Midterm Review

DDS Based Transceiver

For Wireless Communication of Low Vhf

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INTRODUCTION

Private use two-way land mobile radio systems is one of the common uses for Very High Frequency (VHF) radio broadcasting, that has a long-range data communication up to several tens of kilometers. VHF is an International Telecommunication Union (ITU) designation of radio frequency electromagnetic waves ranging from 30 to 300 megahertz (ITU, 2018).

The aim to implement a private low-cost wireless communication system of 70MHz low VHF is achievable using Direct Digital Synthesizer (DDS), accompanying with several other components such as Raspberry Pi and RTL-SDR.

This project utilizes the AD9854 Direct Digital Synthesizer in particular, which is a highly integrated device that uses advanced DDS technology. The AD9854 is coupled with two internal high speed, high performance quadrature digital-to-analog converters (DACs) to form a digitally programmable I and Q synthesizer function. For this individual project, this AD9854 DDS will be used in combination with Raspberry Pi and RTL-SDR for building a radio transceiver, a device that comprised both a transmitter and receiver. Raspberry Pi is a single board computer as a controller, whereas RTL-SDR is a software defined radio (SDR) that uses cheap DVB-T TV tuner dongle.

The scope of the project is focused on the feasibility of implementing such wireless communication system, with the mentioned components using knowledge on how an IQ modulator works and how to program the synced signals in C++. Since this combination has never been considered before in building transceiver, further research is required.

BACKGROUND

OVERVIEW

Researches have been done on previous designs in building low VHF and projects on application of AD9854. There are multiple existing methods and combinations in building a low-cost transceiver, but not with AD9854 DDS and Raspberry Pi as controller in particular.

Since AD9854 is in the list of major components for the 2013 National Undergraduate Electronics Design Contest in China, there are a fair amount of resources in relation to AD9854 functioning with other microcontrollers. The following are several relating previous works to refer to:

PREVIOUS WORK

Simple Frequency Response Tester (ElecFans, 20)

This is a frequency characteristic tester project done by team 1413909 on ElecFans (Elecfans.com, 2014). The design uses DDS AD9854 and STM32 microcontroller to control the DDS to produce sweep signal of 1Mhz to 40Mhz signal (varied through button), with continuous sweep output of minimum step of 100kHz. The RLC series resonant circuit is used as the tested network. The DC signal of the in-phase component and the quadrature component is obtained by the AD835 multiplier and the low-pass filter. Then the ADC conversion is sent to the microcontroller, data processing in the microcontroller is performed. After calculating the phase and amplitude, the graph of amplitude-frequency characteristics and phase-frequency characteristics are displayed. The main structure is as follows:

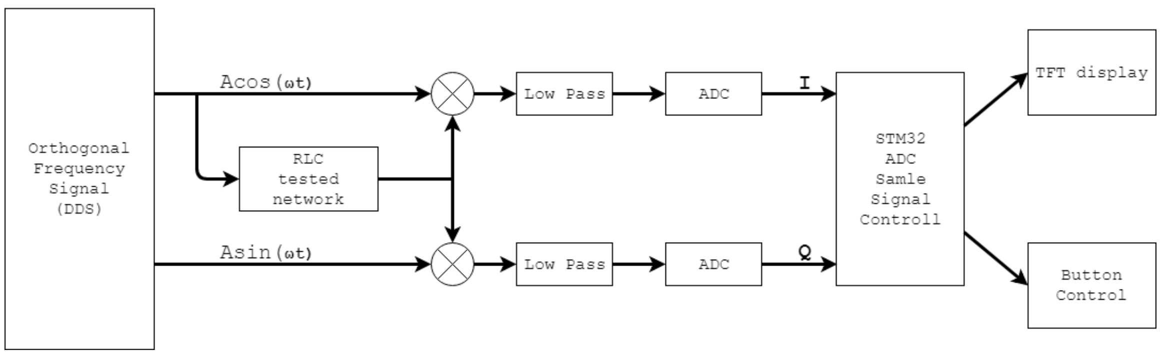


FIGURE 1. OVERALL SYSTEM BLOCK DIAGRAM

The filter and amplifier design are:

$$\mathbf{I = A\ cos(\omega t) \cdot B\ cos(\omega t) = \frac{AB}{2}[cos(2\omega t + \phi) + cos\,\phi]} \qquad (1)$$

$$\mathbf{Q = A\ sin(\omega t) \cdot B\ sin(\omega t) = \frac{AB}{2}[sin(2\omega t + \phi) + sin\,\phi]} \qquad (2)$$

The main reference to this project is the configuration of DDS in C++ and parts of methodology such as filter and amplifier. Further research needs to be is accomplished when actual designing the structure for own individual project.

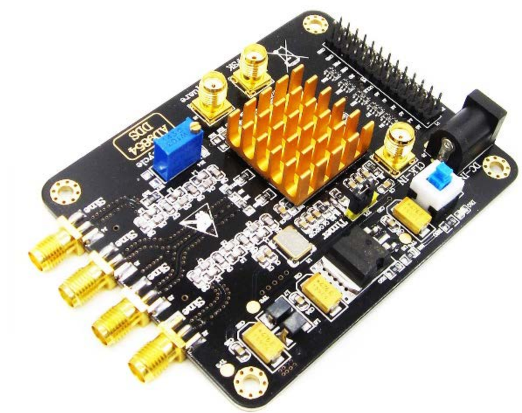
DDS Synthesizer 0-70Mhz on Raspberry Pi and AD9851 DDS (Techniline, 2018)

This work is presents the method to run a very precise sinewave generator with a range of 0-70MHz on the chip AD9851 controlled by Raspberry Pi. The implementation is very basic with just several wire connections between the GPIO connectors Raspberry Pi-2 computer and AD9851 module.

KEY MATERIALS

Other key materials are the datasheet of AD9854 and official site for Raspberry Pi and RTL-SDR respectively. The community forum for Raspberry Pi provides variety of useful resource and problems previously identified. The following table is a list of major components engaged for the project.

TABLE 1. BACKGROUND INFORMATION OF MAJOR COMPONENTS

Components	Image
Direct Digital Synthesizer AD9854 **(ANALOG DEVICE.com, 2003)** • The Direct Digital Frequency Synthesis (DDFS, or simply DDS) is a technique using digital-data and mixed/analog-signal processing blocks as a means to generate real-life waveforms that are repetitive in nature.	 FIGURE 2. AD9854 DDS
The Raspberry Pi B+ V.3 (Raspberry Pi, 2018) • Single board computer which contains a System on chip • Quad-core processor, I/O Peripherals, ROM and GPU • SD is inserted to provide boot medio (system platform) and storage.	 FIGURE 3. RASPBERRY PI B+ VER.3
RTL-SDR Blog W.3. Dongles **(rtl-sdr, 2017)** • A software defined radio (SDR) that uses cheap DVB-T TV tuner dongle. • Through special drivers, the dongle can be turned into a wideband SDR.	 FIGURE 4. RTL-SDR

METHODOLOGY

Methodologies are likely to increase as further research is performed along the design.

SYNTHESISER

The transmission of samples is uniform in time. The I and Q synthesiser function, or the RF signal, used for this research topic is:

$$I(t)\cos\omega t + Q(t)\sin\omega t$$

For signal receiver, the version 3 RTL-SDR radio receiver dongle will be used, which samples a radio frequency signal from 50 MHz to 1700MHz and outputs interleaved 8-bit IQ samples at symbol rate up to 2.4Msps.

VHF design

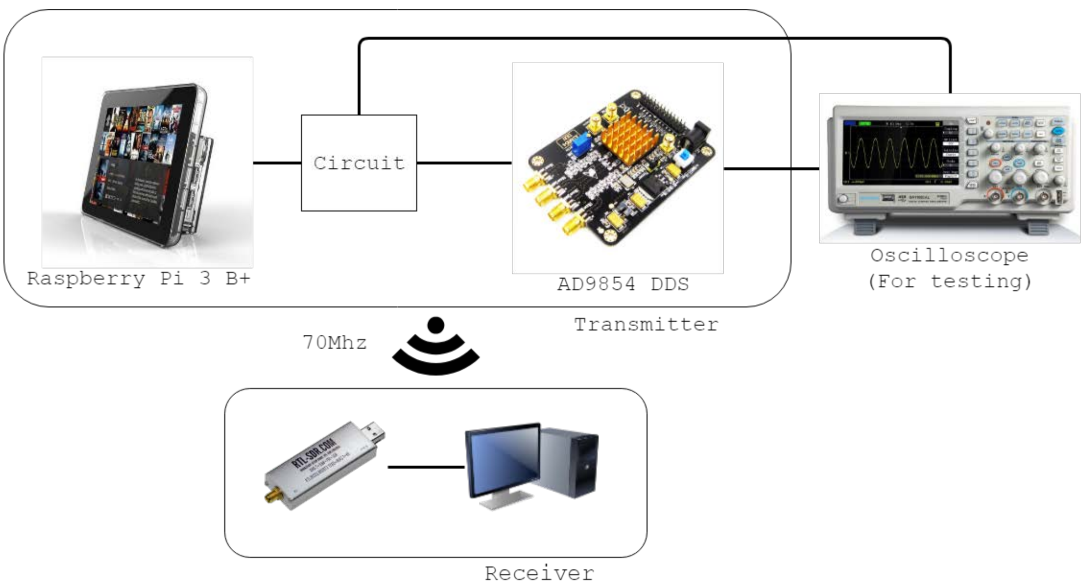


FIGURE 5. BRIEF OVERALL STRUCTURE

The above image shows a brief structure of the whole system. Raspberry Pi is the controller and AF9854 generates the required signal. The initial thoughts are connecting these two together, however the reference previous work suggests extra circuit may be required as well. Details of the circuit will be implemented afterwards. Together these component acts as a transmitter in overall. The RTL-SDR can be plugged in the computer and coded to perform as a receiver.

ENVIRONMENT

For Raspberry Pi, the Raspbian version April 2018 operation system is installed, with Linux Kernel version 4.14.

PROGRAMMING

The major coding language is C++, using Microsoft Visual Studio, Notepad++ and other code editor. Although C++ is intentionally used, Python can also be considered if necessary. The RTL-SDR can be directly connected to PC and the program coding can be done using MATLAB.

WORK COMPLETED

The work completed so far are researches on previous works, the setup for environment for Raspberry Pi and the drive for DDS AD9854 in C++. In addition, the overall project is planned and structure is graphed.

DRIVER FOR AD9854

The drive for AD9854 is implemented in C++. Due to technical issues, the current coding is completed in Windows 10 environment using Microsoft Visual Studio 2017. The execution and further debugging will be done on Linux and Ubuntu afterwards. Refer to the Appendix for the code completed.

SET UP AND CONNECTION OF RASPBERRY PI

The Raspberry Pi 3 B+ is connected to an official 7-inch touch screen. In order to save USB slots, keyboard and mouse are wirelessly Bluetooth connected. One issues is that the ANU Unilodge residential network's protocol is not supported by the Raspberry Pi, hence unable to connect wirelessly and Ethernet / Mobile hotspot has to be used instead. The following figures shows the connection between DDS Module and Raspberry Pi.

In initial thoughts, the DDS module shall be able connect directly to the GPIO header on the Raspberry Pi with schematics shown below, however, in conclusion drawn from the previous work, external circuit connection may also be needed. The circuit design will be considered in future work if necessary.

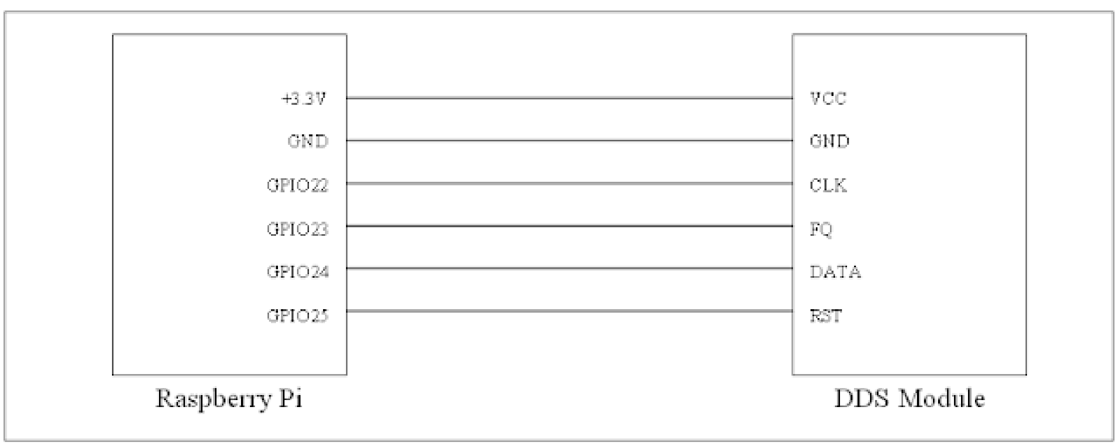


FIGURE 6. SCHEMATICS OF CONNECTION

MAJOR CHALLENGE

There are varies challenges for this project, either already encountered or expected. The major ones currently and recent future encountering are listed as follows. The expected challenges that may occur further ahead are discussed planning. These challenges will be gone through respectively.

1. Raspberry Pi may not be an ideal controller for AD9854. Having view a large amount of previous AD9854 projects, the most commonly used are 16-Bit microcontroller SPCE061A and STM32. The previous work on other DDS modules will be referred.
2. Referring to the setup for AD9854 in related previous work (Appendix B), a much complex circuit may be required to have the AD9854 in function. Research and studies will be done on this topic when designing the circuit.
3. The components are extremely fragile. One encountered issue is that directly charging the Raspberry Pi overnight through socket on the wall actually blown it up. This could possibly be due to the voltage of socket is not matching the Raspberry Pi’s limit. In future, this type of issue may again occur due to false coding and other circumstances, hence multiple checking every time before connecting to power is necessary.

PLAN

The prior key activity is program coding for the entire system. The goal is the complete the C++ coding throughout term break between Semester 1, 2018 and Semester 2, 2018. During the break, the coding will be done on Ubuntu platform. Any alternate circuit design is aimed to be completed at the stage as well. For semester two, the major focus will be testing on varies parameters, refining and debugging the built system. All activities will be recorded into logs and kept track on, for later to organise into thesis. Further research will be done along the way.

In addition, expected challenge includes technical challenge. In planning, the main period used to build and test the AD9854 is during term break, which there might not be accessing to is oscilloscopes. This may cause a delay in process that the testing on oscilloscope may be move to later when Semester 2 starts.

CONCLUSION

So far for this project, the main progress is to notify all the challenges and to find solutions to encounter then. The environments are set, and all the components are purchased, readily used. The overall structure of the system is drafted and the coding for drive is in process. The next steps are as mentioned in the plans, further debugging and completion of the program will be the next goal. Research journals are hardly discovered for this particular project, most references are previous works done by professions and students. Through the previous works, many new challenges are identified and will be taken under account as the project process.

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