SWADAS- a flexible , high resolution space weather observation system

SWADAS

SWADAS Space weather Analytics & Data Acquisition Systems is a collection of instruments for gathering space weather data critical to real time HF communications planning and conducting scientific research tasks.

SWADAS comprises of a package of instruments- these can be used as a system or purchased / operated individually. These are the Ionosonde, a Magnetometer, Riometer and TEC receiver.

The heart of the system is the OXsonde2, a state of the art *Ionosonde* system, developed in 2021, is performance enabled by the use of the very latest signal processing capabilities afforded by advances in programmable logic

The OXsonde2 is supplied as a small form factor modular electronics assembly enclosed in either a full width or half width 19” rack enclosure, and weighs less than 5kg .

Capable of fast , configurable high resolution imaging that virtually eliminates interference to other radiocommunications users, this chirp ionosonde offers substantially improved resolution, interference mitigation and operational flexibility. The chirp method superior resolution and sensitivity to conventional market impulse ionosondes.

Built on a Linux platform that runs on an FPGA, initial correlative signal processing is accelerated with an FPGA, and the complex post correlation analysis is performed within sci-kit based Python scripts that are fully user configurable and able to be modified by users if desired.

The FPGA based embedded Linux system provides a high reliability where standard PCs would not meet reliability requirements of remote systems. Raw and post correlative data is available to be processed internally within the box, or be exported via the ethernet interface / data pipe to a PC.

The ionosonde electronics are self contained inside two enclosures. One enclosure houses the processing electronics , and another enclosure houses the power amplifiers and antenna switching / filtering, which may vary depending on deployment objectives. The electronics are completely fan-less.

Built-in standard configuration options provide for standard 1 to 22 MHz sweeps, and can include sounding variations to enable, for example, improved sensitivity at low frequencies/high D layer absorption, fast continuous imaging of TIDs, compensation of low ERP antennas are some. Depending on antenna and power amplifier choices, the OXsonde2 may operate between 0.5MHz and 40 MHz

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Transmitter signal generation and Receiver function are all performed using direct sample software defined radio, using high performance converters that provide resistance and capability to operate in a high noise, high signal , necessarily high dynamic range HF environment.

The completely waveform programmable design permits customized waveforms and sounding methods that may be tailored to research tasks. Tied to a GPS, the OXsonde2 can also participate in bi-static oblique sounding networks.

Emphasis is provided on robustness and survivability of the electronics when located at tropical , lightning intensive sites. The processing unit front panel provides for a basic control keypad and a real time ionogram display. General communications and interaction would be via an SSH connection.

The ionosonde systems can be supplied with a range of antennas, and a standard apex delta configuration is the most general and robust.

Designed for simplified, reliable low cost deployment, several antenna options are available including ***single*** guyed mast systems support TXANT, RXANT and house all electronics in a small enclosure on the mast base, eliminating any need for huts , buildings, cable trenching and other earth works, and can provide excellent ionograms inside a 30x30m footprint- Smaller footprints are possible.

A remote system can be comfortably powered using a 3kW PV solar array (mid latitude insolation) and small 48V battery system, thus isolating the system from mains power, again, all self contained in an enclosure at the single mast base.

While connectivity to an ionosonde would normally by via IP connection, the OXsonde2 can provide a unique method of data transfer using it's internal HF modem, that can provide a data link to other OXsonde systems or a base station in places where there is no wireless IP infrastructure.

Magit is the Magnetometer instrument, capable of reading disturbances in the geomagnetic field . Disturbances are highly correlated with adverse effects on ionospheric communications. Our Magnetometer features an optical interface that mitigates damage due to lightning potential differences in cabling.

Teco is the Total Electron Content (TEC) instrument, and uses the GNSS data to provide accurate estimates on ionospheric absorption, which strongly influences frequency choices.

Rio is a Riometer, that, in conjunction with an alternate antenna, uses the OXsonde's receiver chain to measure galactic noise in the 30 MHz region, which is a secondary method of measuring ionospheric absorption, and is able to put absolute numbers onto absorption at lower radio bands.

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Specification , standard high resolution URSI vertical observations

Ionosonde sounding waveform	Linear Chirp. Other pulses or emulation available
Method of modulation / demodulation	IQ direct to RF FPGA based software defined radio.
Peak power output	1kW / 5kW option
Receiver noise figure	approx 20dB , waveform dependent
Dynamic range, std waveform	greater than 110dB, wideband
Timing and frequency control	GPS
Transmitter, Receiver system bandwidth	1MHz – 30 MHz. Usable bandwidth 500kHz – 40 MHz. Lower frequency cutoff is high pass filter dependent and may be varied.
Output formats	Binary, Numpy, ASCII, etc formats supported, vector complex formats
Vertical resolution, std waveform :	Approx 1km to 3km , definition dependent
Processing / System Language	Python V3.x
Operating system	Linux Debian.
Pulse Duration	430uS (total)
Pulse type	windowed linear chirp 93kHz sweep (216 MHz/second)
Transmit Energy per pulse	128mJ at 1kW PEP
Repetition Rate	10mS typical. four pulses per frequency typ.
Number of frequencies scanned	Unlimited, but approx 500 is typical in an increasing step size versus frequency - is standard configuration.
Time between frequency steps	Configurable typ. 30mS
Duty Cycle per frequency	4%
Peak Power	at feed point : ~ 800W
Average Power over sounding period	~ 32W
Standard Sounding period	~ 50 seconds (1-22 MHz high resolution scan)
Sounding Frequency	Every 120 seconds
Duty Cycle over 30 minute Period	2%
Average Power over 30 minute period	16W

Physical Specification

Power supply	44 to 50 Volts
Dimensions	3RU or 6RU
Connectors	N female x 4 (low band TX antenna),(high band TX antenna), (RX-NS) and (RX–EW) antennas.
Power consumption	approx 10 W standby
Protection	GDTs , shorting relays and PIN blankers
Connectivity	Ethernet (SSH) & front panel ionogram display & status