A NEW IONOSONDE FOR ARGENTINE ISLANDS IONOSPHERIC OBSERVATORY, FARADAY STATION

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Abstract. An IPS-42 ionosonde was deployed at the ionospheric observatory of Argentine Islands, Faraday station (65°S, 64°W), in January 1983. It replaces the Union Radio Mark II ionosonde previously used for data collection. This paper describes the characteristics of the new ionosonde and the aerial array used.

Introduction

The high quality of ionospheric data from the unique geophysical location of Argentine Islands (Dudeney and Piggott, 1978) has enabled considerable progress to be made in the understanding of ionospheric processes. The collection of such data has been made using a Union Radio Mark II ionosonde (Clarke and Shearman, 1953) since 1962. This ionosonde uses not only many specially made components, but also thermionic valves and electromechanical parts, a large number of which are becoming increasingly unreliable and obsolete. Therefore to ensure the continuity and quality of ionospheric data, a replacement ionosonde was required.

The replacement ionosonde selected was an IPS-42 (Fig. 1) designed in 1974 by the Ionospheric Prediction Service of Australia. A prototype of this ionosonde, which was called 4A, was tested at Argentine Islands in 1977 and its records compared with those from the Union Radio (Rodger and Williams, 1981). These tests revealed several areas of weakness in its design and performance. Many of these have been improved in the production version, the specification of which is given in Table I.

Ionosondes utilize the fact that high frequency (HF) radio waves of a given frequency are reflected by plasma of a certain concentration. The relationship between electron concentration, N_e (in units of m^{-3}), and frequency, f (in MHz), is given approximately by $N_e = 1.24 \times 10^{10} f^2$. Thus by varying the frequency of an HF transmission a measure of the vertical electron density profile can be made. Height information is obtained from the time of flight of signals between the earth and their reflection points; this so-called virtual height only approximates to the true height of reflection as signals travel slower through an ionized medium than in free space.

Ionosonde Characteristics

The IPS-42 ionosonde transmits on 576 logarithmically spaced frequencies in the range from 1.0 to 22.6 MHz. Each of the frequencies is generated by a digital synthesizer and a scan of the entire range takes 12 s. Transmissions on each frequency consist of three pulses 41.7 μs long separated by 5.33 ms. Signals reflected from the ionosphere are detected by a receiver which is automatically tuned to the frequency of transmission. The receiver is a triple conversion unit, with intermediate frequencies (IF) at 70.0, 10.7 and 1.6 MHz, and has a bandwidth of 25 kHz. Signals from the final IF are passed to an amplifier whose output is a logarithmic function of its input. The output from this amplifier undergoes two stages of signal processing. Firstly the output is integrated over a long period (~500 μs) compared with the transmitted pulse length, and then subtracted from the original output. This

Fig. 1. The IPS-42 in use at Faraday.

separates interference generated by other HF transmissions from ionospheric reflections from its own transmissions. The second stage of processing removes spurious repetitive signals. This is achieved by comparing the virtual height of echoes received from each of the three transmitted pulses on each frequency. Echoes with virtual heights not coincident over all three pulses are rejected.

Ionograms are produced by displaying processed signals on a cathode ray tube together with calibration marks. The y-axis is the time of flight expressed as virtual height in the range 0–800 km, whilst the x-axis is the transmitted frequency. A permanent record of the display is made by photographing it with a 16-mm camera operated in a single shot mode. Examples of this type of ionogram are shown in Fig. 2. On each ionogram the serial number of the ionosonde, year, day number and time of the recording are displayed in the upper left corner. The integrated noise signal from the first stage of signal processing is displayed in the space between 0 and 50 km. The presence of strong interference from transmissions other than from the IPS-42 raises the level of this trace with respect to the ionogram graticule. The effect of such interference can be seen in the upper left ionogram where the minimum frequency of

Table I. General specifications of the IPS-42 ionosonde.

Frequency range	1–22.6 MHz
Frequency generation	Digital synthesizer
Number of channels	576
Frequency sweep configuration	Logarithmic
Frequency sweep time	12 s
Transmitter pulse power output	5 kW peak
Transmitter pulse width	41.7 μs
Pulse interval	5.33 ms, three on each frequency channel
Maximum virtual height range	800 km
Height marker interval	100 km
Frequency markers	Ten markers, equally spaced on a logarithmic scale, at 1.0, 1.4, 2.0, 2.8, 4.0, 5.6, 8.0, 11.3, 16.0 and 22.6 MHz
Date/time/identification	8-segment digital numerals 'written' on ionogram
Programming	Four manually selected automatic programs: 1 each 15 min; 1 each 5 min; 1 each 1 min; 1 each 20 s
Film	16 mm
Film consumption	750 mm per day at four soundings per hour
Power supply	Mains operated, but is operated from two lead-acid batteries in the event of mains failure
Size	height = 609 mm, depth = 457 mm, width = 520 mm
Weight	52 kg

ionospheric echoes is consistent with a reduction in the noise level. A complete ionogram takes 20 s to record, comprising 12 s for the frequency scan and 8 s for resetting electrical and mechanical controls. The upper two ionograms in Fig. 2 are from a magnetically quiet period during the austral summer. The lower two ionograms are for similar times of day during a magnetically disturbed period.

The manufacturer of the IPS-42 suggests that two vertical delta aerials are suitable for the ionosonde. The theoretical response (Bailey, 1951) of such an aerial system was compared with that of a vertical rhombic array already erected at Argentine Islands. It was found that the existing array had much greater sensitivity at all but the highest frequencies used by the IPS-42 than did the delta array (Fig. 3).

The rhombic array consists of two pairs of aerials, the dimensions and orientation of which are shown in Fig. 4. This array was designed to cover the frequency range of 0.6–25.0 MHz, with the larger aerial being used for frequencies below 7.0 MHz. In order to take advantage of the improved response of the rhombic aerial array it was necessary to sense the sounding frequency during a scan and to effect the changeover of aerials at a preselected frequency. This was achieved by comparing the ten digital signals that control the frequency synthesizer with a similar set of signals derived from ten preset switches. A further signal was combined with the result of the comparison which ensures that the changeover takes place while no power is being transmitted, thus preventing gaps in the data recorded. A 'scan start' signal is used to reset the system. An interface converts the logic level signal to a higher voltage for the operation of relays which reroute the transmitted and received signals to the appropriate aerial.

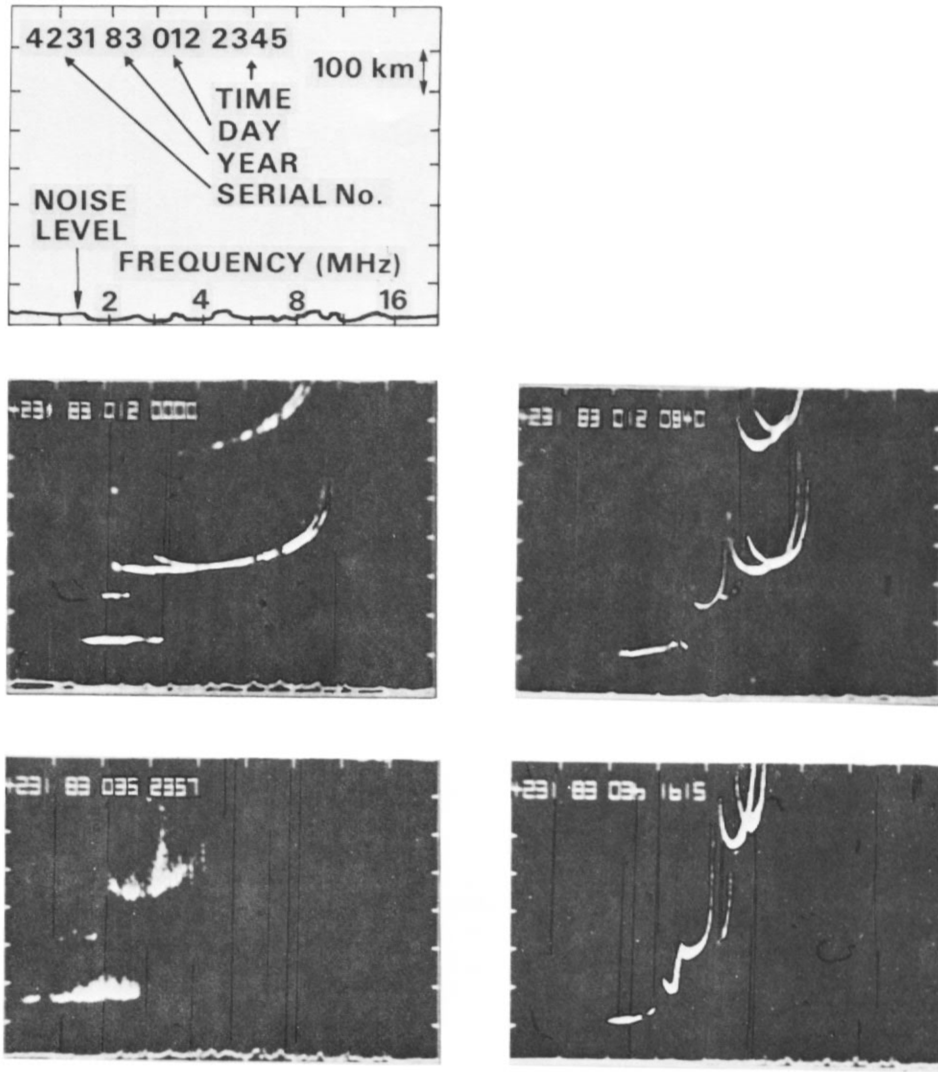

Fig. 2. Sample ionograms produced by the IPS-42, with an indication of scales and markings.

The ionosonde is operated from the main Faraday station complex on Argentine Islands. It is connected to its aerial system, a distance of approximately 40 m, by coaxial and open wire feeder cables. The inclusion of the aerial changeover circuitry makes the IPS-42 very satisfactory for an observatory ionosonde. As it uses mainly solid state electronic components, which require very little maintenance, high reliability is possible. Operational costs are kept low by the use of 16 mm film and the compact format of the ionograms. Continuing commercial production of these units means that potential exists both for design improvements and for system expansion. Also, their world-wide distribution will make for easier comparison of records from various localities.

As this ionosonde has the ability to make soundings at 20-s intervals, several

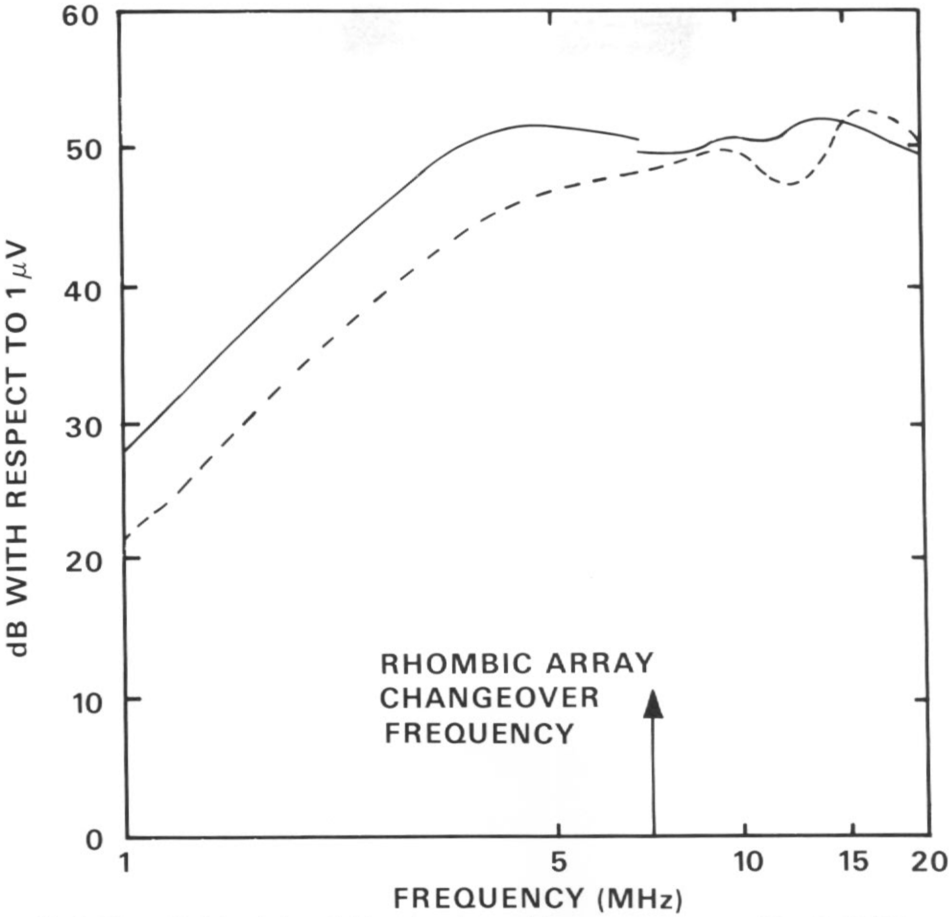

Fig. 3. Theoretical signal strength 1 km above two aerial arrays assuming an aerial current of 1 A. ——— Rhombic array at Argentine Islands. – – – – Suggested delta array.

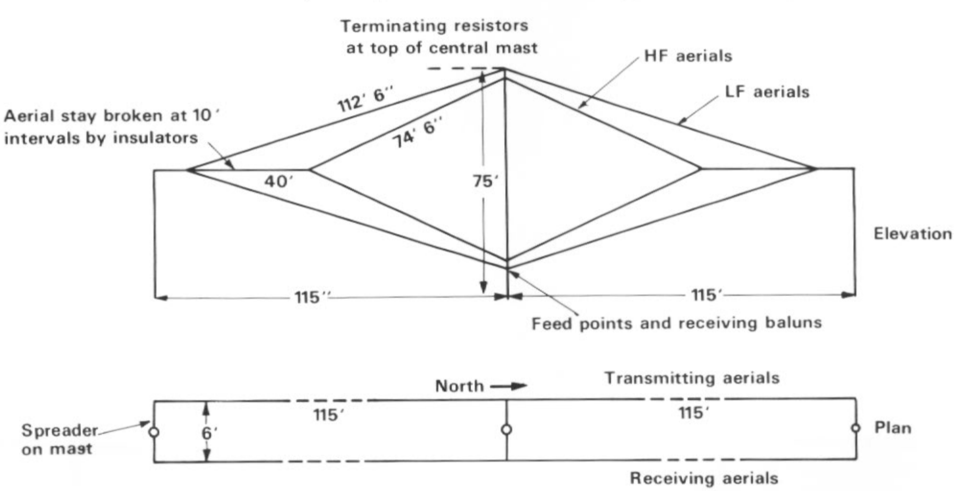

Fig. 4. Dimensions and orientation of rhombic aerial array at Argentine Islands.

research possibilities exist. These could not be exploited with the Union Radio ionosonde which took 5 min to produce one ionogram. For example, the ionization trail created by a meteor passing through the ionosphere may exist for only a few seconds and hence be completely missed by the Union Radio ionosonde.

The operational regime of this ionosonde at Argentine Islands consists of a sounding every quarter of an hour; this is supplemented with more rapid soundings, up to three per minute, during periods of special interest. Data analysis, according to international convention (Piggott and Rawer, 1972, 1978), is completed at the observatory with the help of a microcomputer. Monthly summaries of selected parameters are telexed via BAS HQ in Cambridge to World Data Centre C1 (WDC C1) at Rutherford Appleton Laboratory, Chilton, Oxfordshire, and thence to numerous industrial and research organizations throughout the world. A full analysis and the original data are returned from the Antarctic annually, and published by WDC C1. Interested workers may also access the data via the WDC C1 computerized database.

Received 14 September 1983; accepted 23 September 1983

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