Renewal of file 0238-EX-RR-2016 call sign WA2XXL : narrative

The applicant Dr. Pierre Flament (pflament@hawaii.edu) is a faculty member of the School of Ocean and Earth Science and Technology (SOEST). SOEST is an academic and research unit of the University of Hawaii at Manoa, a public institution of the State of Hawaii. The mission of SOEST is focused on ocean and earth science research and exploration. See www.soest.hawaii.edu for more information.

SOEST operates High Frequency Doppler Radar (HFDR) instrumentation at 7 permanent fixed locations given in FCC form 442:

System Location	Call sign	System Hardware
Kaena Point, Oahu	WA2XXL KNA	University of Hawaii, MK-II
Kapolei/Barbers Point, Oahu	WA2XXL KAP	University of Hawaii, MK-II
Kalaeloa, Oahu	WA2XXL KAL	University of Hawaii, MK-II
Kakaako, Oahu	WA2XXL KAK	University of Hawaii, MK-II
Koko head, Oahu	WA2XXL KOK	University of Hawaii, MK-II
Pepeekeo, Hawaii	WA2XXL PPK	University of Hawaii, MK-II
Keaukeha, Hawaii	WA2XXL KKH	University of Hawaii, MK-II

The fixed HFDR are operated as part of the Pacific Island Ocean Observing System (PacIOOS). PacIOOS is one of eleven regional associations funded by the NOAA IOOS program office to provide coastal oceanographic data for a variety of government and societal stakeholders. The nationwide HFDR network of approximately 170 stations provides critical ocean surface current maps to NOAA and the United States Coast Guard (USCG) for planning search and rescue missions and spill response in addition to other purposes such as maritime domain awareness and public outreach.

In addition, SOEST operates intermittently 4 mobile HFDR units for the purposes of (i) limited-time rapid deployments in support of emergency operations, and (ii) limited-time deployments for technology research, development and testing. These mobile HFDR units may also be swapped with the fixed units whenever repair is needed, to avoid interrupting the data stream to the federal agencies funding the operation.

System Location	Call sign	System Hardware
Mobile unit #1	WA2XXL	Helzel Messtechnik, WERA
Mobile unit #2	WA2XXL	Helzel Messtechnik, WERA
Mobile unit #3	WA2XXL	University of Hawaii, MK-II
Mobile unit #4	WA2XXL	University of Hawaii, MK-III

The equipment available to SOEST consists of 2 commercial WERA HFDR, 8 experimental HFDR internally designed and built at the University of Hawaii, referred to as MK-II, and 1 new generation experimental HFDR also internally designed and built at the University of Hawaii, referred to as MK-III.

The broadcast signals of all three models are identical and consist of an uninterrupted frequency-modulated continuous wave (FMCW) linear chirp with no further coding. The bandwidth governs the mapping resolution with 100 kHz giving 1.5 km resolution and it is chosen based on the ITU band allocation. The chirp repetition rate governs the maximum Doppler velocity, typically 1 to 6 Hz are optimum given the homodyne detection used in the receiver section (RX). All fixed stations installed by the University of Hawaii use a four-element rectangular TX array of resonant vertical monopoles $\lambda/2*\lambda/4$, broadcasting a ~120˚ beam towards the ocean with a 20-dB back-lobe power rejection, effectively increasing the ERP by 3 dB. Although the power amplifiers available allow 30W, most of the fixed stations currently operate with 3-10W transmit power.

The transmitter section (TX) of all three HFDR models follow identical concepts and consist of 4 essential components:

1- an ultra-low phase noise Oven-Controller Crystal Oscillator (OCXO)
2- a Direct Digital Synthesis signal generator (DDS)
3- a RF power amplifier
4- a low-pass anti-harmonic filter

The three models differ in implementation details, as follows.

1. The WERA HFDR is commercially produced by Helzel Messtechnik GmbH in Kaltenkirchen, Germany (FCC ID 2AV3S-WERA, FCC form 731 TCB). It features: a 45-MHz OCXO manufactured by Vectron (now Microsemi), with a single-sideband (SSB) phase noise better than -160 dBc @ 1 kHz; a signal generator module based on the Analog Devices model AD9852 DDS, with a 1 microhertz tuning precision and a 14-bit DAC; a class A power RF amplifier rated at 30W CW output based on Motorola MOSFET transistors; and 4-stages lumped-LC low-pass anti-harmonic filters, that are swapped to match the actual operating frequency of the HFDR.

2. The University of Hawaii MK-II is produced by the University of Hawaii and only used internally. It features: a 100 MHz OCXO manufactured by Vectron (now Microsemi), with a single-sideband (SSB) phase noise better than -160 dBc @ 1 kHz; a signal generator module commercially produced by Novatech Instruments in Seattle WA (model DDS8m), based on the Analog Devices model AD9854 DDS with a 1 microhertz tuning precision and a 14-bit DAC; a class A-B power RF amplifier rated at 50W CW output commercially produced by Tomco Technologies in Stepney, South Australia; and 5-stages lumped-LC low-pass anti-harmonic filters produced by DLW Associates in St Charles MO, that are swapped to match the actual operating frequency of the HFDR.

3. The University of Hawaii MK-III is also produced internally by the University of Hawaii and used in programs with collaborative institutions funded by joint awards. It is identical to the MK-II, except that it features a 100 MHz OCXO manufactured by Bliley in Erie PA, with a single-sideband (SSB) phase noise of -150 dBc @ 1 kHz, and a signal generator module also based on the AD9854 DDS, but commercially produced by D-Tacq Solutions, in Blantyre, UK (model RAD-CELF).

The funding for the operation and maintenance of the fixed HFDRs comes from NOAA IOOS office (POC: Carl Gouldman, carl.gouldman@noaa.gov , 240-533-9454, award NA16NOS0120024). The funding for the development and construction of the HFDRs is coming from a variety of additional sources including the National Science Foundation, the Office of Naval Research, the Department of Homeland Security as well as the State of Hawaii.

SOEST is also providing copies of the MK-III HFDR to collaborative institutions in the US. Currently the Woods Hole Oceanographic Institution (call sign WI2XUH) has 4 units operated with funding from the National Science Foundation (POC: Mete Uz, bmuz@nsf.gov) and the University of Guam (license pending) has 2 units to be installed in 2022 with funding from the NOAA IOOS Office.

The SOEST HFDRs have been operating, some as far back as 2002, at the custom frequencies listed in the FCC experimental license WA2XXL first awarded in 2001, and renewed unmodified in 2006, 2011 and 2016.

The goals of the present ELS application are to:

(i) register the positions of the fixed stations at which the SOEST HFDRs are presently transmitting operationally;

(ii) transition the frequencies of the fixed stations to the new ITU bands designated for oceanographic HFDRs, as outlined in FCC order 17-33 (March 27, 2017);

(iii) terminate all transmissions at the old custom frequencies of WA2XXL upon expiration of the previous license;

(iv) expand the list of frequencies of the mobile units used intermittently for research, development and testing, to include all ITU bands in which oceanographic HFDRs are allowed to operate.

The capability of testing at any ITU frequency is needed for preparing units dispatched to the collaborative institutions.

Because the new ITU frequencies are close to the experimental frequencies originally awarded to WA2XXL, no modification of the radio electronics or array configuration of the fixed stations will be needed. Only a minor re-tuning of some passive transmit antennas may be required on a case-by-case basis.

Once the new license to operate at the ITU frequencies is awarded, all transmissions at the prior licensed frequencies will cease. The applicant does not request exemptions for operating outside the ITU bands designated for oceanographic HFDRs, nor would there a need for, because the electromagnetic environment of Hawaii has already been verified to be quiet and devoid of major interference sources in the designated ITU bands.

GNSS timing signals will be used to ensure that the start of the chirps of multiple units operating at the same frequency (KNA KAL KOK KKH) are staggered so that they do not overlap in the demodulated spectrum. SOEST has completed the development of the necessary hardware and firmware.

SOEST has also completed the development of the firmware necessary for periodically broadcasting the call sign of the stations, as required by FCC order 17-33 (March 27, 2017). This is achieved by toggling the FMCW transmitted signal to a 1 kHz chirp repetition rate (emission designator F3N), following the dots and dashes of the Morse code. This results in a SSB-demodulated buzz of 1 kHz audible at any frequency within the permitted bandwidths, which could not be achieved with a single-frequency emission designator N0A.