and communication, IoT (internet of things), artificial electromagnetic materials, and STEM outreach to rural communities and is supported by NASA grant 80NSSC22K0878. The NASA POC is George Jackson, NASA Goddard Space Flight Center, 301-957-6793, George.L.Jackson@nasa.gov

Frequency Issues

We seek to use a center frequency in the range of 127-133 GHz and various forms of PSK modulation signals with bandwidths up to 20 GHz to test modulation efficiency and propagation issues. The allocation status of this spectrum is shown in Table I. The spectrum we seek access to ranges from 117 to 143 GHz and includes no bands subject to the "All emissions are prohibited" provision of RR 5.340 or the "No station shall be authorized to transmit" provision of US246. There is a coprimary allocation for Earth Exploration-Satellite (passive) in 115-122.25 GHz. We note that 122-123 GHz has been identified for ISM use in RR5.138. In the *First Report and Order* on Docket 18-21/"Spectrum Horizons",[2] the Commission adopted rules

> "to permit enhanced experimental licensing and unlicensed applications within this spectrum band as well as advance our overall commitment to identify and make available unused and underused spectrum regardless of the frequency"

and also stated that

> "experiments are vital for the development of new applications and services suited for the unique properties of the bands above 95 GHz. These applications and services, in turn, will generate additional interest in these bands and can ultimately provide a basis for the further expansion of permissible uses throughout the frequency range…We will not, by rule, preclude the use of any specific frequencies."

Appendix B of the NPRM in Docket 18-21[3] contains a list of "current and proposed passive satellite operations above 95 GHz … provided by the National Aeronautics and Space Administration". This list identifies 3 satellite sensors on 3 different satellites in the 116-122.25

[1] https://experts.okstate.edu/oharaj
[2] https://docs.fcc.gov/public/attachments/FCC-19-19A1.pdf
[3] https://docs.fcc.gov/public/attachments/FCC-18-17A1.pdf

GHz band.[4] The more recent WMO OSCAR database[5] shows operating and planned sensors in this band and is given in Table II. Most of the sensors listed are not yet in orbit.

In the FCC experimental license granted to the University at Buffalo in 2018, call sign WM9XXI, File 0753-EX-ST-2018, the Commission conditioned the license on not transmitting "when the NASA AURA spacecraft (NORAD designation 28376 or international spacecraft ID 2004-07015) is within horizon-to-horizon view of the testing location". OSU requests a similar condition with respect to all EESS(p) sensors in the 115-122.25 GHz band. OSU believes that this lack of transmission while a passive satellite is visible overhead will reliably protect the satellite from any interference during this experiment. Indeed, considering the high propagation loss at low elevation angles to satellite altitudes in this frequency range , it is actually possible to protect satellites when they are visible at such low angles. But for simplicity and to follow precedent, the exact working of the Buffalo licenses quoted above is acceptable.

The situation at 130 GHz for the ESA CRISTAL satellite (launch expected in >2027) and the EUMETSTAT Sentinel-6A (launched in 2020) and Sentinel-6B (launch expected >2025) is more complex since they are not in an allocated protected band. OSU will make reasonable efforts to protect these satellites by avoiding transmissions when they are visible from the testing location. As OSU develops antennas with improved sidelobe suppression at high elevation angles we will seek a license amendment on a maximum EIRP limit as a function of elevation angle as the Commission's UK counterpart Ofcom has done for outdoor use of the 116-122, 174.8-182, and 185-190 GHz bands. [6]

OSU has decided to request use of the 127-133 GHz because of the immediate availability of key equipment for such operation. This is a true experiment and does not involve 24/7 operational use so the experiment can cease as required to protect passive satellites passing overhead that are operating in allocated protected bands.

Equipment

OSU will use a VDI Model 130AMPS amplifier for a transmitter
https://www.vadiodes.com/en/waveguide-amplifiers
Maximum emitted power is +22dBm.

The transmitter antenna will have a maximum gain of 56 dBi. Thus maximum EIRP will be 78 dBm.

The antenna will be on an OSU building at the licensed location. It will be pointed at a retroreflector so the receiver can be near the transmitter. The retroreflector location will change throughout the experiment.

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[4] These satellites are SNSB (Sweden) ODIN, NASA AURA, and EUMETSAT METOP-SG-A
[5] https://space.oscar.wmo.int/satellitefrequencies
[6] Ofcom, "Supporting innovation in the 100-200 GHz Range: Increasing access to Extremely High Frequency (EHF) Spectrum", 1 October 2020 at Figure 6.1 (https://www.ofcom.org.uk/__data/assets/pdf_file/0024/203829/100-ghz-statement.pdf)

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STOP BUZZER

Contact is Prof. John O'Hara, oharaj@okstate.edu, (405) 744-3750

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Table I – Allocation status of bands involved in this application

Table of Frequency Allocations			123-191.8 GHz (EHF)		
International Table			United States Table		FCC Rule Part(s)
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table	
116-119.98 EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE 5.562C SPACE RESEARCH (passive) 5.341			116-122.25 EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE 5.562C SPACE RESEARCH (passive)		ISM Equipment (18)
119.98-122.25 EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE 5.562C SPACE RESEARCH (passive) 5.138 5.341			5.138 5.341 US211		
122.25-123 FIXED INTER-SATELLITE MOBILE 5.558 Amateur 5.138			122.25-123 FIXED INTER-SATELLITE MOBILE 5.558 5.138	122.25-123 FIXED INTER-SATELLITE MOBILE 5.558 Amateur 5.138	ISM Equipment (18) Amateur Radio (97)
123-130 FIXED-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) RADIONAVIGATION RADIONAVIGATION-SATELLITE Radio astronomy 5.562D 5.149 5.554			123-130 FIXED-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) RADIONAVIGATION RADIONAVIGATION-SATELLITE Radio astronomy 5.554 US211 US342		
130-134 EARTH EXPLORATION-SATELLITE (active) 5.562E FIXED INTER-SATELLITE MOBILE 5.558 RADIO ASTRONOMY 5.149 5.562A			130-134 EARTH EXPLORATION-SATELLITE (active) 5.562E FIXED INTER-SATELLITE MOBILE 5.558 RADIO ASTRONOMY 5.562A US342		
134-136 AMATEUR AMATEUR-SATELLITE Radio astronomy			134-136 Radio astronomy	134-136 AMATEUR AMATEUR-SATELLITE Radio astronomy	Amateur Radio (97)
136-141 RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite 5.149			136-141 RADIO ASTRONOMY RADIOLOCATION US342	136-141 RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite US342	
141-148.5 FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION 5.149			141-148.5 FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION US342		

Source: 47 CFR 2.106 (https://transition.fcc.gov/oet/spectrum/table/fcctable.pdf)

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Table II --Data on EESS(p) sensors operating and planned in 117-133 GHz from WMO OSCAR

ID	Satellite	Space Agency	Launch	EOL	Service	Sensing mode	Frequency (GHz)	Bandwidth (MHz)	Polarisation	Comments
4273	TROPICS-06	NASA	≥2023	≥2025	TMS	passive	117.8	500	-	Passive MW radiometer in window region
4285	TROPICS-07	NASA	≥2023	≥2025	TMS	passive	117.8	500	-	Passive MW radiometer in window region
4238	TROPICS-01 (Pathfinder)	NASA	2021-06-30	≥2023	TMS	passive	118.24	380	-	Passive MW radiometer in window region
4250	TROPICS-04	NASA	≥2023	≥2025	TMS	passive	118.24	380	-	Passive MW radiometer in window region
4262	TROPICS-05	NASA	≥2023	≥2025	TMS	passive	118.24	380	-	Passive MW radiometer in window region
4274	TROPICS-06	NASA	≥2023	≥2025	TMS	passive	118.24	380	-	Passive MW radiometer in window region
4286	TROPICS-07	NASA	≥2023	≥2025	TMS	passive	118.24	380	-	Passive MW radiometer in window region
4239	TROPICS-01 (Pathfinder)	NASA	2021-06-30	≥2023	TMS	passive	118.58	380	-	Passive MW radiometer in O2 band
4251	TROPICS-04	NASA	≥2023	≥2025	TMS	passive	118.58	380	-	Passive MW radiometer in O2 band
4263	TROPICS-05	NASA	≥2023	≥2025	TMS	passive	118.58	380	-	Passive MW radiometer in O2 band
4275	TROPICS-06	NASA	≥2023	≥2025	TMS	passive	118.58	380	-	Passive MW radiometer in O2 band
4287	TROPICS-07	NASA	≥2023	≥2025	TMS	passive	118.58	380	-	Passive MW radiometer in O2 band
2851	Metop-SG-B1	EUMETSAT	≥2025	≥2032	MWI	passive	115.3 - 122	N/R	V	Oxygen band, 4 channels
2869	Metop-SG-B2	EUMETSAT	≥2032	≥2039	MWI	passive	115.3 - 122	N/R	V	Oxygen band, 4 channels
2887	Metop-SG-B3	EUMETSAT	≥2039	≥2046	MWI	passive	115.3 - 122	N/R	V	Oxygen band, 4 channels
2568	FY-3E	CMA	2021-07-04	≥2027	MWHS-2	passive	112.75 - 124.75	N/R	H	Oxygen band, 8 channels
3747	FY-3C	CMA	2013-09-23	≥2023	MWHS-2	passive	112.75 - 124.75	N/R	H	Oxygen band, 8 channels
3752	FY-3D	CMA	2017-11-14	≥2023	MWHS-2	passive	112.75 - 124.75	N/R	H	Oxygen band, 8 channels
3756	FY-3H	CMA	≥2023	≥2029	MWHS-2	passive	112.75 - 124.75	N/R	H	Oxygen band, 8 channels
2993	FY-3F	CMA	≥2022-12	≥2028	MWHS-2	passive	112.75 - 124.75	N/R	H	Oxygen band, 8 channels
3008	FY-3J	CMA	≥2027	≥2035	MWHS-2	passive	112.75 - 124.75	N/R	H	Oxygen band, 8 channels
3023	FY-3G	CMA	≥2023	≥2027	MWHS-2	passive	112.75 - 124.75	N/R	H	Oxygen band, 8 channels
3058	FY-3I	CMA	≥2026	≥2034	MWHS-2	passive	112.75 - 124.75	N/R	H	Oxygen band, 8 channels
2088	Aura	NASA	2004-07-15	≥2025	MLS	passive	118.753	10	-	Band for temperature and pressure using 118GHz O2 line.
2089	Aura	NASA	2004-07-15	≥2025	MLS	passive	118.753	1250	-	Band for temperature and pressure using 118GHz O2 line.
2090	Aura	NASA	2004-07-15	≥2025	MLS	passive	120.5	500	-	Temp and Pressure sounding using 118 GHz line.
4199	Aura	NASA	2004-07-15	≥2025	MLS	passive	122	500	-	Temp and Pressure sounding using 118 GHz O2 line
4191	Sentinel-6A	EUMETSAT	2020-11-21	≥2027	HRMR	passive	130	5000	linear	High freq window channel
4194	Sentinel-6B	EUMETSAT	≥2025	≥2032	HRMR	passive	130	5000	linear	High frequency window channel
4197	CRISTAL	ESA	≥2027	≥2034	HRMR	passive	130	5000	linear	High frequency window channel

https://space.oscar.wmo.int/satellitefrequencies