# SECTION 2
# *GENERAL SYSTEM DESCRIPTION*

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## THE DIGISONDE PORTABLE SOUNDER (DPS) AND RECEIVE ANTENNA SYSTEM

201. The DPS (generally referred to hereafter as the "sounder") and receive antenna sub-system is a computer controlled ionospheric sounder transceiver capable of real-time characterization of physical properties of the ionosphere and of the electrical properties of radio signals propagated via the ionosphere. These two groups of measured parameters include:

a. ***Physical Parameters.***

1) Height profile of plasma (electron) density.

2) Position and spatial extent of irregularity structures.

3) Motion vectors of irregularity structures.

b. ***Electrical Parameters (Concerning Signals Propagated via the Ionosphere)***.

1) Frequency.

2) Signal amplitude.

3) Signal phase.

4) Wave polarization.

5) Time delay.

6) Doppler shift.

7) Angle of arrival.

8) Impulse response of the ionospheric medium.

9) Amplitude variations (fading, absorption, focussing, etc).

10) Doppler spread (measurement of the Doppler spectrum).

202. The system is capable of making and storing preprogrammed automatic measurements unattended for long periods at remote operating sites using mains AC power. High capacity batteries provide continued operation through power outages and fluctuations.

203. Site preparation and installation instructions for the whole system are provided in Section 3 of this manual, a full technical description of the sounder and receive antennas sub-systems is provided in Section 5, and instructions for organisational and depot level maintenance plus reference to technical data required to support depot level fault finding and repair of sub-assemblies are contained in Section 7.

## PHYSICAL DESCRIPTION

### Sounder Transceiver Sub-system

204. The sounder transceiver sub-system physically consists of two stack-mounted, fan-cooled chassis mounted in 19" roller racks inside a forced-air ventilated fibre-glass outer case (Figure 2-1).

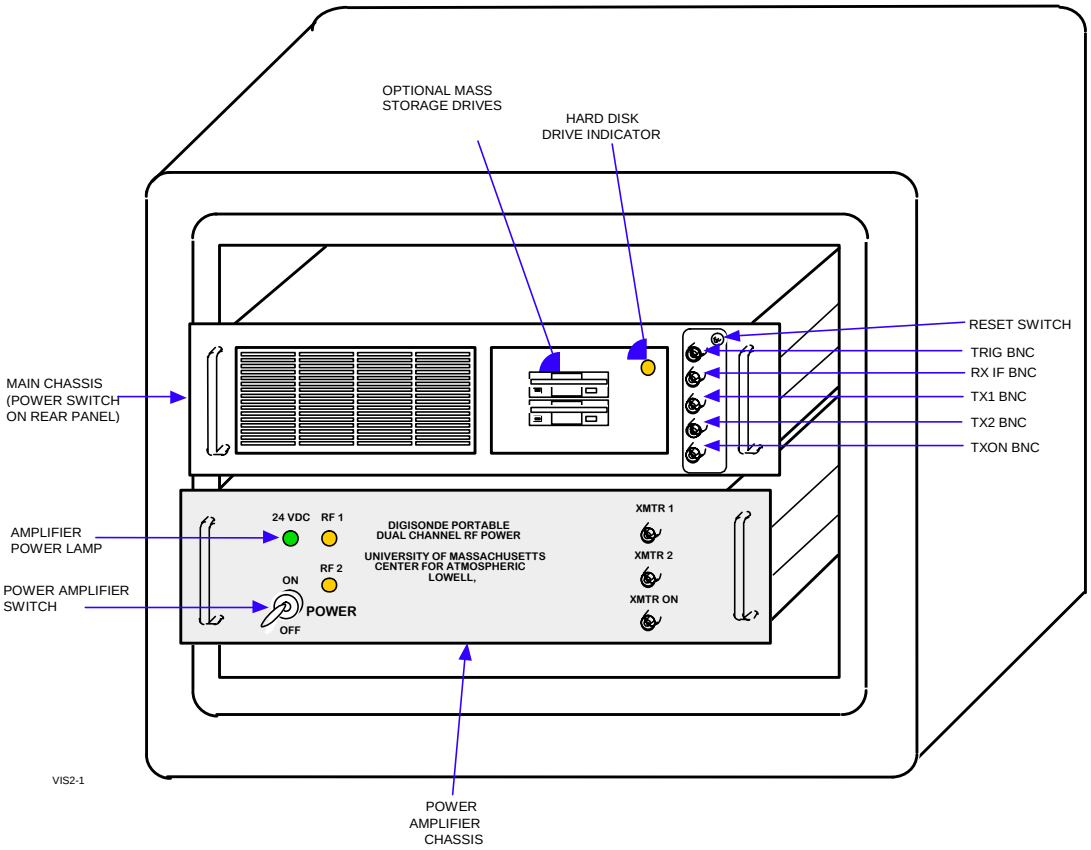


**Figure 2-1 Sounder Transceiver Sub-system (Front View)**

205. The Main (upper) Chassis comprises the following functional assemblies:

a. Two computer(Main and Auxillary) ,

b. Digital signal processor,

c. Timing controller,

d. Phase coherent oscillators and clock generators,

e. Crystal oscillator (master frequency standard),

f. Direct digital synthesizer,

g. Transmitter exciter and controller,

h. Tracking filters (“tuners”)[1],

i. Receivers[2],

j. Power converters and distribution,

1 Electronically tuned 5% bandwidth solid state tracking filters covering the entire frequency range of the DPS.

2 Only one receiver in the DPS-1 variant.

k. Antenna switch,

l. Digitizer,

m. Two 3.5" 1.44 Mbytes floppy disk drives,

n. 40 Gbytes hard disk drive,

o. 4 Mbytes flash ROM, and

p. two axial fans.

206. The Power Amplifier (lower) chassis contains the following assemblies:

a. Two 100 W solid state amplifiers,

b. Two half-octave filter boards for harmonic suppression,

c. current limiting relay, and

d. two axial fans.

207. The outer moulded case, and its removeable front and rear covers, protect the main and power chassis during operation, transit and storage. As well as containing chassis mounting hardware and miscellaneous fittings, the case houses a 28 VDC power supply unit, two high volume axial fans, a power and data distribution panel and main on/off switch, a battery charging controller and an RFI filter (Figure 2-2).

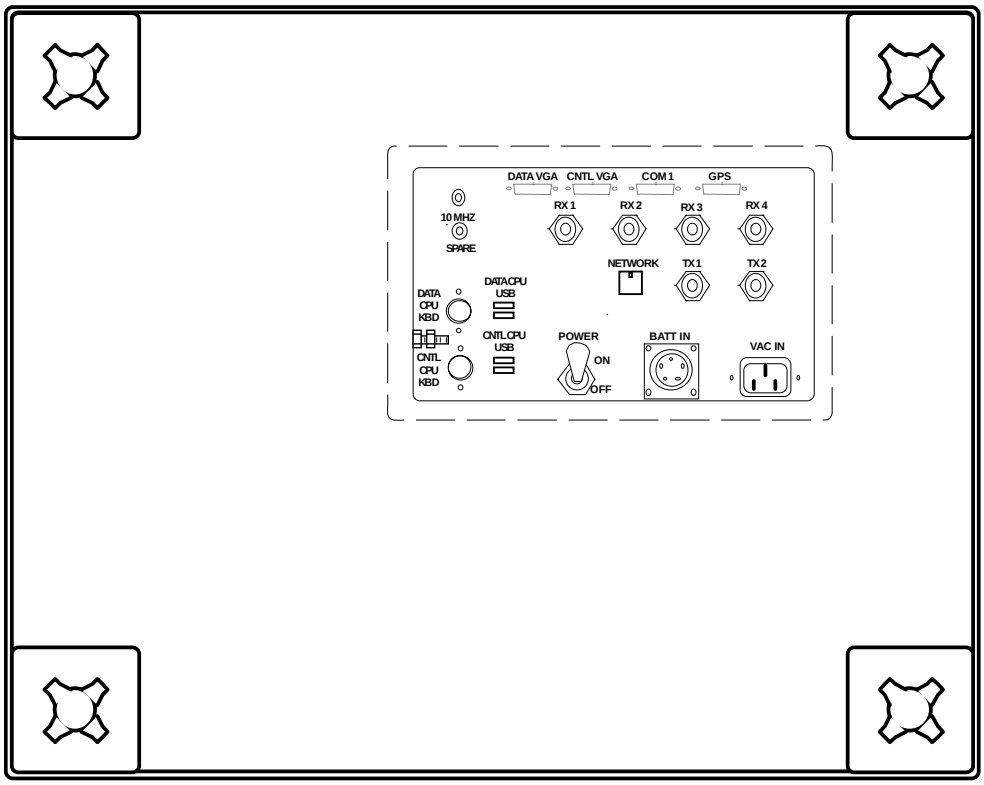


**Figure 2-2 Sounder Transceiver Sub-system (Rear View)**

208. A color monitor and keyboard are provided for installation, maintenance and testing purposes but are not required for remote operation. The GPS receiver is mounted externally to the sounder site building.

209. Figure 2-3 shows the structure of the sounder in block schematic form.

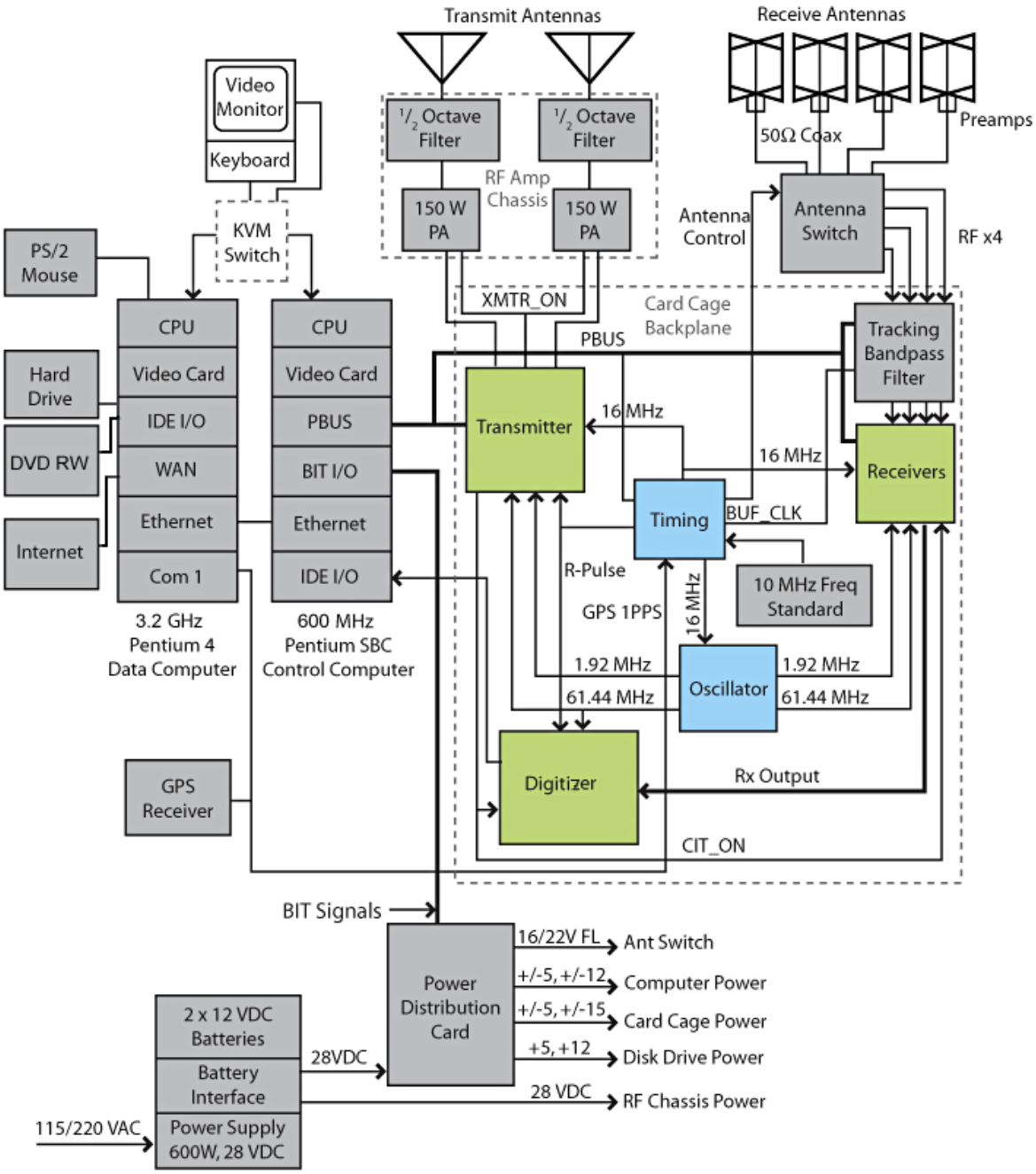


**Figure 2-3 Sounder Sub-system Block Schematic Diagram**

### Receive Antennas Sub-system

210. The receive antennas sub-system comprises four crossed-loop turnstile arrays made of copper ground braid supported by heavy duty (Schedule 80) PVC (Figure 2-4). A four-pole cable termination block and pre-amplifier, are fitted to each antenna assembly. This preamplifier box combines the signals from the two loop antennas into a right-handed or left-handed circularly polarized receiver function, which can be switched by command from the Main computer. The combined signal is conducted by 50 coax cable to the antenna switch at the rear of the main chassis.

**Figure 2-4 Receive Antenna (1 of 4) with 4-terminal preamplifier modulc**

## SPECIAL FEATURES

211. Special features of the sounder are:

a. Multiple levels of digital signal processing (DSP) allow a low cost, easily transportable, low power system configuration with no high voltage power busses.

b. A directional receiving array that uses digital beamforming to detect off-vertical echoes, plus a “super-resolution” technique for precise angle-of-arrival measurements.

c. Five kms height/range resolution, with 2.5 kms height accuracy (i.e., leading edge location), plus a High Precision mode for precise height measurement at better than one km accuracy and resolution.

d. Precision time synchronisation (microsecond accuracy anywhere in the world from internal GPS receiver and programmable precision time offsets to facilitate making bi-static measurements.

e. Precision frequency control for measurement of absolute Doppler.

f. Real time remote data delivery via TCP/IP networks.

g. Unattended operation using remote control (via TCP/IP) and battery backup power.

## SYSTEM SPECIFICATIONS

| DPS General Specifications (all operating modes and configurations): | |
|---|---|
| **Receiver** | |
| Frequency Range | 1.0 – 45 MHz (all modes of operation) |
| Bandwidth | 34 kHz @ 6 dB (assuring 5 km pulse resolution) |
| Input Impedance | 50 Ω |
| Noise Figure | 11 dB (at receiver antenna preamplifier) |
| Receiver Sensitivity | -130 dBm (+/-6dB) into main chassis; greater at preamplifier (amount depending on fixed gain setting) |
| Spurious Free Dynamic Range | >80 dB instantaneous<br>>120 dB total operating range including gain control |
| Recovery Time | 70 μs |
| 3rd Order Intercept | >25 dBm (unaffected by –100 dB in /out-of-band ratio) |
| 2nd Order Intercept | >30dBm |
| Output | 12-bit quadrature samples (16-bit after pulse compression) |
| DPS-4 Option | Four phase matched receivers each identical to above |
| | |
| **RF Output** | |
| Frequency Sweep | 1-45 MHz, Start, stop and step size settable to 1kHz |
| Ionogram Sweep Time | VIS ionogram 60 sec (varies with programmable settings) |
| Frequency Synthesis | Fully digital (frequency switching time < 1μs) |
| Pulse Repetition Rate | 50, 100 and 200 pps |
| Pulse Width | 33 or 533 μs for VIS waveform, 275 ms for OIS, three waveforms all with 30 kHz signal bandwidth |
| Peak Pulse Power | 300 W or 150 W (same in any operating mode) |
| Output Impedance | 50 Ω |
| Transmitter Type | Dual RF MOSFET Amplifiers (second Amp either |

| | |
|---|---|
| | for polarized transmission or to serve as a "hot" spare) |
| Lightning Protection | Metal Oxide Varistor and in-line gas discharge devices |
| | |
| **User Interface** | |
| Unattended operation | Controlled by 7 programs, 6 schedules & 1 schedule table |
| Remote access & control (by Internet) | Input/Output access to schedules, measurement data, or diagnostic data, and operating software |
| Time Setting | Integrated GPS receiver keeps time to +/-25 μs |
| Built-in Self Test (BIT) | Full diagnostics to isolate failures to replaceable units run automatically and provide remotely accessible data |
| Self Calibration | Built-in internal cal automatically updates phase/ amplitude adjustment tables. Remotely accessible results. |
| | |
| **Signal Processing** | |
| Processors | Two Industrial x586's single board computers and one Texas Instruments TMS320C40 DSP board |
| Range Bins | 128, 256 or 512 |
| Height Range | 0-2560 km (0 km used for self-calibration) |
| Height Resolution | 5 km (reciprocal of rcvr bandwidth); 2.5, 5, 10 km sample spacing; 250 m in high range resolution measurement |
| Waveform Processing | Pulse compression of 16-chip phase code provides 15 dB signal processing gain, 127chip OIS code provides 24 dB |
| Doppler Processing | 4 to 128 lines provide up to 21 dB signal processing gain |
| Doppler Range | +/-3 Hz to +/-50 Hz range, |
| Doppler Resolution | .0125 Hz |
| Amplitude Resolution | 3/8 dB |
| Standard Operating Modes | Swept-Frequency *<br>Multiplexed Swept Frequency (finer Doppler resolution)<br>Fixed-Frequency (for gravity wave and absorption studies) |

* Can be automatically scaled by ARTIST to provide electron density profiles

| | |
|---|---|
| | Plasma Drift & Tilt (direction and velocities)<br>Multi-Beam (detects off-vertical echoes) *<br>Precision Group Height Ionogram *<br>Oblique incidence sweep (no transmission at rcvr station) |
| Wave Polarization | O/X (right & left circular) or linear on transmit and receive |
| | |
| **Receiver Antennas** | |
| Antenna Type | Active Crossed loops – Turnstile antenna (1.5 m diameter) |
| Antenna Array | 4 antennas in 60m triangle with central antenna |
| Construction | Schedule 80 PVC, with wire braid loop elements |
| Electronics | Preamplifier (powered via RF cable) with Electronically switched polarization combining, selectable gain 10-30 dB |
| Pre-Amplifier Sensitivity | -123 dBm (in 34 kHz bandwidth, no signal processing) |
| Pre-Amplifier Gain | |
| **Transmitter Antenna (optional)** | |
| Antenna Type | Vertical Crossed Rhombic or Delta (2 radiating elements) |
| Tower | 20 – 60 m height (typically supplied by user) |
| | |
| **Data Analysis Workstation (optional)** | |
| Computer Hardware | Pentium IV, 19” monitor, DVD-R/W, Color Printer |
| Computer Software | Windows XP |
| Ionogram Editing | SAO Explorer 3.4 with NHPC electron density profile inversion tool, International Reference Ionosphere (IRI) model, and access to the UML DIDBase data repository |
| Profile Inversion | NHPC – Inversion of ionogram traces to N(h) profiles with to 700 km altitude and real-time Ionosonde Total Electron Content (iTEC) |
| Skymap analysis | Drift Explorer 1.2 with access to UML Drift-DB data repository |
| | |
| **Software (included with system)** | |
| System Software | Windows XP Embedded |
| WEB Server for Real-time Data Monitoring | Apache 2, with access to real-time displays of ionogram, Directogram, skymap, and drift velocity data |

| | |
|---|---|
| Operating Software | DpsCntl, Dispatcher, CWFFT9(DSP), GPS interface, etc |
| ARTIST | Automatic Real-Time Ionogram Scaling with True Height Analysis (ARTIST) |
| Online Skymap Data analysis | DDAS (Drift Data Analysis for Skymaps), DDAV (Drift Data Analysis for Velocities), Tilt (Ionospheric tilt derivation) |
| Online WWW Publishing tools | Ion2PNG, DrgMaker, Drg2PNG, Sky2PNG, Dvl2PNG, Search, Latest |
| | |