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Microcontroller Based DDS Function Generator

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***Abstract*— In Industrial and Research application it is needed to test the experimental set-up using basic waveforms which are sine, square and triangular waves. Function Generator plays a very important role in communication, electronic circuits, radar and other electronic systems. This paper describes a Microcontroller based DDS function generator by using AD9833 as frequency synthesizer and AT89s52 microcontroller. A DDS technology is used to generate all signals at precise frequencies and is based on phase control. It relies on serial interface enabled Atmel 89s52 microcontroller and a DDS chip AD9833. A GUI is developed in National Instruments LabView software which allows simple control of the hardware.**

Index Terms— **Direct Digital Synthesis (DDS), Function Generator, LabView, Microcontroller.**

I. INTRODUCTION

Function generators are two types: Analog function generator and DDS function generator. Although Analog function generator is simple and easy to use, there are several weaknesses which limit its application and its usage. In Analog function generator potentiometers are used to control various parameters such as frequency, amplitude which makes it often difficult for the users to adjust the frequency and amplitude of the waveforms to the exact value. Therefore users have to manually adjust the function generator every time they intend to change the waveform. A typical function generator does not allow interfacing and combination with other devices. So by using PC as an interface between hardware and software we can generate different waveforms of different frequencies. So this circuit can be used in any another project where we require the basic wave forms to be generated. Direct digital synthesis, which generates analog waveforms with digitally adjustable high-resolution phase and frequency, is useful in a wide variety of applications in test, measurement, and communications. Integrated-circuit DDS devices are compact, require little power and space, are low in cost, and easy to apply. This function generator plays a very important role in communications, electronic measuring instruments and automatic control systems.

II. AD9833 FUNCTION GENERATOR

Direct Digital Synthesis is a technique for using digital data processing blocks as a means to generate a frequency and phase-tunable output signal referenced to a fixed frequency precision clock source. In essence, the reference clock frequency is 'divided down' in a DDS architecture by the scaling factor in a programmable binary tuning word. The tuning word is typically 24-48 bits long which enables a DDS implementation to provide superior output frequency tuning resolution.DDS devices like the AD9833 are 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). Functional block diagram of AD9833 is shown below in the figure1 [1]. The internal circuitry of the AD9833 operates as a numerically controlled oscillator (NCO), frequency and 28-bit phase modulators, SIN ROM, a digital-to-analog converter and regulator. Typically consider sine waves in terms of their magnitude form, A(t)=sin(ωt). The amplitude is non-linear and is, therefore difficult to generate. The angular information is perfectly linear. That is the phase angle rotates through a fixed angle for each unit in time. Knowing that the phase of sine wave is linear, and given a reference interval (clock period), the phase rotation for that period is:

$$\Delta phase = \omega dt;$$

$$\omega = \frac{\Delta phase}{dt} = 2\pi f \text{, and } \quad f = \frac{\Delta phase \times f_{MCLK}}{2^{28}} \quad \text{where } 0 < \Delta phase < 2^{28} - 1$$

Using this formula output frequencies can be generated, knowing the phase and master-clock frequency. Theoretically, a maximum output frequency of $f_{MCLK}/2$ is possible.

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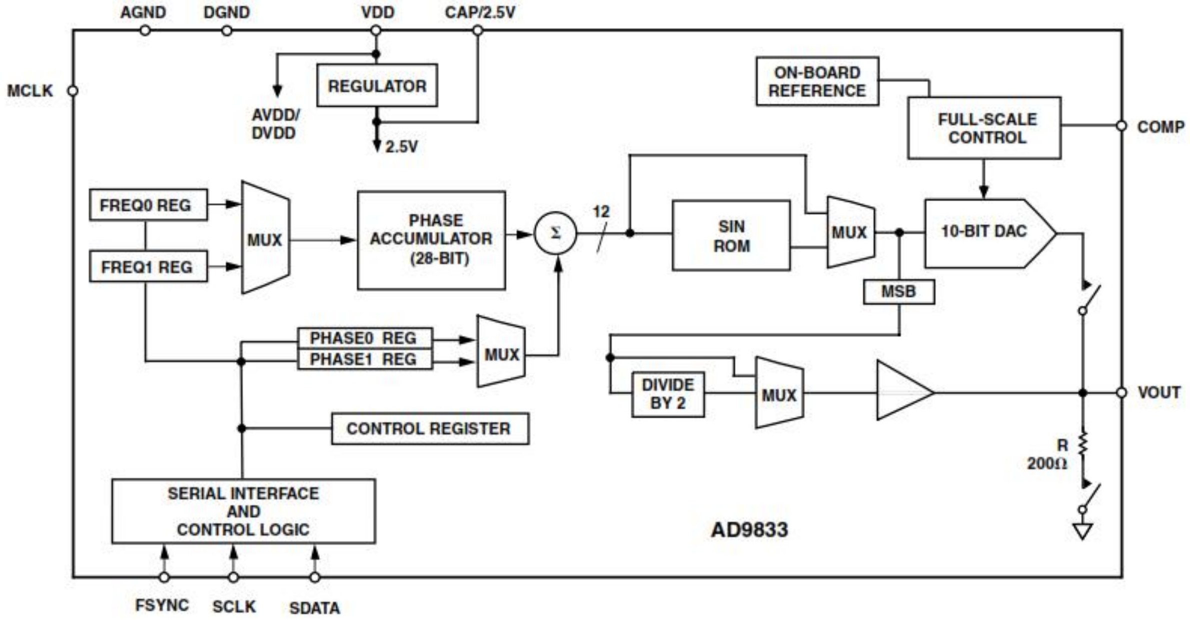

Fig 1 Functional Block Diagram of AD9833

The DDS can be programmed by writing to the frequency registers. The analog output from the part is then:

$$f_{OUT} = \frac{MCLK}{2^{28}} \times \text{(Frequency register word)}$$

Here Frequency register word is loaded into the selected frequency register. The signal will be phase shifted by

$$\text{Phase shift} = \frac{2\pi}{4096} \times \text{(phase register word)}$$

Where phase register word is the value contained in the selected phase register. The Ad9833 contains 2 frequency registers and 2 phase registers. Each frequency register has 1 size of 28 bits while each phase register has 12 bits. In order to have better frequency resolution, the number of bits employed in the phase accumulators is increased.

III. System Design

There are two main parts in the microcontroller based DDS function generator as shown in Figure 2.

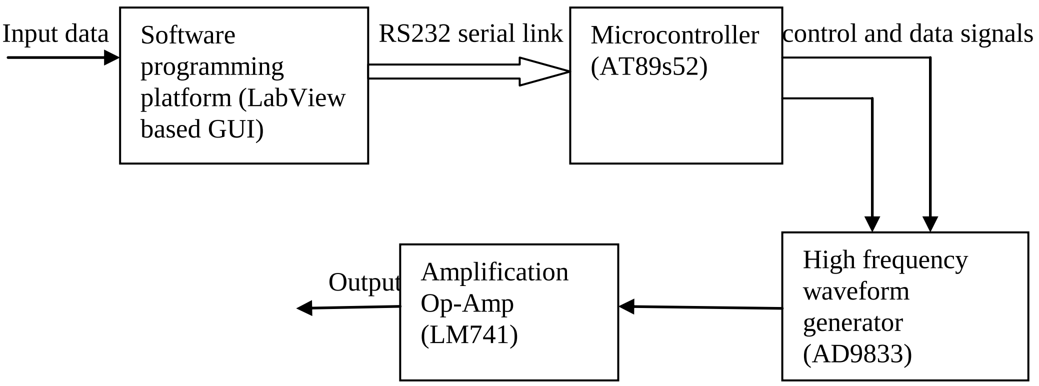

Fig 2 Block Diagram of System Design

A. Software: The software design adopts Keil µvision language and National Instruments LaView. LabView is used to create Graphical User Interface (GUI) to allow user to select the type and frequency of the waveform that needs to be generated. This GUI interfaces to microcontroller through RS232. Keil µvision is used to develop Assembly code. The Keil µvision Software development programs are used to assemble assembly source files, link and locate object modules and libraries, create HEX files, and debug target program.

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In software part firstly, we perform the initialization of microcontroller peripherals like UART and interrupt vector and then interface AD9833.Then we choose waveform from the GUI in PC. The frequency adjustment is done by sending frequency control word to AD9833 from MCU. MCU receives word from LabView via serial Interface.

B. Hardware: The schematic diagram of hardware is shown in figure 3. The hardware part is waveform generation circuit, MCU control unit and oscilloscope. The data received from the PC is input to a microcontroller through a serial link. This micro-controller will convert the data to suit the requirement of the function generator in order to generate the waveform.

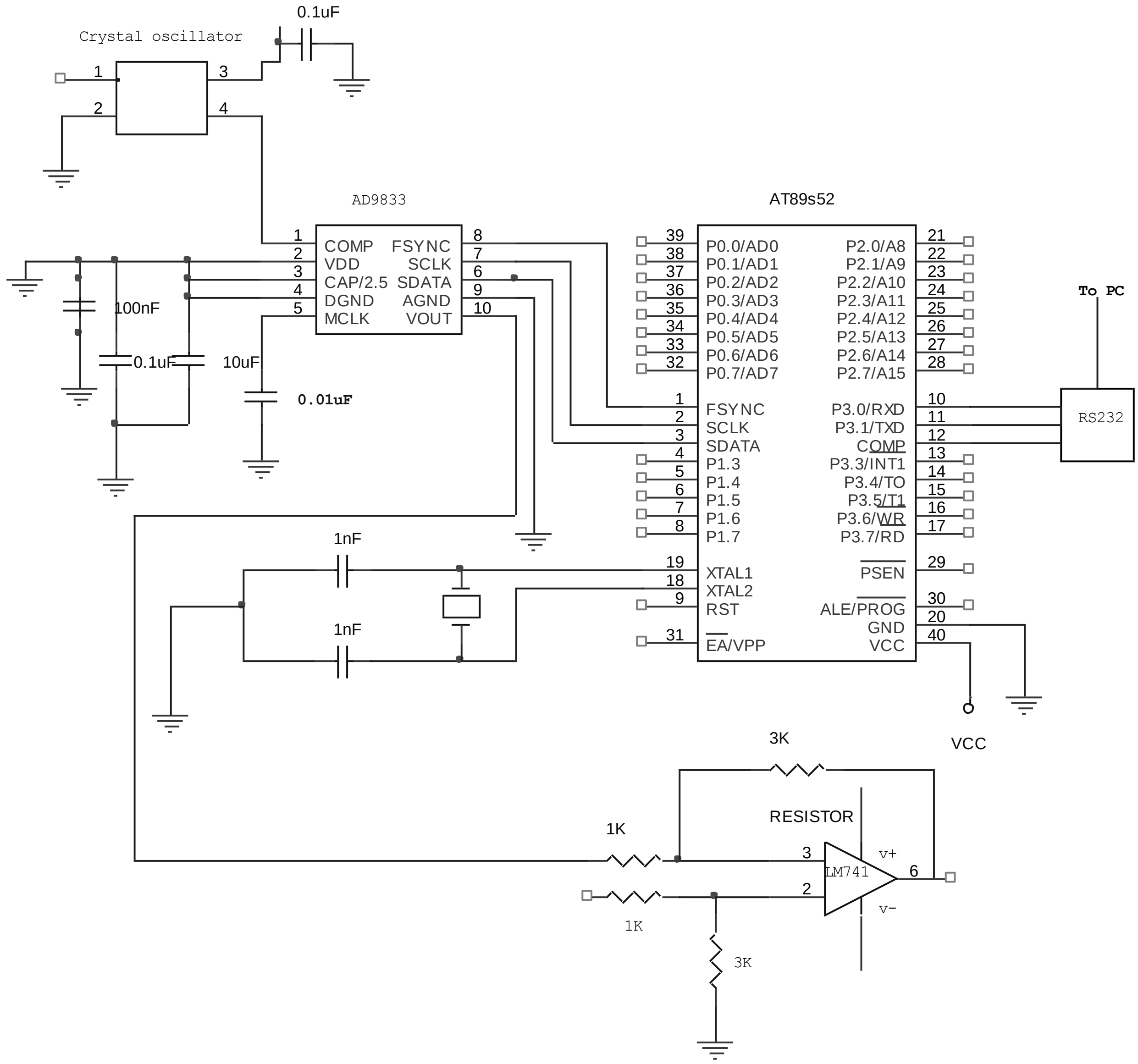

Fig 3 Schematic Diagram of Hardware

The modified data is then sent to the function generator IC AD9833 which is a main part to generate the waveforms. AD9833 generates the type and frequency of the waveform as required. However the amplitude of the output waveform is constant. The output from the AD 9833 is then amplified using LM741 Op-Amp.

IV. WORKING OF SYSTEM DESIGN

The AD9833 is a low power (12.65 mW) programmable waveform generator with 10-lead MSOP (Mini Small Outline Package).The AD9833 contains a 16-bit control register that allows the user to configure the operation of the AD9833. Hence the control register has to be first initialized before loading the frequency. The AD9833 as two

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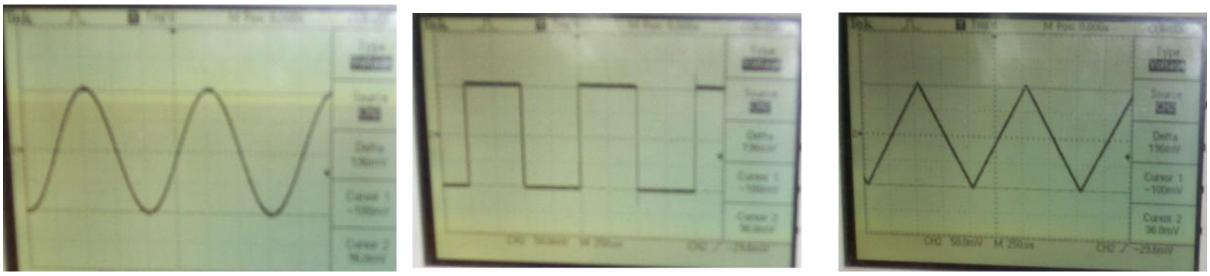
Frequency Registers and two Phase Registers. Each of the register is 28-bit long. While loading the frequency in the registers 2-bits are used to select the register and we have remaining 14-bits for loading. The Frequency registers are loading using two write cycle. So we require write cycles to be loaded. To program theAT89s52, Keil µvision is used to write the program and compile it. The complied HEX file is loaded using a Parallel port MAX coder. The AT89s52 was loaded with the program and theAD9833 was successfully loaded with the desired frequency and checked on the oscilloscope.

V. RESULT AND CONCLUSION

The GUI is successfully built by using National Instruments LabView software programming platform. It provides easy navigation between user and the function generator in selecting desired type of waveform and frequency.

The AT89s52 microcontroller along with the serial link was constructed. It receives data from GUI and send to the amplifier LM741 circuit and AD9833 after suitable conversion.

DDS generator produces the waveforms as shown in figure 4. Here we used master clock frequency of 4MHz. The DDS generator offers not only exceptional accuracy and stability but also high spectral purity, low phase noise, excellent frequency ability. Direct Digital synthesis, which generates analog waveforms with digitally adjustable high resolution phase and frequency, is useful in a wide variety of applications in test measurement and communications.



(a) Sine Wave **(b) Square Wave** **(c) Triangle Wave**

Fig 4 output of the DDS based on Microcontroller

Integrated circuit DDS devices are compact, require little power and space, are low in cost, and easy to apply.

VI. FUTURE WORK

Here in this work various amplitude implementations for various waveforms can be done. For Amplitude implementation we can use programmable Gain Amplifier whose gain can be controlled by different analog or digital signals.

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