Transmitter Chain for HF radar i.e. Ionosonde using Direct Digital Synthesizer

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ABSTRACT

An Ionosonde is high frequency radar which sends very short pulses of radio energy vertically into the ionosphere. If the radio frequency is not too high, the pulses are reflected back towards the ground. It is basically a combination of radio transmitter and receiver capable to transmit pulses toward the ionosphere above and receiving the same signal pulse as it returns back. The time delay at different frequencies can be recorded while varying the carrier frequency of pulses. Minimum range in which Ionosonde can work is 0.5 MHz to 20 MHz. Work is in progress for designing a transmitter chain for Ionosonde generating the bi-phase coded pulse to transmit the signal upwards. For frequency synthesis DDS (Direct Digital Synthesizer) IC AD9854 is used here which synthesized the frequency in 0.5MHz to 20MHz range. RF power amplifier and bidirectional coupler is used to amplify the signal and to avoid reflected back signal which may damage the system. The Ionosonde records the time delay between transmission and reception of the pulses over a range of frequencies. This system is 'stand alone' system which measures the time delay, calibration in the signal .

Keywords - **Bidirectional coupler; DDS; Ionosonde system; IC9854; RF power amplifier**

I. INTRODUCTION

The ionosphere is a part of the upper atmosphere, comprising portions of the mesosphere, thermosphere and exosphere, distinguished because it is ionized by solar radiation. It plays an important part in atmospheric electricity and forms the inner edge of the magnetosphere. It has practical importance because, among other functions, it influences radio propagation to distant places on the Earth. In the region extending from a height of about 50 km to over 500 km, most of the molecules of the atmosphere are ionized by radiation from the Sun. This region is called the ionosphere. It is the ions that give their name to the ionosphere, but it is the much lighter and more freely moving electrons which are important in terms of HF (high frequency) radio propagation. The free electrons in the ionosphere cause HF radio waves to be refracted (bent) and eventually reflected back to earth. The greater the density of electrons, the higher is the frequencies that can be reflected. Ionosphere reflects most radio waves because of its ions and free electrons. An Ionosonde or chirp sounder is special radar for the examination of the ionosphere.

In order to accomplish ionospheric radio link some parameters have to be determined, as the frequency of the carrier, the transmitted power, the type of modulation, the angle of radiation, etc. The work carried out knowing the profile of ionization, or at least some parameters related to it. Various methods have been used to investigate the ionosphere and the most widely used instrument for this purpose is the Ionosonde. An Ionosonde consist of transmitter, receiver and controlling DSP (Digital Signal Processing) system. For measurement of different parameters of Ionosonde transmitter chain is designed which has to transmit the signal and receiver has to receive it properly. In this paper work is done on transmitter chain hardware which generates bi-phase coded signal of transmitter using DDS IC AD9854. Code is written on KEIL software.

II. LITERATURE SURVEY

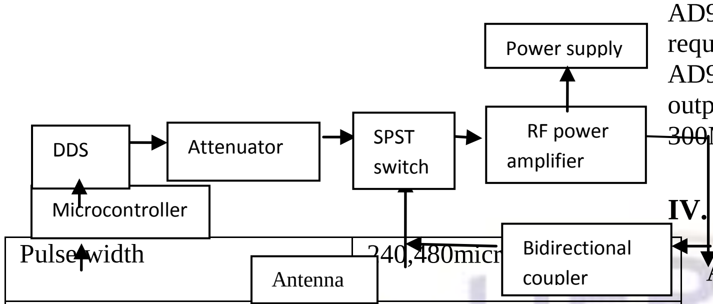
To design Ionosonde transmitter system, proper knowledge of ionosphere, its effect on radio communication and study of Ionosonde is essential. In 1902, Oliver Heaviside proposed the existence of the Kennelly - Heaviside layer of the ionosphere which has his name. Heaviside's proposal included means by which radio signals are transmitted around the Earth's curvature. Heaviside's proposal, coupled with Planck's law of black body radiation, may have hampered the growth of radio astronomy for the detection of electromagnetic waves from celestial bodies until 1932 (and the development of high frequency radio transceivers). Also in 1902, Arthur Edwin Kennelly discovered some of the ionosphere's radio-electrical properties In 1912, the U.S. Congress imposed the Radio Act of 1912 on amateur radio operators, limiting their operations to frequencies above 1.5 MHz (wavelength 200 meters or smaller). The government thought those frequencies was useless. This led to the discovery of HF radio propagation via the ionosphere in 1923. In 1926, Scottish physicist Robert Watson-Watt introduced the term ionosphere in a letter published only in 1969 in nature [1].

Lloyd Berkner first measured the height and density of the ionosphere. This permitted the first complete theory of short wave radio propagation. Maurice V. Wilkes and J. A. Ratcliffe researched the topic of radio propagation of very long radio waves in the ionosphere. Vitally Ginzburg has developed a theory of electromagnetic wave propagation in plasmas such as the ionosphere. This plasma is not stationary, but is constantly circulating around. The plasma flow pattern is related to the space weather, and thus to the strength and direction of the interplanetary magnetic field and the solar wind. As this pattern is not stationary its effect on radio communication is also not always of same kind. When radio waves strike these ionized layers, depending on frequency, some are completely absorbed, others are refracted so that they return to the earth, and still others pass through the ionosphere into outer space. Absorption tends to be greater at lower frequencies, and increases as the degree of ionization increases. It is the result of ionopheric variations which causes the picking up a distant AM radio station at night which disappears in the next day. And hence the ionospheric study is being carried out since 1864.

Oblique chirp sounders sweep a phase-continuous signal over the frequency band of interest at rates of up to several hundred kilohertz per second. Due to the method of receiver operation a comparatively narrow receiver bandwidth, of the order of a few hundred Hertz, is used and so a relatively low transmitter power (10- 100 W) is required. One of the main disadvantages of chirp sounders is the relatively complex analysis that must be carried out to determine the ionospheric propagating modes [4]. Vertical-incidence (VI) ionospheric measurements, traditionally performed with 5- to 50-kW Ionosonde , may be obtained alternatively using FM CW transmissions of much lower peak power. The FM signal must be interrupted periodically to permit both transmitting and receiving with a single antenna. An Ionosonde of this type has been constructed and operated. The monostatic FM sounder radiates a peak power of 8 W and sweeps the frequency range of 0.5 to 30 MHz either linearly or logarithmically. Records from the FM Ionosonde are comparable in time delay resolution, S/N, and overall quality to conventional pulse ionograms; the effects of interference from other HF users are somewhat less conspicuous on the FM sounder records [2] ,[3]. The AD9854 DDS device is used to generate low frequency reference signal and to drive the to PLL and VCO to generate RF [5]. A dual- phase sine wave generator based on the direct digital- synthesis technique, by using the new Analog Devices direct- digital-synthesizer (DDS) AD9854. Particular attention is paid on the stability and accuracy of the sine wave amplitude in order to achieved high-accuracy impedance measurements [6].

III. METHODOLOGY

The Ionosonde system, there is three subsystems . In in this to transmit the signal transmitter, for receiving purpose there is receiver and for controlling there is DSP control system is installed. In the transmitter side the hardware chain of blocks contain microcontroller to program the hardware as per the command. For this ADUC814 is used which analog devices controller IC. Then for bi-phase coded signal generation there is a AD9854 IC is used which is DDS (Direct Digital Synthesizer)IC. Generation requirements in both communications and industrial applications. Single-chip IC devices can generate programmable analog output waveforms simply and with high resolution and accuracy.DDS devices like AD9854 programmed through a high speed serial peripheral-interface (SPI), and need only an external clock to generate simple sine waves. DDS devices are now available that can generate frequencies from less than 1 Hz up to 400 MHz (based on a 1-GHz clock). The benefits of their low power, low cost, and single small package, combined with their inherent excellent performance and the ability to digitally program (and re-program) the output waveform, make DDS device an extremely attractive solution—preferable to less-flexible solutions comprising aggregations of discrete elements.DDS bi-phase coded output of 1V, +13dbm is given to the attenuator to attenuate the signal up to 0 dbm. Coaxial attenuator mod. 8343-200 s/n3281 is used which has attenuation up to 20db. This attenuated signal is feed to the SPST switch. SPST switch is for the protection of input side from the reflected signal if any. Then it is given to RF power amplifier model-BTM00250-AlphaSA which has frequency 500 KHz-150MHz, and power of 250 watts. Power supply is provided of 48V which is required for CW pulsed wave generation. Signal get amplified and fed to the bidirectional coupler Model: C50-109-481/1N At this moment the signal get amplified from 0dbm to 230.4 dbm in the power amplifier. And it is given further to the bidirectional coupler through the incident port. Output port is connected to the antenna which acts as a load to the coupler. One port is isolated and coupled port is connected to the SPST switch to protect the system from any kind of malfunctioning at any stage of hardware design. The first purposes to connect the SPST switch to protect the system from the reflected signal if any. In this way the hardware design is done. But to generate the signal there is very important to run hardware through software programming. Program is written in the KEIL software which is basically for microcontroller.



Pulse width	240,480micr
Code	Complementary;Bi-phase Code
Code length	8 and 16 bit
Code Bit Length	30 micro-second
PulseRepetition Period (PRP)	2.5 ; 5; 7.5; 10 msec
Transmit Frequency	750 KHz to 20MHz
Frequency Step	50 , 100 KHz
No. of Channels	2 (Orthogonal)

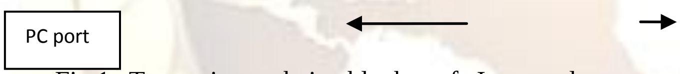


Fig.1 Transmitter chain blocks of Ionosonde system.

As with all Analog Devices DDS devices, the value of the frequency tuning word which is required for the programming is determined by-

FTW = (Desired Output Frequency × 2N) /SYSCLK (1)

Where N is the phase accumulator resolution. Desired Output Frequency is expressed in hertz. FTW (frequency tuning word) is a decimal number. After a decimal number has been calculated, it must be rounded to an integer and then converted to binary format, that is, a series of 48 binary-weighted 1s and 0s. The fundamental sine wave DAC output frequency range is from dc to half SYSCLK. Changes in frequency are phase continuous meaning that the first sampled phase value of the new frequency is referenced from the time of the last sampled phase value of the previous frequency. The I and Q DACs of the AD9854 are always 90° out of phase. The 14-bit phase registers do not independently adjust the phase of each DAC output. Instead, both DACs are affected equally by a change in phase offset. Microcontroller ADUC814 interfaced with AD9854 i.e. DDS IC by SPI interface. Our frequency requirement is from 0.5 kHz to 23MHz .Serially AD9854 support up to 10MHz. so that we are expecting output up to 10MHz by giving system clock of 300MHz of DDS device.

IV. SPECIFICATION

A. Transmit(Actual) Signal Generation

The specification of bi-phase coded transmit signal generated using DDS IC shown in Table 1.

B. Simulated Signal Generation

Specification of the bi-phase coded simulated signal will be used for channel phase equalization, testing the signal processing hardware and software and evaluate the performance of the whole system shown in Table 2.for the evaluation bi-phase coder have to attached at the output of DDS, Becouse the single tone simulation only possible to the DDS and for the bi-phase , bi-phase coder is required.

Table1.
Specifications of desired signal to be transmitted

Table2.
Specifications of Simulated Signal

V.RESULTS

DDS IC AD9854 generates bi-phase coded signal i.e. in phase and quadrature phase output at different frequencies. The in-phase and quadrature phase waveform at 10 MHz, actual transmitted signal and simulated signal shown in the fig. 2, 3, 4 respectively.

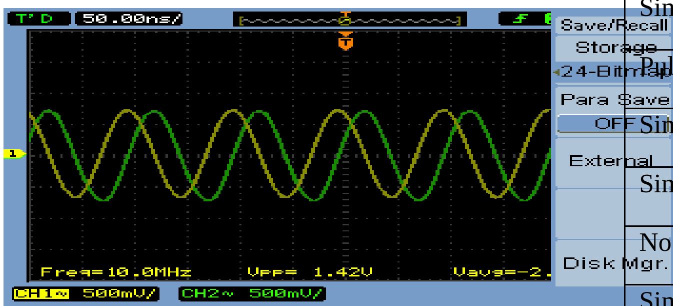


Fig. 2 10 MHz I/Q output

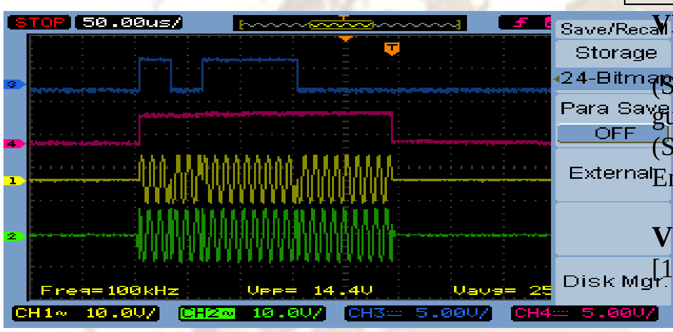


Fig. 3 TX Pulse generation

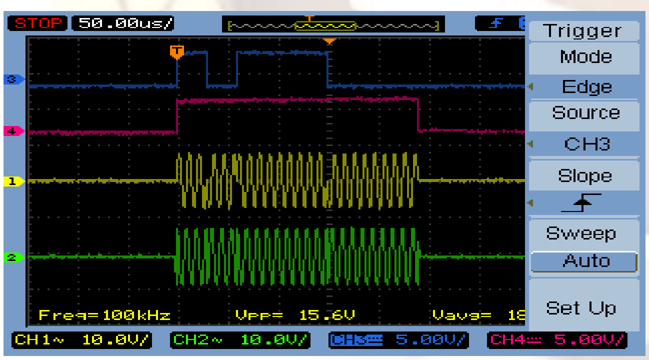


Fig. 4 Simulated TX pulse generation

Sim Signal Start (SSS)	(micro-second)
Sim Signal width (SSD)	240 , 480 micro-second
Sim Signal Code Type	Complementary; Bi-phase Code
Sim Signal Code length	8 and 16 bit
Pulse Repetition Period (PRP)	2.5 ; 5; 7.5; 10 msec
Sim Signal Transmit Frequency	750 KHz to 20MHz
Sim Signal Frequency Ste	50 , 100 KHz
No. of Channels	2 (Orthogonal)
Sim Signal Doppler	0.5 Hz to 50 Hz in step of 1 Hz

VI. CONCLUSION

Generated bi-phase signal is transmitted into the space and received back by the receiver in echo form. In this way the working of transmitter chain of Ionosonde system is checked. It measures different parameters of ionosphere. It has great significance in radio communication.

VII. ACKNOWLEDGMENT

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