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MSSI's HF Pulse Interference Concerns Regarding 47 CFR Part 90, 80.229 and 87.149 Regulations

Summary

MSSI's HF pulse transmitter for use in ionospheric sounding experiments has minimal interference potential to existing Part 80.229, 87.149 and 90 radio devices. This interference mitigation is achieved via the characteristics of the MSSI's HF pulse waveform and the experimental test procedures summarized here.

1. MSSI's wideband pulse spreads the RF energy instantaneously and evenly over the pulse spectral bandwidth without concentrating energy into any resolution bandwidth at any instant in time.
2. MSSI will implement a very low pulse repetition frequency (PRF) during the experiment, resulting in extremely low average power density over any spectrum band within the HF pulse bandwidth.
3. MSSI's experiments will not require the pulse train transmissions to last longer than 50 seconds with a total transmitter on-time for the experiment to be at most 4,000 seconds distributed over a three (3) day period.
4. The ionospheric sounding experiment will be performed in a remote in-land region of Alaska with the antenna pointed skyward minimizing any potential interference with private mobile land radio bands and restricted maritime bands.
5. The antenna is horizontally polarized for minimum surface wave propagation and the surrounding area to the antenna is forested providing absorption for potential sidelobe radiation.
6. Aviation band interference is mitigated since the antenna is 55 kilometers from the nearest airport with a skyward pointing directional antenna and spatially defined antenna lobe requiring the aircraft to fly through the main antenna lobe of the antenna while the HF pulse transmitter is operational. Test procedures to stop transmitting when aircraft are overhead will eliminate this from occurring.

Additional Information Supporting Summary Statements

Statement 1

The waveform characteristics of MSSI's wideband HF pulse cannot be characterized by conventional continuous waveform (CW) metrics used to define the federal regulations. With MSSI's pulse implementation, the wide bandwidth is generated *directly* and not by modulation with a chipping sequence such as pseudo-noise (PN) code of a direct sequence spread spectrum system. Thus, the wide bandwidth is essentially a *time-domain* concept in which an extremely short pulse generates an extremely wide bandwidth signal expressed by the direct Fourier transform relationship between time and frequency. The resulting very low energy densities result in a waveform which is exceedingly difficult to detect and, as a consequence, very unlikely to cause interference to other radio systems. The figure below shows the time and frequency domain representation of a single HF pulse. The table below shows the peak power of the pulse for multiple resolution bandwidths within the pulse spectrum.

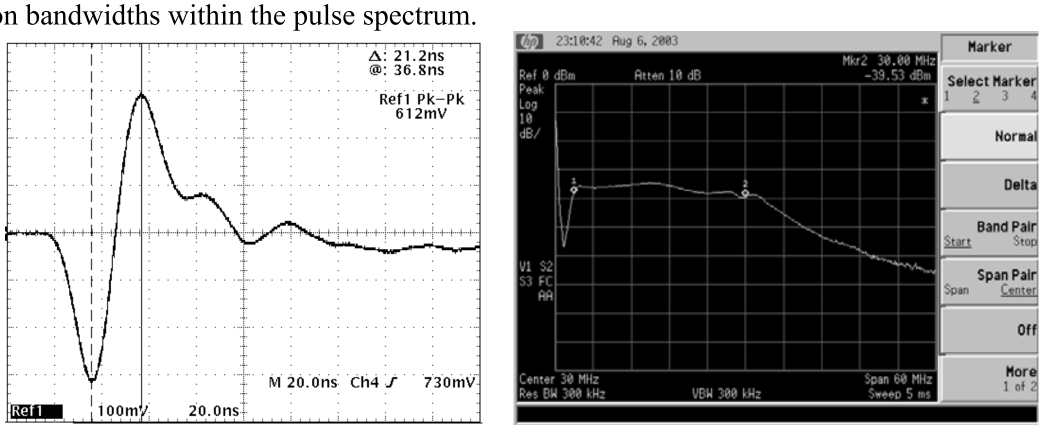

Figure: The HF Wideband Pulse Time and Frequency Responses

Table: HF UWB Signal Power Specrtal Density

Resolution B/W (KHz)	Pulse Rep Freq (Hz)	Peak Power (mWatts/Hz)	Average Power (μWatts/Hz)
1	100	37.0	0.137
2	100	74.1	0.274
5	100	185.2	0.686
10	100	370.4	1.372
30	100	1111.1	4.115
100	100	3703.7	13.717
1000	100	37037.0	137.174

Statement 2
The short high power pulse followed by a long off time minimizes emitted average power. The peak to average power ratio of MSSI's pulse waveform is the pulse bandwidth (BW) of 27 MHz divided by the Pulse Repetition Frequency (PRF) of 100 Hz, resulting in a ratio of 270,000. This is considerably higher than a conventional CW systems or radars. The table above illustrates average power of the pulse for various potential intercept receiver resolution bandwidths.

The average power in a resolution bandwidth is (resolution BW)/(pulse BW) x Peak Pulse Power/(peak to average ratio). A resolution bandwidth of 73 KHz is required to exceed the 10 microWatts power spectrum density level as defined in the requirements of Part 87.149 and Part 80.229. None of the protected frequencies and restricted bands including the +/-6 KHz guard bands will have sufficient bandwidth for the MSSI's HF pulse exceed this power density level.

Statement 3
The ionosond tests will not require more than three (3) days of sporadic transmissions. The test plan only calls for 17 different data points, each data test point requiring at most a 100 Hz pulse train of 50 second duration to provide a return signal processing gain by 37 dB. Transmission times can be reduced if it is determined not as much processing gain is required. The tests will be repeated at least 4 times at different parts of the day for night, day and two tests in transition between day and night during twilight. The test plan also calls for transmitter antenna analyses to characterize the antenna performance when transmitting the wideband waveform. These antenna tests will require the transmitter to radiate a couple of seconds for each sample. Summing up the entire HF pulse transmitter on time for the tests and system set up will have the transmitter operational for a total of 3,500 to 4,000 seconds spread over a period of three days.

Statement 4
The test site for the HF wideband pulse transmissions is remote, outside of Fairbanks, Alaska where the signal will be directed skyward in a vertical launch into the ionosphere. Most of the energy transmitted will go directly into outer space with minimal lateral propagation. The signal will not affect the maritime restricted bands (Part 80.229 regulations) since the location is inland several hundred miles from the coast. The private land mobile services (Part 90) will be affected minimally since the radio antenna is directed skyward. Searching the FCC site for licenses in the region of the antenna only returned 26 active licenses for an 80 km radius in the HF band of operation. Half of the licenses are held by the State of Alaska and are mostly state-wide.

Statement 5
The antenna location is surrounded by forests to absorb any lateral sidelobe antenna radiation. The polarization of the signal will be horizontal minimizing any potential surface wave propagation of the HF

signal since surface wave propagation requires vertical polarization. This provides for further interference protection for private land mobile systems.

Statement 6
Finally, the probability of aircraft interference is minimized (Part 87.149) since the antenna location is 55 km from the nearest airport. If an aircraft were to fly into the beam lobe of the vertically pointed antenna, the beamwidth would be approximately 65 – 80 degrees wide. With this beamwidth, the time of flight of any aircraft flying through the beam will be a function of altitude and airspeed. For a jetliner at 10,000 ft and airspeed of 300 kts, the time in the longest path through the radiated lobe is 24 seconds. MSSI will include as part of the test procedures to scan the sky for aircraft. If an aircraft is spotted, the tests will be paused until it has left the airspace. Current managers of the Department of Defense antenna facility stated the location of the antenna is not on the flight path of any airport and air traffic is rarely seen whether commercial or small general aviation aircraft.