Direct Digital Synthesizer used in MRI Application

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Abstract— In this paper DDS system is used to generate a radio frequency signal for MRI application. The MRI machine contains a magnetic field of 1.5T.For these MRI machine there is compulsions of generating of 63.87MHZ radio frequency signal. AD9914 is a DDS chip used for generating this radio frequency signal.ADUC7026 microcontroller controls the operation of DDS chip. The programmed code is written in Keil. For generating RF frequency signal this DDS chip is a suitable method.

Key words: MRI, DDS Chip, Modulation.

I. INTRODUCTION

According to theoretical analysis of DDS technology, these systems require very low power and it is highly flexible. DDS technique is used to generate waveform by using a single chip IC device which produces analog output waveform of high frequency resolution and accuracy. In the MRI system, there is widely focuses on resolution and bandwidth requirement of frequency synthesizer in order to get analog improved performance. It generates analog waveforms with digital adjustable high-resolution phase and frequency. It is useful in a wide variety of applications in test, measurement and communications. Now a day there is required of such a frequency synthesizer which is capable of tuning different output frequency with fine resolution and switching speed of nanoseconds. The DDS technique is limited by the Nyquist criteria and the sampling theorem. During the process, we can modify the phase, frequency and amplitude characteristic of the synthesized output signal.

II. DDS ARCHITECTURE

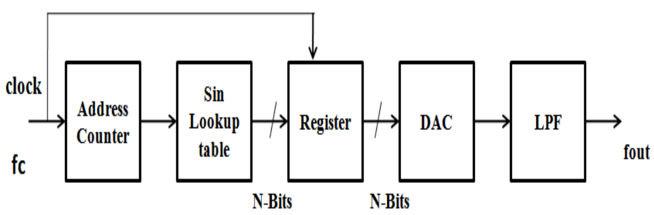

Fig1: Basic Block Diagram Of Direct Digital Synthesis.

When clock fc is driven, it operates the PROM which stores the number of cycles of a sine wave. In address counter the data is stored at each memory location and at each step it operates the DAC. Sine lookup table store integral number of cycles of data . The lookup table contains amplitude information for complete sine wave cycle. The relation between generated signal (fout) and clock frequency (fc) is given by

$$fout = (M \times fc)/2^n$$

Where 'n' =32bit .... (1)

Where,

fout = Output frequency of DDS system.

fc=Input clock frequency of DDS system.

M=It control DDS frequency.

n=Number of PROM address line.

III. SYSTEM BLOCK DIAGRAM

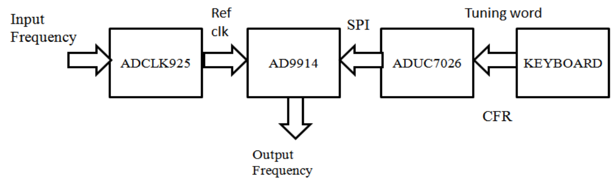

Fig. 2: Operational Block Diagram Of DDS System

A. ADUC7026 Microcontroller:

The ADUC7026 is an ARM7 microcontroller having 16 or 32 bit architecture. It can execute most instruction within a single clock cycle. This microcontroller is highly flexible and cost effective solution to many embedded control applications. It accepts the frequency from the keyboard in the form of 32-bit HEX value and give to DDS. This process is done by Serial peripheral interfacing (SPI).

B. DDS Modulator Ad9914:

AD9914 DDS Chip has internally Digital Analog converter, high accuracy and they are digitally programmable. This frequency Synthesizer is capable of generating analog output having sinusoidal waveform. Frequency tuning words are loaded into DDS sent by microcontroller via serial or parallel port. The 'n' bit value is loaded into DDS chip have formula is given by equation 1. The output waveform can be seen on CRO by connecting CRO and DDS board.

C. ADCLK925:

It is ultrafast data buffer having 95 ps propagation delay, 7.5 GHz toggle rates. ADclk925 is used to feed 3.5 GHz input frequency to DDS chip.

D. Key Board:

The tuning word is given with the keyboard. When a key is pressed then it generates interrupt to a microcontroller which takes rest for reading data and then produces output.

IV. PROPOSED WORK

The system consists of two main components, the microcontroller Aduc7026 and DDS AD9914.The SPI is used to interface Aduc7026 and DDS AD9914.The ADUC7026 is interfaced with keyboard to take the user inputs. The Master reset pin is there to reset the memory content of the microcontroller. The tuning word is put by user in keyboard. Once input is given, the microcontroller ADUC7026 generates 32 bit value loaded into the register 0 of DDS AD9914.The SPI is loading the data in two cycles. Frequency register 0 is selected by writing addressed 0X0B in frequency tuning word register (FTW).The MSB of 32 bits is loaded and write pulse is given at falling edge and data is stored in a specific register of AD9914.The LSB of 32 bits is then loaded and write pulse is given at falling edge and data is stored in a specific register. After loading the data into a specific register write pulse is again going high. Any input frequency ranging from 0 to 3.5 GHz, output can be seen successfully. For reducing the noise and distortion for higher frequency, low pass filter is there in DDS system.

V. PRODUCT DESCRIPTION

The mode of operation for AD9914 is single tone, profile modulation, Digital ramp modulation, parallel data port modulation, programmable modulus mode. The data source to DDS is defined by modes with control parameter, i.e. frequency, phase and amplitude. Based on mode selection or specific control bit the data is given to frequency, phase and amplitude. Modes are defined independently; they are enabled at the same time. It provides flexibility for generating complex modulation schemes. In single tone mode, the profile programming register gives DDS signal control parameter, i.e. frequency, phase and amplitude. In digital ramp modulation mode, digital ramp generator supplies the DDS signal Control parameter. Polar modulation is used to store unmodulated DDS signal control parameter by parallel data port. By selecting mode the unmodulated DDS signal control parameters are stored in programming registers.OSK function Use digital linear ramp generator for changing amplitude parameter of DDS .OSK has a priority over data to move DDS amplitude parameter.

VI. RESULTS

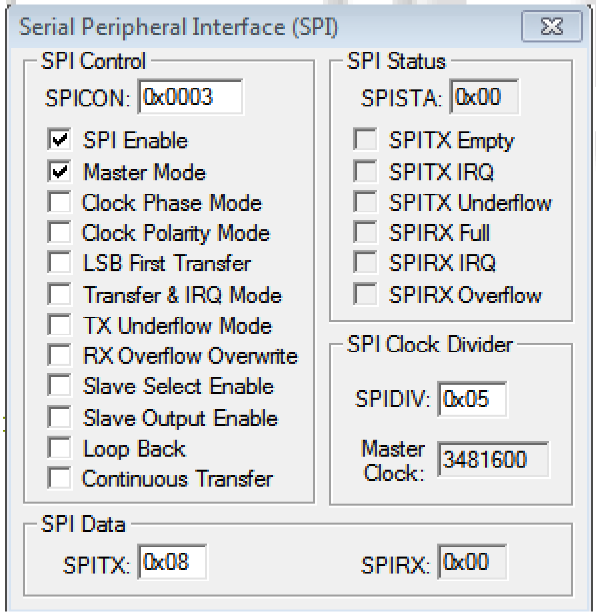

Fig. 3: Serial Peripheral Interfacing

DDS	AD9914
Reference Clock Frequency	2.5501GHZ
Desired Output Frequency	63.87 MHZ
Reference Clock Multiplier	Bypass
Actual output Frequency	63.8700000029057 MHz
Frequency Tuning Word	06696B70

Table 1: Plotting Sine Wave

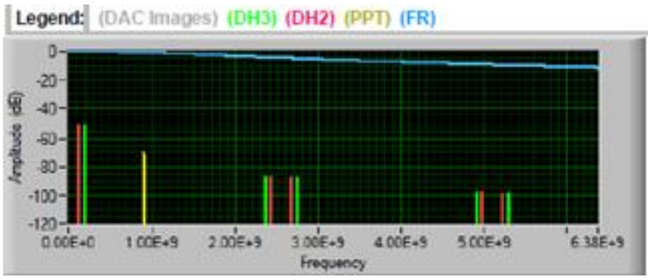

Fig. 4: Frequency Spectrum (*f*= 63.87MHz).

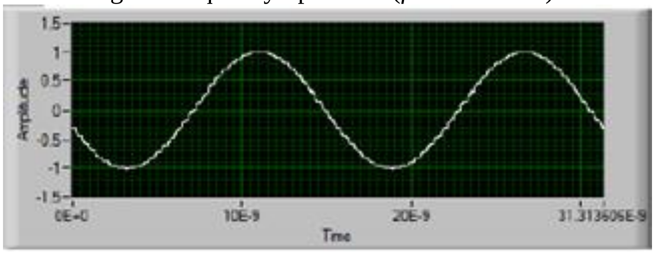

Fig. 5: Time Domain Sine Wave (*f* = 63.87MHz)

In Fig3, Microcontroller is sending data to AD9914 through SPI. The instructions are sent through SPI. Instructions contain tuning word data and contain control function register data. SPISTA is used to check status of Data whether it is going from microcontroller to AD9914. Table I show details for plotting sine wave. The output frequency is 63.87MHz and input frequency 2.5501GHz is given in the above table. The tuning word is 06696B70 is sent to DDS by Microcontroller. In fig4, frequency domains have DAC harmonic spur configuration is -50dbc .The primary phase truncation spur is -70dbc.In fig 5, in time domain, the sine waves have a smooth curve.

VII. CONCLUSION

This DDS system has been successfully designed and tested. The radio frequency required for MRI has been successfully given by DDS system. The microcontroller is successfully sending data by SPI to DDS chip. The radio frequency signal is having high accuracy and precision. It is a replacement for analog generator which is not having a capacity to generate very high radio frequency.

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