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Preliminary results of SAMEER-Dibrugarh University Digital Ionosonde at Dibrugarh

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Abstract
A digital ionosonde was designed and built by SAMEER, Mumbai in collaboration with Dibrugarh University to suit the needs of equatorial and low latitude region of India. The design objectives were to obtain good SNR to mitigate the heavy noise due to interference and obtain short duration ionograms. Pulse compression by 8 bit and 16 bit bi-phase codes was employed to increase height resolution and noise immunity. 1 Kwatt transmitted power and dual delta antenna transmission is used with dual channel magnetic loop receiver antenna. The basic ionogram recorded by this system called SAMMER-DU Digital Ionosonde (SDDI) is compared with co-located CADI ionograms. Reasonably clear trace of E and F layer is obtained without coherent pulse integration and pulse coding. The performance of the coding schemes is investigated with and without coherent integration. Some sample ionospheric experiments conducted with SDDI and interesting results are presented to highlight the potential and capabilities of the system.

1 Introduction
Progress in semiconductor technology like higher density chips, high power solid state transmitter, large storage capacity have translated into lower cost and size of the modern digital ionosondes without compromising on quality of received signal. The new systems use low power transmitter but still achieve improvements in Signal-to-Noise (SNR) ratio by utilizing advanced signal processing techniques like pulse compression by pulse coding (Coll and Storey, 1964, 1965), coherent integration and Fast Fourier Transform (FFT) etc. These systems can measure not just the virtual height and the amplitude of the echo but can extract precise phase, Doppler, angle of arrival (AOA), polarization state etc. Therefore, the scope of application of the digital ionosonde has broadened, and, in addition to HF propagation/communication applications, study of plasma motion, waves, turbulence, irregularities, structures are also possible with these systems. The Indian region is mostly equatorial and low latitude and present a peculiar challenge due to very dynamic equatorial atmospheric and ionospheric conditions manifested in Equatorial Ionization Anomaly (Appleton, 1946), Equatorial Spread F, Equatorial ElectroJet, etc. Therefore, a digital ionosonde using the latest electronic techniques but customizable to the peculiarities of this region was envisioned by SAMEER, Mumbai and build in collaboration with Dibrugarh University. The main objectives were to build reliable, robust, low noise/latency and cost effective system with performance comparable to or better than the existing systems. The design objectives were specifically to obtain good SNR to mitigate the interference and environmental noise, to record ionograms in reasonably short time to study the ionospheric dynamics and to estimate the ionospheric vertical/zonal drifts. In this paper, we describe the ionosonde system, discuss the design and technology used, present some preliminary results of running SDDI at Dibrugarh (27.5ºN, 94.8ºE, 43º dip) on the first two objectives and validate the system by comparing with a co-located CADI system.

2. System Description
Table1 shows the technical specification of the system. The transmitted power of about 1 KWatt is higher than that of the most of the modern low power ionosondes (CADI, Digisonde). This is in line with the strategy to obtain good quality ionograms in very short duration (without much sample integration), counter the interference and other spurious noise in the ionograms and to improve the low frequency response of the system due to the smaller transmitter antenna size. The block diagram of the system is shown in Fig 1. A novel double loop delta is design for transmission antenna, with magnetic loop receiver antenna.

3. Preliminary results

The validation of the system with co-located CADI system and performance improvement with pulse coding is shown in Fig 1 and Fig 2 respectively.

TABLE 1

1	Frequency range	1-23MHz
2	Peak Transmission power	1Kwatt
3	Frequency resolution	50Kz
4	Transmitted code	8/16 bit Bi-phase
5	Height resolution	5 Km
6	IPP	2.5/5/7.5/10 ms
7	Maximum range	1020 km
8	Receiver antenna	Magnetic Loop Turn-style
10	Transmitter antenna	Dual loop delta antenna
11	Transmitted polarization	Right hand circular
12	Signal Processing	DDC,CIC filter decoding coherent integration, FFT
13	Observables	Signal power/phase, Doppler shift, AOA, polarization

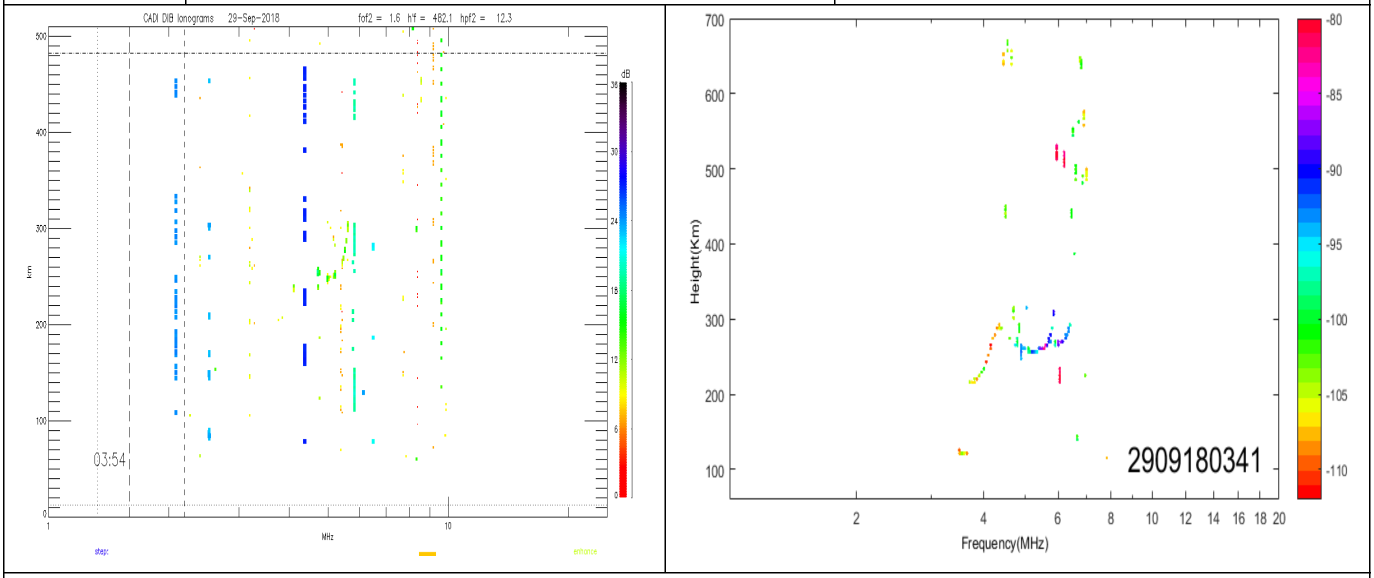

Fig. 1 The comparison of SDDI ionograms (right) with CADI ionogram (left).

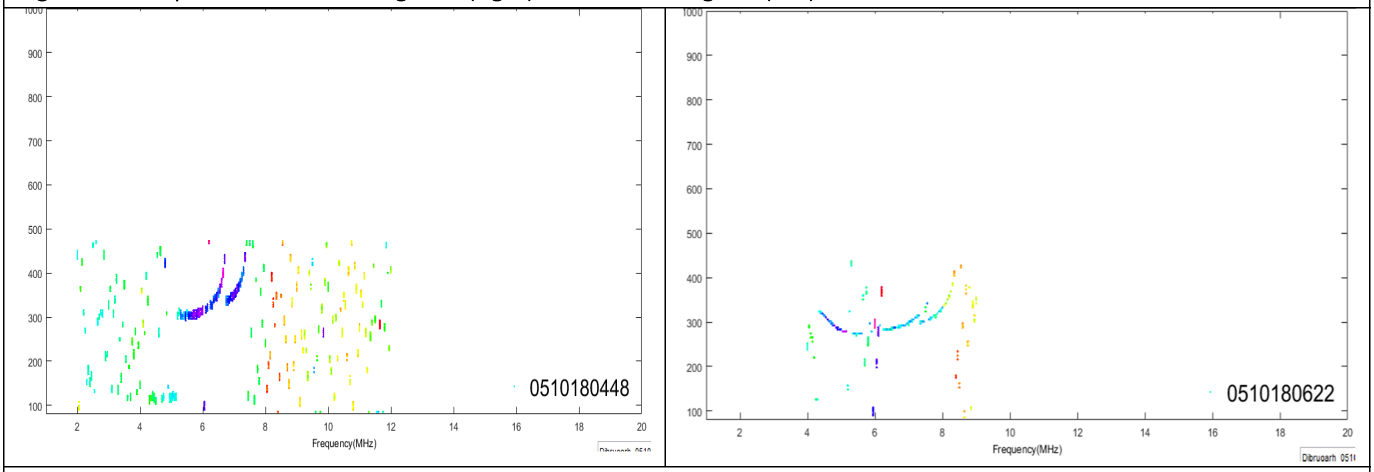

Fig. 2 Sample SDDI ionograms for (left) uncoded and (right) 16 bit coded transmission. The improvement in height resolution and noise can be clearly observed.