Automated Amplifier Frequency Response Tester

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Abstract

With current developments in Integrated circuit technology, an approach to automatically plot the frequency response of different Audio amplifier circuits is presented in this paper. Use of specialized IC named Direct Digital Synthesizer (DDS) in programmable generation of frequency/ phase tunable output signal based on a reference clock source is incorporated. Interfacing of DDS with a microcontroller based Arduino board provides the basis of frequency generation in this project. This output from DDS is fed to test Audio amplifier circuit and the response from amplifier is recorded, voltage gain is calculated and a plot of gain versus frequency is displayed on PC by means of MATLAB graphic user interface (GUI). The aim is to replace the costlier and rigid option of Data acquisition (DAQ) card for the acquisition and display of frequency response plot on PC with microcontroller based Arduino board interfaced with MATLAB. This approach is cost effective, portable and unconstrained.
Keywords- AD9850 signal generator module, Arduino UNO interfacing with MATLAB, Bode plot, DDS (Direct Digital Synthesis), MATLAB GUI, Programmable frequency generation

I. INTRODUCTION

Many applications in electronics today involve gathering and decoding data for digital signal processing. One of the applications involves frequency response analysis that consists of stimulating a circuit with frequencies of known amplitude and phase, and analyzing the characteristics of the response. Thus, frequency response of a device or a circuit describes its operation over a specified range of signal frequencies by showing how its gain, or the amount of signal it lets through changes with frequency.

Frequency Response of an Amplifier allows the designer to characterize his/her design by depicting the variation of the gain of the amplifier and the phase difference between the output and input signals as a function of frequency over the desired frequency range. It can thus help him in assessing the suitability of the designed circuit for the intended application and enable him to carry out suitable changes if the design falls short of the requirements. It allows the designer to identify any peaks or valleys in gain or phase (as a function of frequency) that might be present as unwanted entities against which suitable corrective actions may be necessary as per the demands of the application

An approach to find out the frequency response of different amplifier circuits, especially Audio amplifiers, automatically by designing a device named Automated Amplifier Frequency Response Tester. Various approaches have been used, but the most flexible one is using Direct Digital Synthesizer (DDS). The frequency response is determined by stimulating the test amplifier circuit by range of frequencies of constant amplitude that are generated by programming the DDS IC interfaced with a microcontroller based Arduino board. The Bode plot is displayed on PC using MATLAB R2015a. A cost effective, convenient and unconstrained approach is presented in this report that replaces the need for costlier and rigid approach viz. use of Data Acquisition (DAQ) card for the display of Bode plot on PC.

II. OVERVIEW & LITERATURE SURVEY

A. Problem Definition

Frequency response analysis is an important exercise for measuring the performance characteristics of amplifiers. Audio amplifiers available in market claim frequency response as a major parameter of the respective unit. The conventional approach of testing such amplifiers becomes cumbersome. Hence a personal computer based instrument to automatically obtain and plot the frequency response characteristics of audio amplifiers is necessary. The gain and phase plot obtained will be helpful for us to test whether the actual performance characteristics of audio amplifier are correct or not as per the manufacturer's specifications. Commercially, such units are not available. The work proposed here is based on a Direct Digital Synthesizer device that operates under computer control.

B. Background Literature Survey

The literature survey begins with the study of a digitally-controlled method of generating multiple frequencies from a reference frequency source called Direct Digital Synthesis (DDS) presented in “MT-085: Fundamentals of Direct Digital Synthesis

(DDS)" by Walt Kester[1] and The advantages and applications of DDS proposed in the application note "Ask The Application Engineer—33 All About Direct Digital Synthesis" by Eva Murphy and Colm Slattery [2]. Latest Functional trends in DDS technology is very well explained in "A Technical tutorial on Digital Signal Synthesis" by Analog Devices [3]. Along with the in-depth functional working of DDS devices, other inherent DDS attributes like the ability to tune with extremely fine frequency and phase resolution, and to rapidly 'hop' between frequencies as proposed in "Direct Digital Synthesizers" by Jouko Vankka and Kari Halonen [4]

III. IMPLEMENTATION AND MEASUREMENTS

A DDS AD9850 signal generator module is interfaced with Arduino Uno. The programming of DDS is done in Arduino environment to generate range of frequencies. This frequency controlled output waveform from DDS is given to the input of the test amplifier circuit. As the frequency response of an amplifier is presented in a form of a graph that shows output amplitude (or, more often, voltage gain) plotted versus frequency, the output of the amplifier needs to be given to the PC for gain and phase calculation and for display. This is done by installing Arduino interface package with MATLAB R2015a, where calculations for Bode plot is performed and displayed on GUI.
Block diagram of highly compact Automated Amplifier frequency response tester is shown in figure 3.1, is based on the following blocks:

1) DDS AD9850 signal generator module
2) Microcontroller based Arduino UNO board
3) Application Software, MATLAB R2015a and its Control system toolbox installed on PC
4) Test Amplifier circuit using LM386

The procedure for developing an "Automated amplifier frequency response tester" begins with the interfacing of DDS AD9850 signal generator module with Arduino UNO for generating train of frequencies required for stimulation of audio amplifier circuit. This is done by programming the microcontroller based Arduino UNO board. The digital out pin from the Arduino serves as an input to the D7 pin of AD9850 module. This digital code is converted to sine wave of constant amplitude and frequency output from DDS. This in turn serves as an input to the audio amplifier circuit (LM 386). The output (amplitude/phase) of the amplifier is modified according to its gain. This signal is given to the Arduino UNO as Analog input, also the output from the DDS is given to another analog input pin of Arduino. These two signals viz. one output from amplifier and another output from DDS are acquired and transferred to PC using MATLAB through USB. The calculations of Bode plot performed in MATLAB/Simulink are done in Real-Time environment. The display of Bode plot is done using MATLAB Graphical User Interface (GUI) application

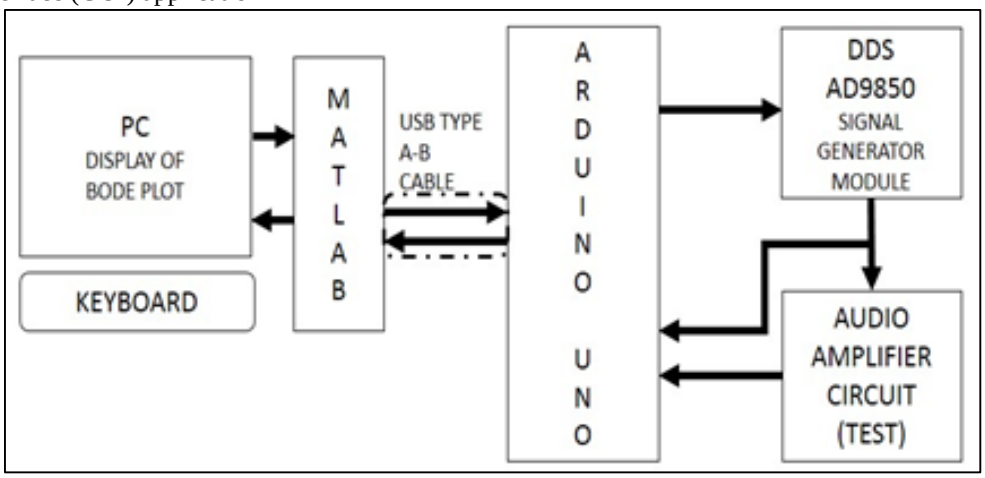

Fig. 3.1: Block Diagram of Automated Amplifier Frequency Response Tester

Procedure to obtain the Frequency Response Plot is as given below:

1) A MATLAB GUI is created to acquire the Start frequency, Stop frequency and increment steps from the user.
2) The code to generate these frequencies in steps is written in Arduino UNO and programmed into DDS AD9850 module who's output is given to Test Amplifier(LM386)
3) The output from the DDS and Test amplifier is acquired in the form of Analog inputs in Arduino and code for calculating the Gain/Phase is written in Arduino environment. This data in the form of string is acquired in the MATLAB environment and plotted versus frequency on MATLAB GUI

1) Interfacing DDS AD9850 and Arduino UNO

Direct digital synthesis (DDS) is a technique which generates frequency/phase tunable output signal based on fixed-frequency reference clock source. It is a method of generating an analog waveform by generating a digital code for time-varying signal and

then performing a digital-to-analog conversion. DDS can generate frequencies with high switching and its frequency agility upon specific frequency command, fast switching between output frequencies, fine frequency resolution, and operation over a broad spectrum of frequencies are features which cannot be achieved by other conventional waveform generation technique.

The AD9850 module is based on AD9850, a CMOS, 125MHz Oscillator and a complete DDS synthesizer. The AD9850 is a highly integrated device that uses advanced DDS technology coupled with high performance, high speed, D/A converter and a comparator, to form a complete digitally programmable frequency synthesizer and clock generator function.

All the external components which are needed are integrated on board. Only power and control signals are added to drive this module. This unit provides an easy means to set the frequency to any value up to 40MHz. The interfacing diagram is shown in Figure 3.2 below. Communication with the DDS module is by the three wire serial interface, going to the Data, FQ-UD and W_CLK pins. A fourth line also controls chip Reset. This latter is not essential, but has been included as it may be useful in the future to have a reset capability. The Arduino software in the PC maintains a 32 bit frequency word that is incremented or decremented using programming. This word represents the desired frequency in units of 0.01Hz, and is independent of the DDS clock.

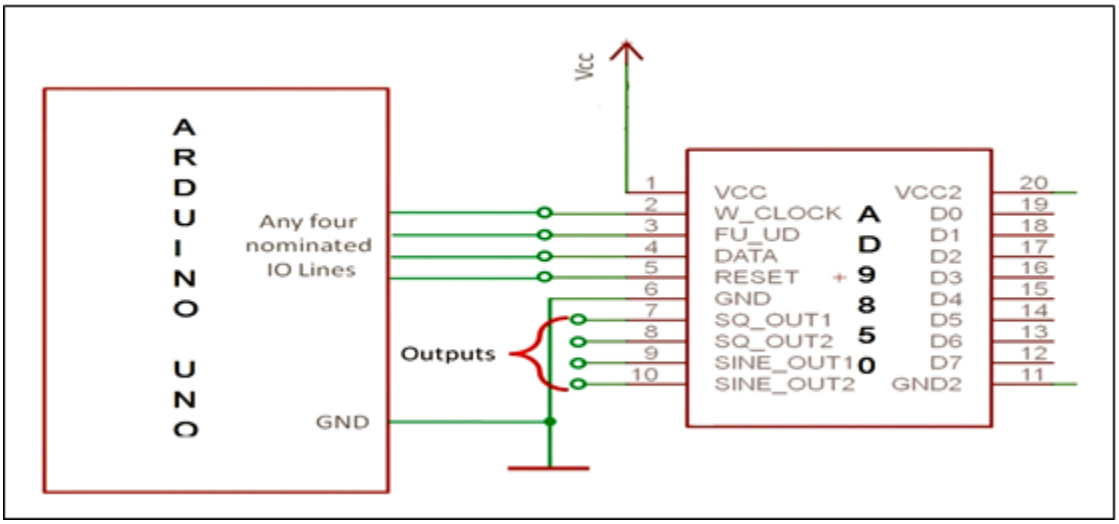

Fig. 3.2: Interfacing diagram of AD9850 and Arduino UNO

2) Interfacing Arduino with MATLAB

MATLAB® Support Package for Arduino® Hardware enables use of MATLAB to communicate with an Arduino board over a USB cable. The data from DDS is read and write through the Arduino and Bode plot in MATLAB GUI is acquired. Using Arduino® serial communication reading and writing data to both digital and analog pins is done. The MATLAB version of R2015a is used for real time simulation of control signals. A code is written in the Matlab Script to display Bode Plot on PC.

3) Test Audio Amplifier Circuit using LM386 and Arduino Interfacing

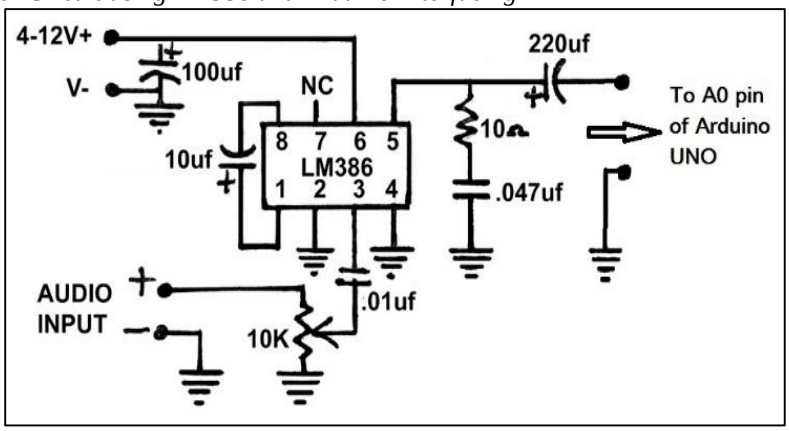

Fig. 3.3: Circuit diagram of LM386

The test amplifier circuit is as shown in figure 3.3. The gain of the amplifier is adjustable and works in the range of 20Hz to 20 kHz. The output from audio amplifier serves as an Input to Arduino which can be taken on any analog input pin of Arduino UNO. This data obtained in Arduino is used in the Arduino program for Gain calculation and is plotted on PC through MATLAB.

IV. RESULTS AND FUTURE SCOPE

The complete connections are made as shown in the Figure 3.1 and Figure 3.2. Following are the results obtained on MATLAB GUI. The real time Bode plot of LM386 Audio Amplifier (refer Figure 3.3) is as shown in the Figure 4.1(a) while the Bode plot through simulation is as shown in Figure 4.1 (b) below. Code to continuously send a range of frequencies in steps is written in Arduino UNO and accordingly DDS AD9850 module is programmed.

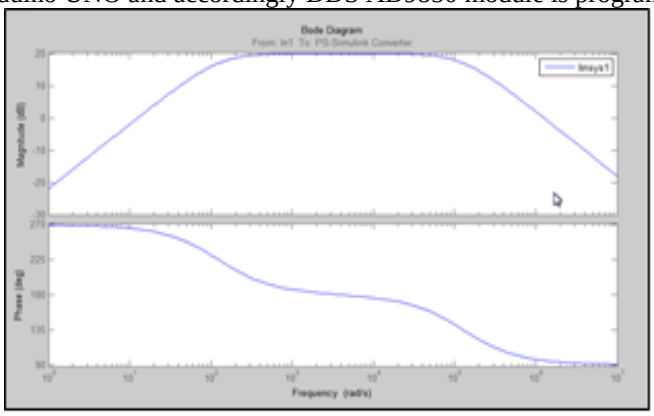

Fig. 4.1: (a)

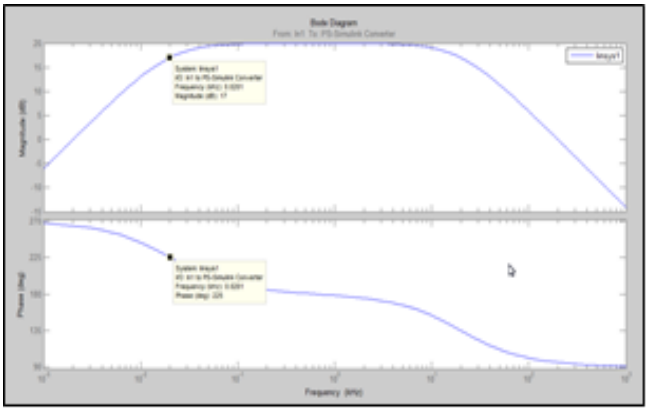

Fig. 4.1: (b)

This output from DDS is around 1.2V is given to Test amplifier and both the outputs are acquired in MATLAB in the form of string and displayed on MATLAB GUI as shown in the Figure 4.1(a). The output sine waves from DDS and Test amplifier are verified on CRO as shown in Figure 4.2(a) and Figure 4.2(b) below.

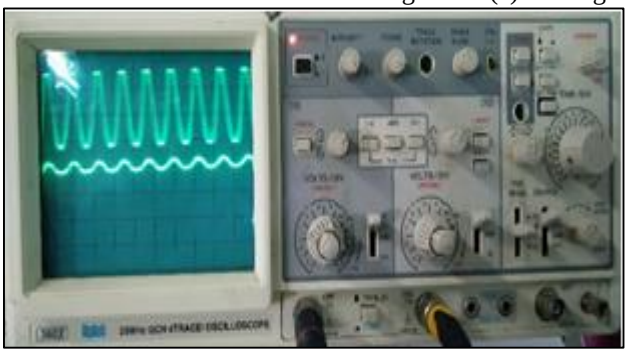

Fig. 4.2: (a)

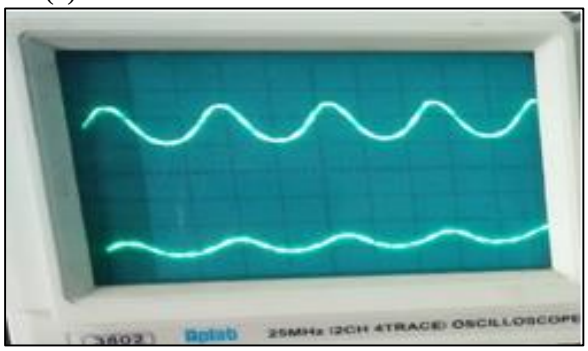

Fig. 4.2: (b)

The Thermal Harmonic distortion(THD) , Linearity and other working specifications of Audio Amplifier can be measured by this method using proper coding in the MATLAB script.

V. CONCLUSIONS

A Frequency Response plot is displayed on PC using Microcontroller based Arduino UNO board and MATLAB. The frequency range programmed is from 20 Hz to 20 kHz temporarily for Audio Amplifiers.

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