Thesis for the Degree of Master of Engineering

Design Of Portable Digital-Controlled Ultrasonic Pulser-Receiver 2 Channels

by

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Design of portable digital-controlled ultrasonic pulser-receiver 2 channels

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by

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List of Abbreviations

LPF	Low pass filter
HPF	High pass filter
PR	Pulser-receiver
FPGA	Field Programmable Gate Arrays
SNR	Signal-to-noise ratio
PCB	Printed circuit board
MCU	Microcontroller

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Firstly, I would like to express my deepest gratitude to my advisor Dr. Junghwan Oh, the professor of the Department of Interdisciplinary of Industry 4.0 Convergence Bionics Engineering, Pukyong National University, for his great assistance, support, and encouragement in completing this thesis's research and writing. I will always be appreciated for his education, guidance, and mindset.

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Abstract

Nowadays, the applications of ultrasound in various fields are becoming more widely and commonly, especially in medical imaging and nondestructive testing. One of the most vital parts of an ultrasound system is the ultrasonic pulser-receiver. An ultrasonic pulser-receiver device is utilized for general-purpose ultrasound imaging and testing. Based on learned knowledge, this thesis focuses on researching and developing a digital controlled ultrasonic pulser-receiver 2 channels. The pulser allows generating the high voltage up to 90V in nanoseconds. The receiver is available in 300MHz bandwidth included ultra-low noise, variable gain control amplifier and the selectable filter with both low pass filter (LPF) and high pass filter (HPF). The device is designed costly, portable, lightweight, digital-controlled by software on a PC for extended use.

Chapter 1 : Ultrasonic pulser-receiver device

1.1 Introduction

The ultrasonic gadget is extremely valuable in a variety of industries, including medicine and science. Nowadays, in industry, it is applied with nondestructive testing (NDT) to help to evaluate properties of a material, component, structure like thickness, velocity, or system for characteristic differences or welding defects and discontinues without causing damage to the original part and so on. Some materials, such as glass, metals, polymers, and chemical compounds, are also suited for this type of machine.

Commonly, the ultrasonic pulser-receiver system is operated with an ultrasonic transducer and digitizer. The pulser-receiver will act as a high voltage generator to excite the ultrasound transducer. Afterward, the ultrasound transducer converts electrical power into ultrasound power. This kind of power of ultrasound will travel through the transferring ambiance and inside the material sample. Due to different characteristics between transferring environment and inside environment of the sample, the reflection signals appear, it also can be called echo signal. That echo signals then turn back to ultrasound transducer and but this time, it converts ultrasound power into electrical power. These electrical signals are amplified the amplitude and filtered the noises in the pulser-receiver device before coming to be processed at the digitizer. The digitizer helps to convert analog signal to digital signal then work as an analytical and processing device to build a complete ultrasound imagine of the material sample.

Currently, in the global market, there are many kinds of ultrasound transducers. They can be cataloged by the features such as frequency, utilizing purpose, a number of elements, focusing or flat, etc. And in order to divide simply, it's based on the range of frequency transducer. The low-frequency transducers operate from 500kHz to 25 MHz, the high-frequency transducers operate over 100MHz. The low ones are applied to the applications requiring high penetration, long focal length detection but they give the low resolution imagine. On the other hand, the high ones are suitable for the application requiring high-resolution images, and short focal length detection. Each kind of transducer needs to proper excited signal form to get the highest amplitude of echo signal. When using a low-frequency transducer, a burst or square wave is generated, and its width corresponds to the frequency of the transducer. And when using a high transducer, a spike-wave is created, the higher frequency of the transducer the smaller pulse width.

In practice, the commercial ultrasound pulser-receiver can generate vast voltage pulses with an ultra-short rising and falling edge and a nanosecond duration. This electrical signal is received by the ultrasound transducer, which then turns it into mechanical energy, which is known as an ultrasound wave. When the wave collides with a material that is tested, depending on the distinct genres of material, the echo signal comes back pulser-receiver with different shapes, amplitude, frequency, etc.

We no longer deny that now there are a bunch of pulser-receivers on the market that originate from repetitive and famous companies or lab groups such as UTEX, JSR, Parametrics, and so on. Each branch has its own specifications satisfying vary of requirements in industry application. For instance, UT340 of UTEX company is considered as the powerful pulse, exceptionally wide bandwidth, and quiet performance, which made the UT340 an industry-standard reference instrument for the past 25 years. Its pulser of UT340 controls pulse width in steps as small as 0.2 nanoseconds and pulse voltage in steps of 2 Volts. This precise control enables the UT340 to match the excitation characteristics of any transducer, dramatically increasing its energy output. A full 350 μJ of energy is available to excite transducers up to 500 Volts. While its receiver has the low-noise, wide-bandwidth receiver characteristics improve inspection sensitivity throughout the 63 dB gain adjustment range.

Besides the incredible upside features as mentioned above, those devices have a downside in cost. They have a cutthroat price of approximately from $7,000 to $20,000, this is huge money and is not suitable to the company budget for the small and mediumsized project. For this reason, it is desirable to research and develop a low-cost ultrasonic pulser-receiver.

We developed a portable, lightweight, small size, and digital-controller ultrasound pulser-receiver with 2 channels well designed for ultrasound imaging or any non-destructive ultrasound testing applications. The device consists of the pulser which can be easily configured by digital controller with positive voltage (85V) and adjustable pulse width along with very small rising time, which produces an adjustable amplitude of excitation pulse to the ultrasonic transducer. And the receiver including the amplifier and the filter has 300MHz bandwidth. The amplifier has a range from -11 to 51dB with a 1dB step size allowing till +/- 3V peak-to-peak of the echo signal. The filter allows choosing low pass filter, high pass filter. With low pass filter has 300MHz or 100MHz and the high pass filter has 2MHz or 0MHz depending on the purpose's user.

The software runs on the computer and controls the pulser-receiver. It can operate in either pulse-echo or pulse-through mode. With rising edge-triggered detection, the user can arrange in internal or external trigger mode. The device's transmit/receive connector is a standard 50 SMA, and it uses a coaxial cable to connect to any BNC or SMA type interface connector.

The device works with a 12V DC power supply and can withstand temperatures ranging from 0 to 85 degrees Celsius. The ultrasonic pulser-receiver is a complete instrument with a stand-alone enclosure that may be used for extended periods of time.

1.2 Material and methods

1.2.1 Methods

When observing the term “ultrasound pulser-receiver”, it is not hard to recognize that as an electrical device, it contains two parts: pulser and receiver. Each of them has its distinct structure and specific function in the system. The following contents will demonstrate both pulser and receiver section as well as the measured parameters of them.

Firstly, in pulser section, it acts as a pulse generator or driving circuit. There are several noticed technical features as pulse width, pulse repetition rate (PRF), the voltage amplitude of pulse (or pulse energy). All of them play a significant role in perform to drive ultrasound transducers effectively. For example, an ultrasound transducer has its own resonant frequency, to obtain the highest amplitude of echo signal, it should excite at proper pulse width that proportions to resonant frequency following a math equation.

Another feature being also immensely important when exciting a transducer is pulse signal form. The most popular signal forms are spike pulse and square pulse. In terms of spike waves, it generates a broadband pulse with a rapid rise time and an exponential recovery. It commonly is used for the high-frequency transducer. In respect of square wave, it produces a single cycle square wave adjusted to the transducer's center frequency.

Back to pulse energy factor as mentioned, it requires a high voltage and short duration. The higher voltage allows better penetration capacity, a typical voltage fall in the ranges from 100V to 500V. About short duration, it resembles pulse width as talked above.

Next, pulse repetition frequency (PRF) of excitation pulse expresses how swift the transducer is the trigger, normally ranges from 100Hz to 10kHz or greater. A high PRF permits faster scanning and data acquisition is applied in FSAM (Fast SAM system). But a low PRF secures battery life, restricts the wraparound noise, and is applied in TSAM (Traditional SAM system).

In practice, two modes of scanning used are pulse/echo mode and through transmission. The most typical setup is pulse/echo, which uses a transducer with a single element that works as both transmitter and receiver. When two different transducers are utilized on opposing sides of the test piece, thru mode is used.

An additional factor that can be considered when designing a pulser-receiver device is damping. Their standard value is between 50 ohms and 500 ohms. Higher damping resistance decreases damping and improves penetration, whereas lower damping resistance enhances near-surface resolution and pulse damping.

Secondly, in the receiver section, the signal after being excited to the transducer will turn back to the receiver part. The primary duty of this part is to amplify, filter echo signals; in some cases, it can be used to reverse the signal phase. Besides, a bandwidth of the receiver section also a crucial factor, the bandwidth's value should be twice the resonance frequency of the transducer, this secure that the output signal's shape and amplitude do not distort or dimmish. For instance, a 150MHz transducer requires a 300MHz bandwidth or bigger.

In the amplification part, common designs, contain an attenuator and amplifier. The amplifier has a fixed gain, while the attenuator allows adjusting the desired attenuation, that mechanism creates a controllable receiver gain over a broad dynamic range and gets the amplitude echo signal as the desire. The selection of a suitable echo signal at a specific gain normally bases on a signal to noise (SNR).

In the filter part, it is a remarkable method that helps improve the signal to noise parameter or near-surface resolution by filtering out unwanted components of the signal. In a criterion design, there are three genres of the filter that can be operated such as low pass filter (LPF), high pass filter (HPF), and bandpass filter (BPF). Depending on the design aim, each low pass filter, high pass filter, and bandpass filter can have alternatives differently.

Apart from pulser and receiver section, it will be a shortage when not to mention Transmit/Receiver switch (T/R). The T/R plays a significant role in protecting the components in the receiver circuit. It operates at either connecting to pulser or connecting to receiver. It permits high voltage, short time excited pulse to go through as well as is the path to echo signal comes to receiver part. Based on the state-of-the-art technology in designing chips recently, the Transmit/Receiver switch can be integrated with pulser part. In the prominent among them, there is a family chip coming from ST company (STHV748, STHV800, STHV1600) with several channels up to 16. They enable to program and control digitally by microcontroller (MCU), Field Program Gate Logic (FPGA).

The echo signal of ultrasound transducer after getting out pulser-receiver will be satisfied with signal to noise to support data acquisition process feasibly. Analog signals are processed at the hardware called digitizer under the controlled software written by C+, LabView language. Both this digitizer and software help to convert analog signal to digital signal that called sample data and handle them to display ultrasonic imagine.

1.2.2 System design

In this design, to design PCB for the device, we utilized Altium Designer software that is a PCB and an electronic design automation software package for printed circuit boards.

The pulser uses fixed excitation pulse voltage(81V). It also can be feasibly configured by manual digital control with an adjustable pulse width which produces an adjustable amplitude of excitation pulse to the ultrasonic transducer.

The receiver is available in 300MHz bandwidth included a selectable range from -11 to 51 dB of amplifier that can provide till +/- 3V peak-to-peak of the echo signal.

The ultrasonic pulser-receiver system can be configured internal or external trigger mode with rising edge-triggered detection.

Coaxial cable is used to link any BNC or SMA type interface connectors, and all connectors are standard 50 ohms SMA. Ultrasonic pulser-receiver is a complete instrument with a stand-alone enclosure for long-term usage that is portable, lightweight, modest in size, and digitally operated.

The gadget can be used at temperatures ranging from 0 to 85°C and is powered by a 12VDC power supply.

Pulser	
Pulse Type	Positive Impluse
Pulse Duration	10ns, 14ns, 18ns, 20ns, 24ns, 27ns, 30ns, 34ns (Selectable)
Available Pulse Voltage (no load)	+/-81V
Operation Mode	Pulse-Echo / Thru-transmission (Selectable)
Trigger Mode	Internal trigger / External trigger (Selectable)
Number of Trigger	One
Number of channels	Two
Internal Pulse Repetition Rate	0.1, 0.2, 0.5, 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 kHz
External Pulse Repetition Rate	50 kHz max
Synch Output Pulse	5V TTL compatible
External Trigger Input	Rising edge-triggered. 5V TTL compatible, 2V minimum

Receiver	
Maximum Bandwidth	300 MHz (-3 dB)
Low pass filter	100/300Mhz (selectable)
High pass filter	0/2Mhz (selectable)
Voltage Gain	-11 to 51dB in 1dB step (Selectable)
Voltage peak to peak (max)	6V
Phase	0º (noninverting)
Low Noise Figure	4.5dB max

Unit	
Input/Output	All SMA connectors. USB type B connector.
Power Requirements	12VDC, 5A

Figure 1: Technical specification of pulser-receiver 2 channels

1.3 Schematic design

The schematic design of the ultrasonic pulser-receiver system is divided into seven main blocks: power supply block, controller block, pulser block, trigger block, receiver block, communication block, and high voltage DC-DC block. Each block has a different role in the system:

- Power supply block: Supply the power to all blocks on board.
- Controller block: Control the other block through by FPGA and MCU.
- Pulser block: Drive the transducer by high voltage pulse and receive echo signal.
- Trigger block: Create or get trigger signal from inside or outside device.
- Receiver block: Amplifier and filter the echo signal.
- Communication block: Receive the command for user software.

- High voltage DC-DC block: Supply power to help pulser block exciting transducer.

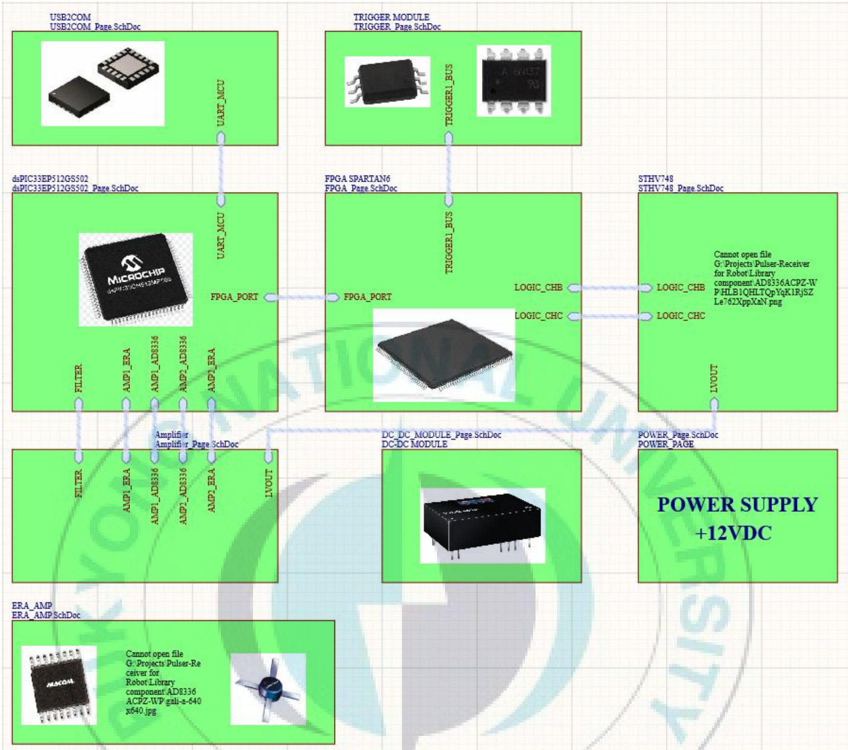

Figure 2: All block in pulser-receiver 2 channels

1.3.1 Power supply block

The power supply block supplies the power for the whole circuit. This section consists of a voltage regulator IC. Voltage regulator IC works as the stable output voltage IC. It provides a constant and stable voltage which is supplied for IC in pulser block, receiver block, and communication block. In general, this part provides all voltage and current for other sections in the whole ultrasonic pulser-receiver system.

Then the voltage regulator ICs can divide the following block where they supply voltage and current.

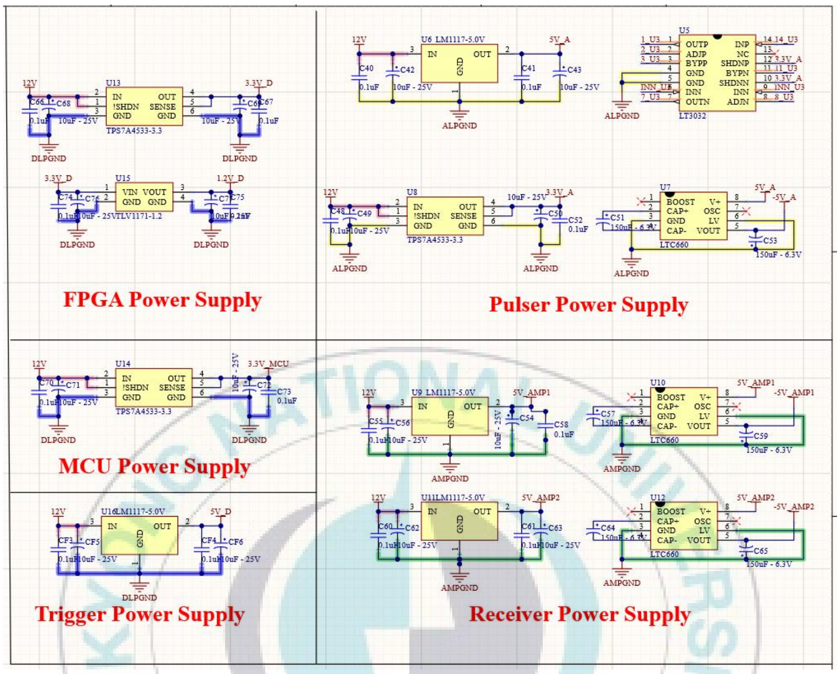

Figure 3: Power supply for whole circuit

Firstly, the controller block needs to supply power for FPGA, dsPIC(MCU) IC with 3.3V and 1.2V. Secondly, the pulser block using STHV748 IC needs +/-3.3V. Thirdly, the receiver block requires a +/-5V supply. And finally, the trigger block ‘s voltage usage is 5V.

1.3.2 Controller block

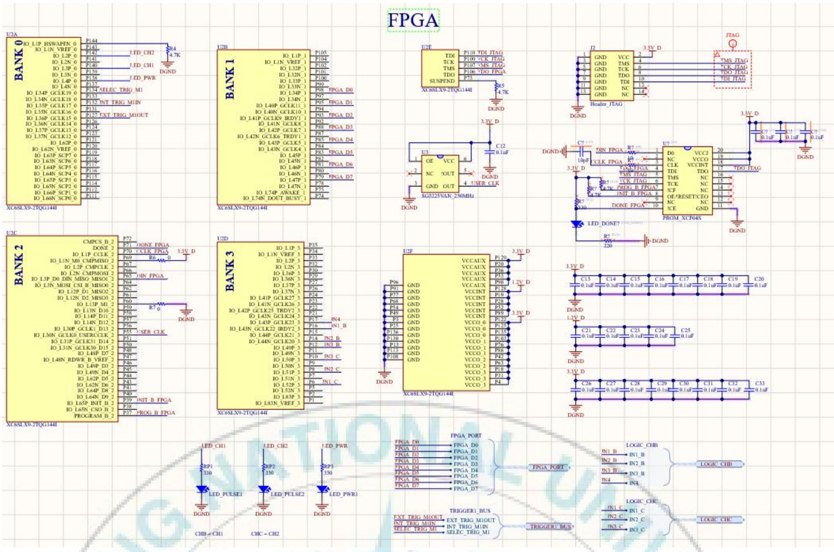

Figure 4: Schematic of FPGA IC in controller block

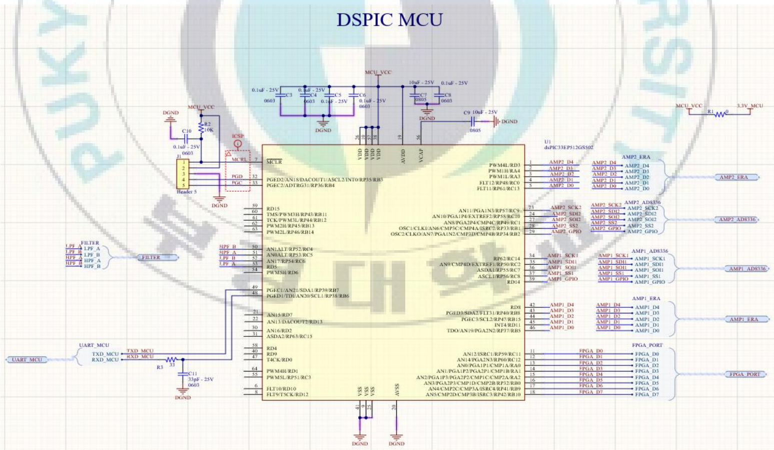

Figure 5: Schematic of dsPIC MCU in controller block

In the controller block, there are 2 IC and they have a different function the controller block. Accordingly, dsPIC gets the requests from a user interface, handles, and responds to that. Then send proper command to FPGA IC, receiver block like choosing gain for amplifier or selecting a filter. Next, the FPGA IC has the task receive the command from dsPIC IC then send the command to the control pulser chip

(STHV748). Because each channel in Pulser block should be excited to the transducer or collect the echo signal simultaneously in some applications using transducer together as well as adjust minimum pulse width, and so it needs the high speed, parallel processing IC like FPGA. In this board, the FPGA is used in the Spartan 6 family. Besides, Spartan 6 family IC also controls the trigger block to select between the external trigger and internal trigger.

1.3.3 Pulser block

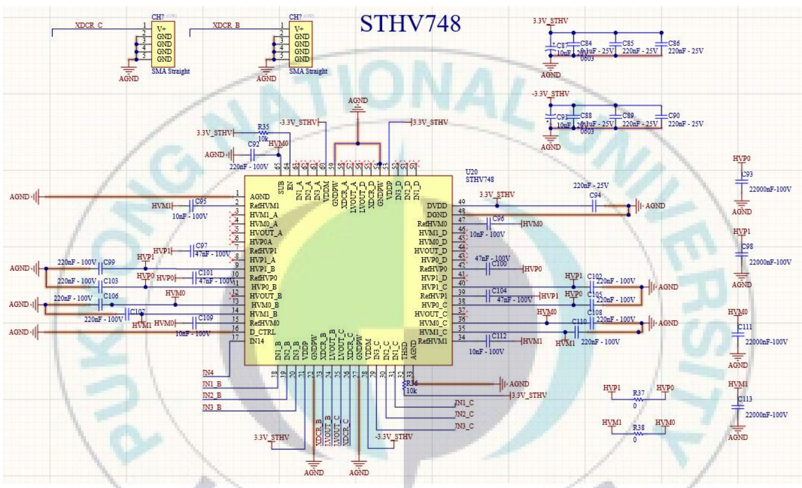

Figure 6: Schematic for pulser IC - STHV748

In pulser block, the STHV748 was utilized, its applications are applied in some fields as medical ultrasound imaging, pulse waveform generators, NDT ultrasound transmission, and piezoelectric transducer drivers. It is a monolithic, high-voltage, high-speed pulser generator that features four independent channels. It is designed for medical ultrasound imaging applications, but it can also be used to drive capacitive or MEMS-based transducers, piezoelectric. The STHV748 comprises a controller logic interface circuit, level translators, MOSFET gate drivers, noise-blocking diodes, and high-power P-channel and N-channel MOSFETs as the output stage for each channel, clamping to-ground circuitry, anti-leakage, anti-memory effect block, thermal sensor, and a T/R switch which guarantees an effective decoupling during the transmission phase. Moreover, the STHV748 includes self-biasing and thermal shutdown blocks. The output stage of each channel is able to provide ±2 A peak output current. On one STHV748, it has 4 channels. In order to control 4 channels, there are 4 bit-control signals (IN1, IN2, IN3, IN4).

1.3.4 Trigger block

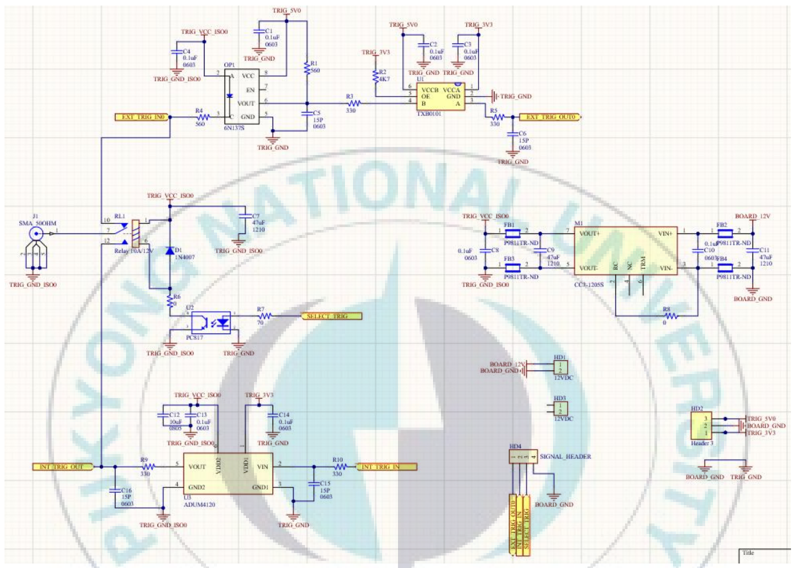

Figure 7: Schematic of trigger block

Trigger block works with 2 modes: external trigger and internal trigger. It transmits or receives a square wave signal outside at approximately 5V. At external trigger mode, it receives the trigger signal from an external device to FPGA IC in the control block. At internal mode is the opposite, the signal comes from FPGA IC to an external device. In addition, because the signal from FPGA IC is square wave 3V and signal from an external device is square wave 5V, so trigger block also has a mission to isolate and convert the signal from FPGA IC to external device as well as from external device to FPGA IC.

1.3.5 Receiver block

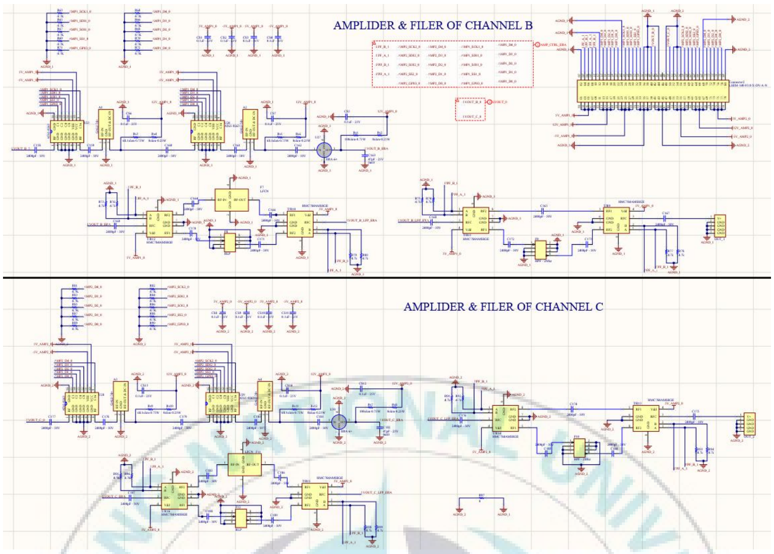

Figure 8: Schematic of receiver block

The echo from the transducer after exciting by high voltage normally has an unsignificant voltage value (< 50mV). For this reason, they need to be amplified to, increase signal value, help the processed signal conveniently. In the receiver block, it includes the amplifier part and filter. Firstly, the amplifier part allows the user to configure the gain from -11 to 51dB using 10 bits-control signals. Each channel comprises 3 fixed-gain amplifiers and 2 digital attenuators. Secondly, the filter part can be selectable with 2 options for low pass filter (LPF) and high pass filter (HPF). The mission of a filter part is to make increase signal to noise. All used filters are LC passive types and belong to the elliptic model. At low pass filter has 100MHz and 300MHz and at high pass filter has 0MHz and 2MHz.

1.3.6 Communication block

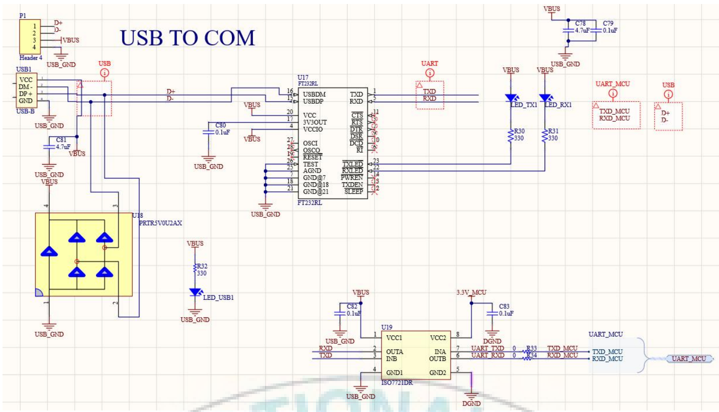

Figure 9: Schematic of communication block

In this block, data or command from the user software will come there by USB interface and need to convert to UART interface to communicate with the control block. For this reason, the FT232R USB UART IC is the main component, it is a USB to serial UART interface with many advanced features. In addition, a dual channels digital isolation IC was also used to isolate between the ground of the communication block and the ground of the control block.

1.3.7 High voltage DC-DC block

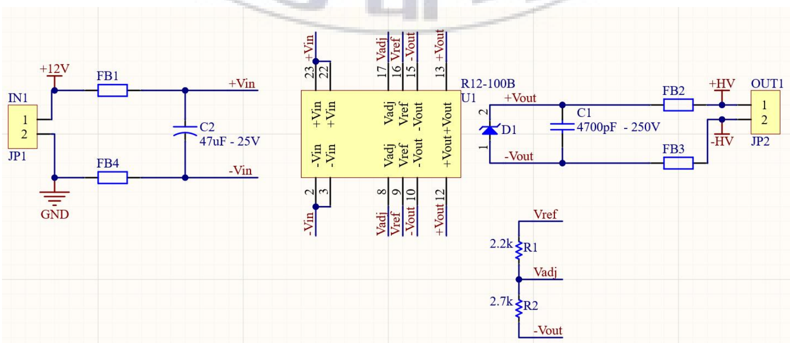

Figure 10: Schematic of high voltage DC-DC block

The high voltage DC-DC block was used a DC-DC module with an efficiency of 82%. The heart of this block is R12-100 DC-DC converters, it is 5W regulated high output voltage isolated DC/DC converters. The adjustable output voltage has ranges from 50 to 135V and the input range is 10 – 14V. The max output power can be 5W. The output can be changed by setting the proper resistor for a module. In this design, to get the highest voltage to excite transducer, meaning while keeping safe and stable for pulser IC, the selected output voltage is positive 81V.

1.4 Printed circuit board (PCB) design

In order to design the printed circuit board, the Altium Designer software is utilized.

In the printed circuit board (PCB) of portable digital-controlled ultrasonic pulser-receiver 2 channels, the power supply block, controller block, pulser block, USB communication block were designed on the same board, and it's called "mainboard". This PCB was made in 8 layers. The trigger block, high voltage DC-DC block, and receiver block were designed on separate boards. Only trigger block, high voltage block was made with 2 layers, the remaining blocks were made with 8 layers.

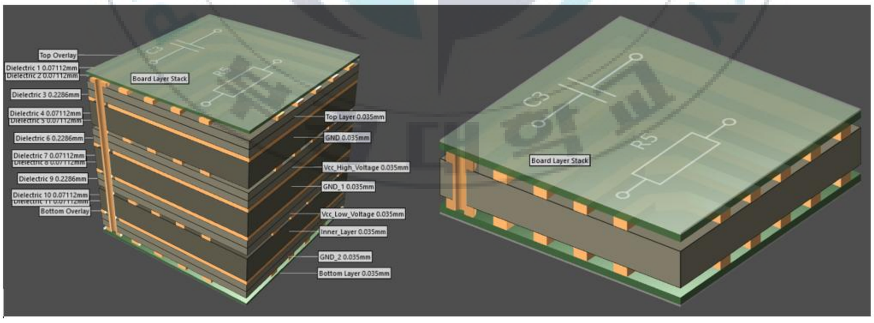

Figure 11: Layer stack visualizer with 8 layers (left) and 2 layers (right)

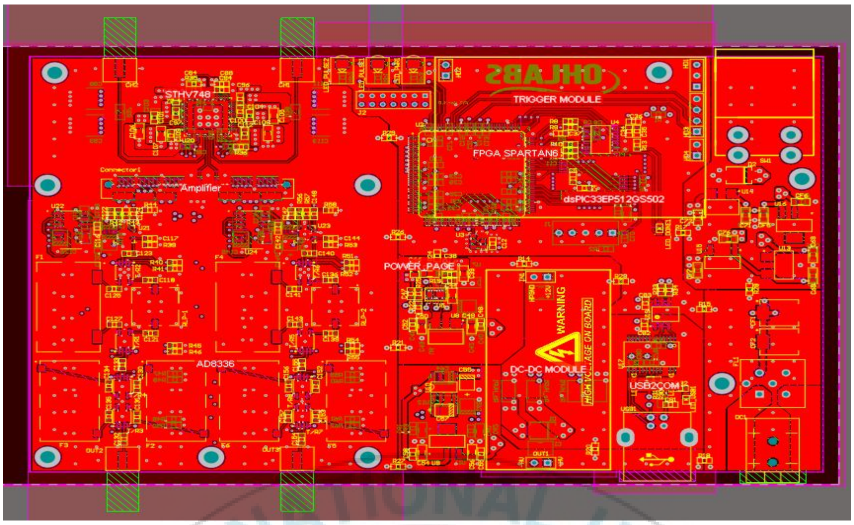

Figure 12: 2D view of main board

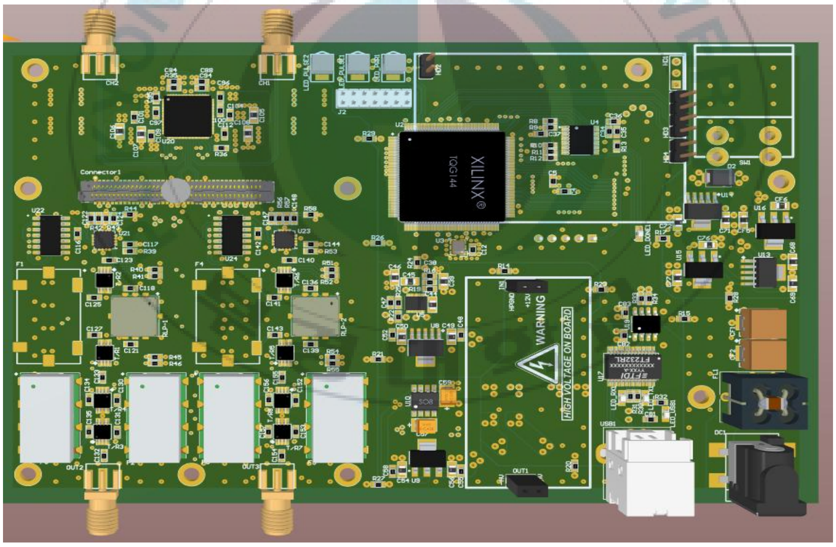

Figure 13: The 3D view of main board

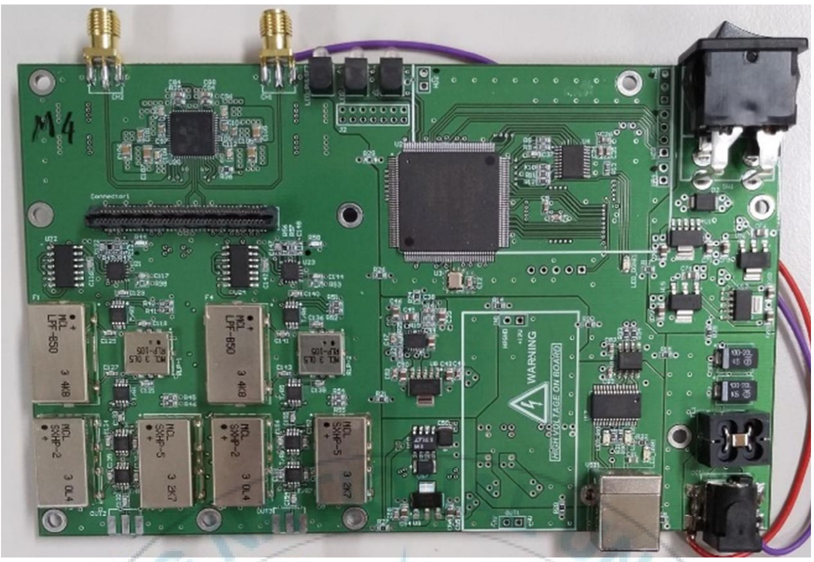

Figure 14: The actual photo of main board

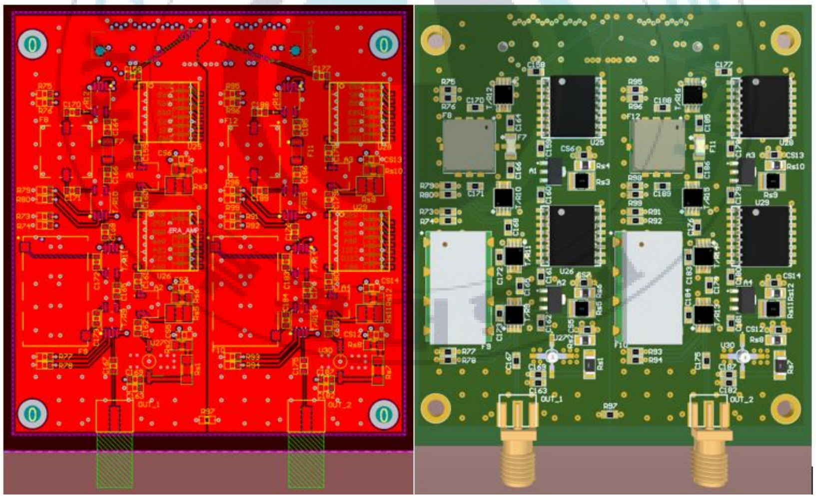

Figure 15: 2D view of amplifier (left), 3D view of amplifier (right)

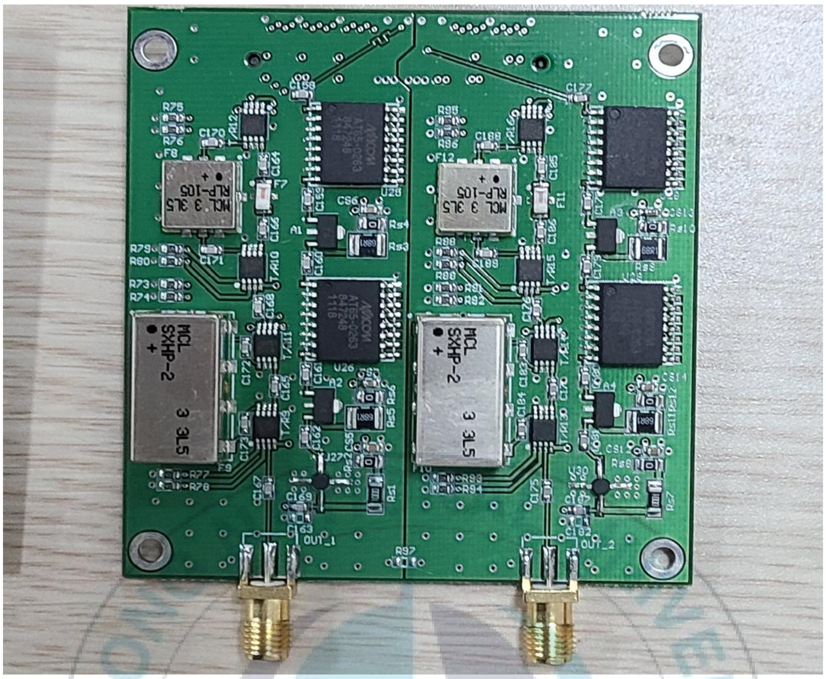

Figure 16: Actual photo of amplifier board

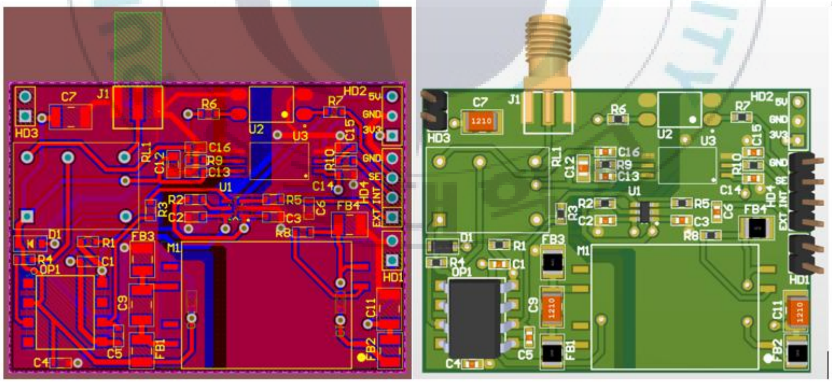

Figure 17: 2D view of trigger (left) and 3D view of trigger (right)

Figure 18: Actual photo of trigger board

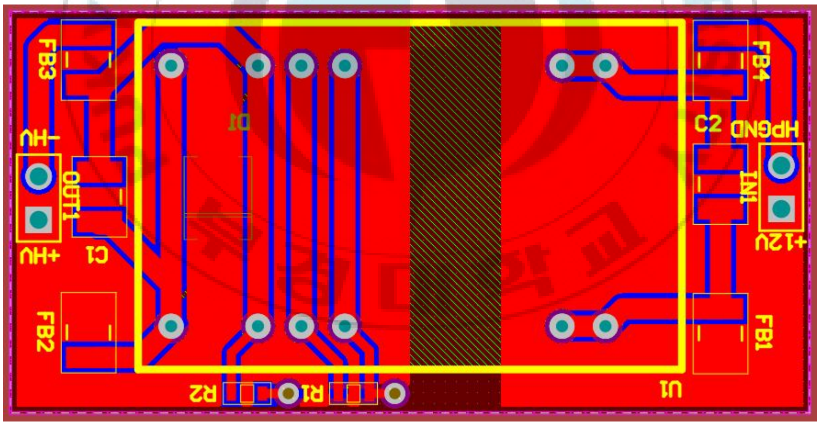

Figure 19: 2D view of high voltage DC - DC board

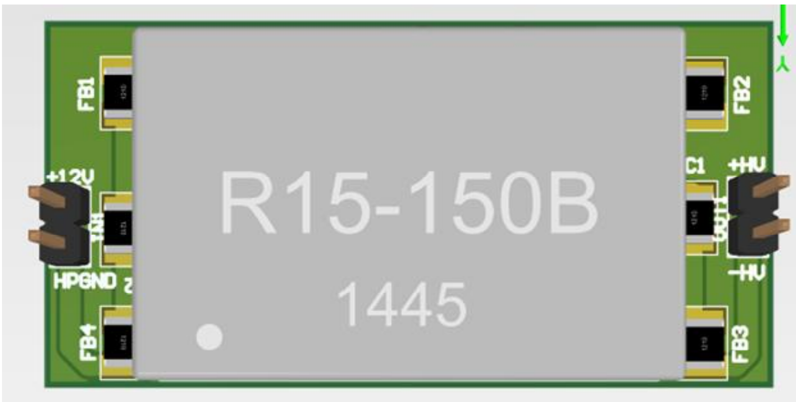

Figure 20: 3D view of high voltage DC-DC board

Figure 21: Actual photo of high voltage DC-DC

Figure 22: Actual phot of all board

Chapter 2 : Applying ultrasonic pulser-receiver device in S.A.M system using Robot Arm

2.1 Circuit test

In the S.A.M system using a robot arm, this application utilized two pulser-receiver boards, each board has 2 channels. To fulfill the standard of this project, it has to be satisfied with 2 basic criteria: 1, Four channels of a device can work independently; 2, Bandwidth of device is 300MHz.

2.1.1 Experiment 1: Four channels of device can work independently

2.1.1.1 Describe the experiment 1

Firstly, the experiment needs 2 measurement requirements: A function generator and oscilloscope. Next, 4 focused transducer was selected. The way to set up measurement equipment, transducers with 2 pulser receivers in the below figure.

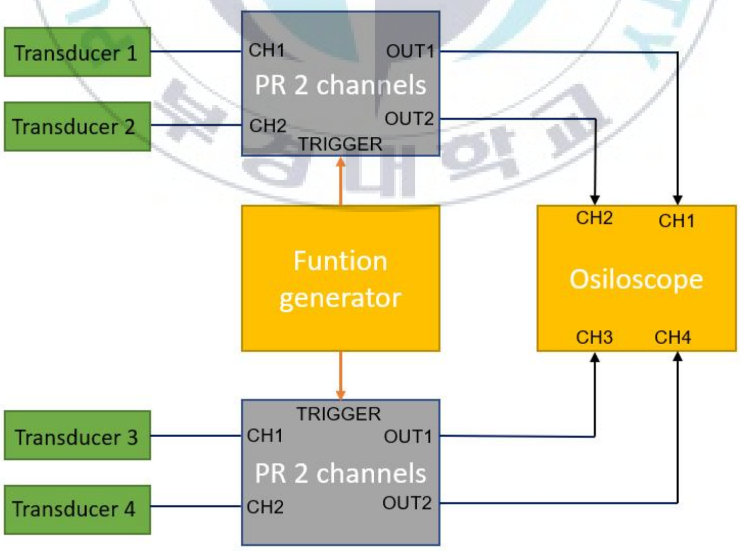

Figure 23: The block diagram of experiment 1

The 2kHz square trigger from Function generator come to 2 board to make them operate simultaneously. Then, 4 channels of 2 boards operating in echo-mode will excite 4 transducers contemporaneously. Because 4 focused transducers did not immersion in the water so only 4 delay line signals from these transducers would back to pulser-receivers and be displayed on the oscilloscope.

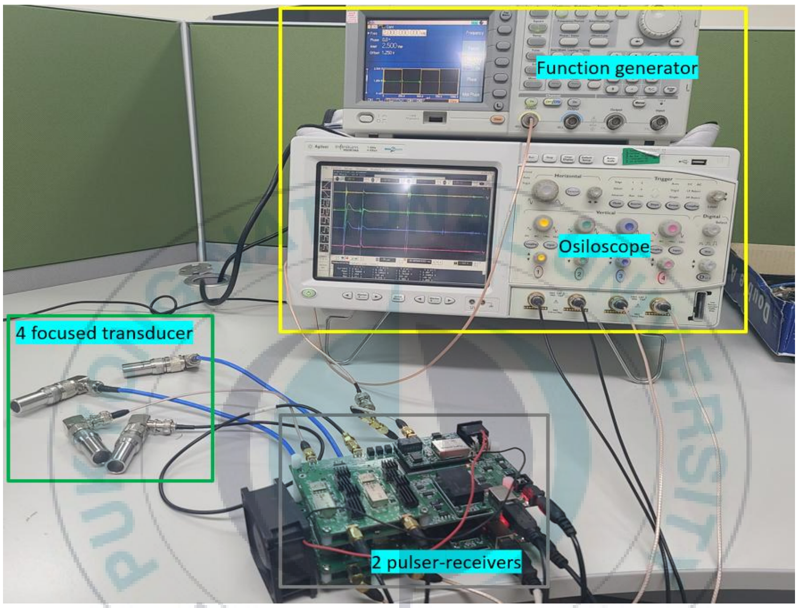

Figure 24: Setup the experiments with transducers and measurement equipment

2.1.1.2 The result of the experiment 1

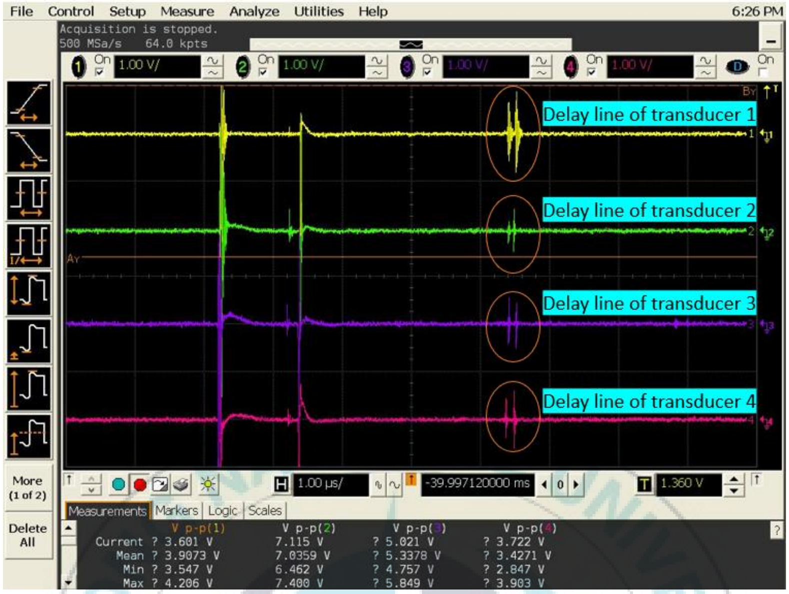

Figure 25: Delay line signal from signal from 4 focused transducers

In the figure 25, delay line signal of transducers from 4 channels of pulser receivers were display on oscilloscope independently. Indeed, due to the difference transducers, so the delay line signal amplitudes of transducer were also not the same (Figure 26).

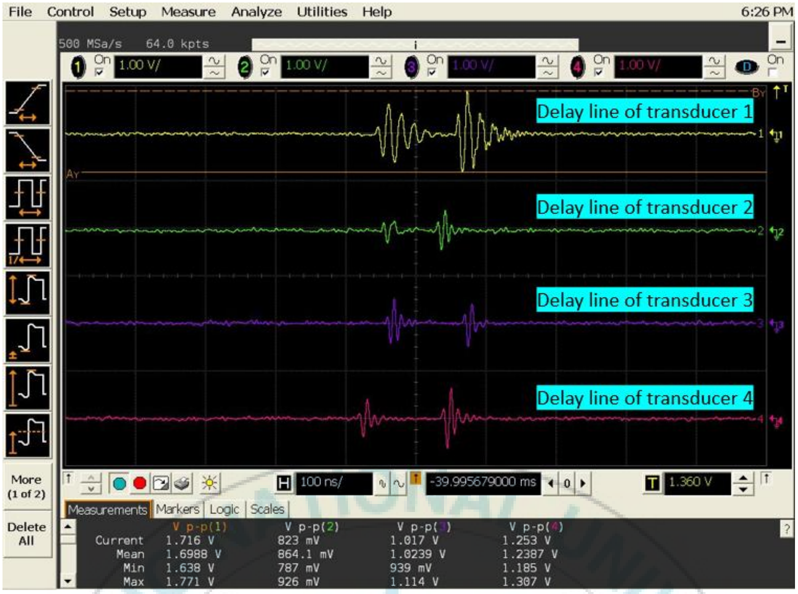

Figure 26: The different signal amplitude from 4 focused transducers

The pulser-receivers allow to control gain of each channel individually. After changing the gain of the channels, the amplitude of signal had approximate value (Figure 27).

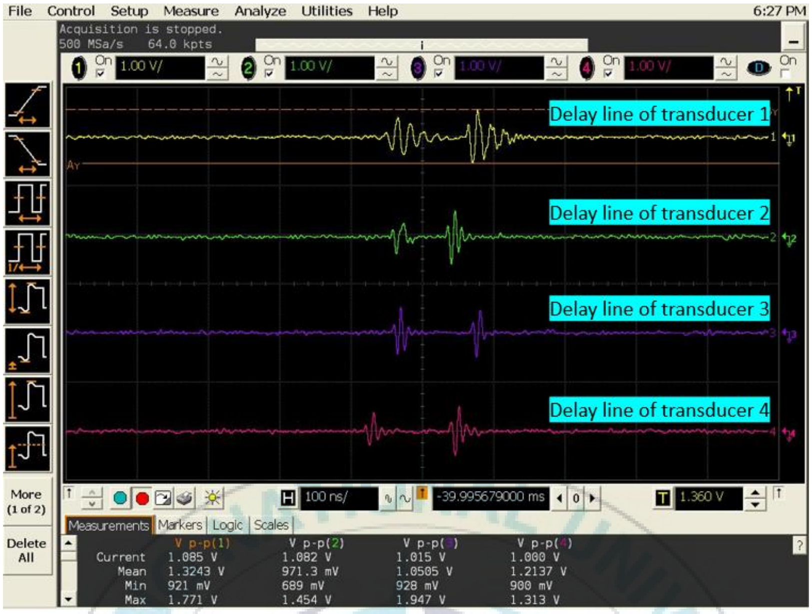

Figure 27: The signal amplitude after adjusting gain on each channel.

In conclusion, 4 channels of pulser-receiver not only can work independently but also the gain of each channel can adjust independently.

2.1.2 Experiment 2: Bandwidth of device is 300MHz

The objective of this experiment is to demonstrate the signal within a range of 300MHz can pass through this device without distortion and decrease significantly.

2.1.2.1 Describe the experiment 2

This experiment needs function generator and oscilloscope, the setup will be handled like the Figure 28.

Figure 28: The block diagram of experiment 2

To check the 300MHz bandwidth, the function generator creates the sine wave to pulser-receiver with amplitude 500mV, the value of frequency is 50, 110, 220, 330MHz respectively. The pulser-receiver at this time was used through mode, which means the channels only receiver the signal. The oscilloscope receiver the signal comes out pulser receiver then display it on time domain and frequency domain. Scale on frequency domain in oscilloscope was be selected 250MHz center frequency, 500MHz span.

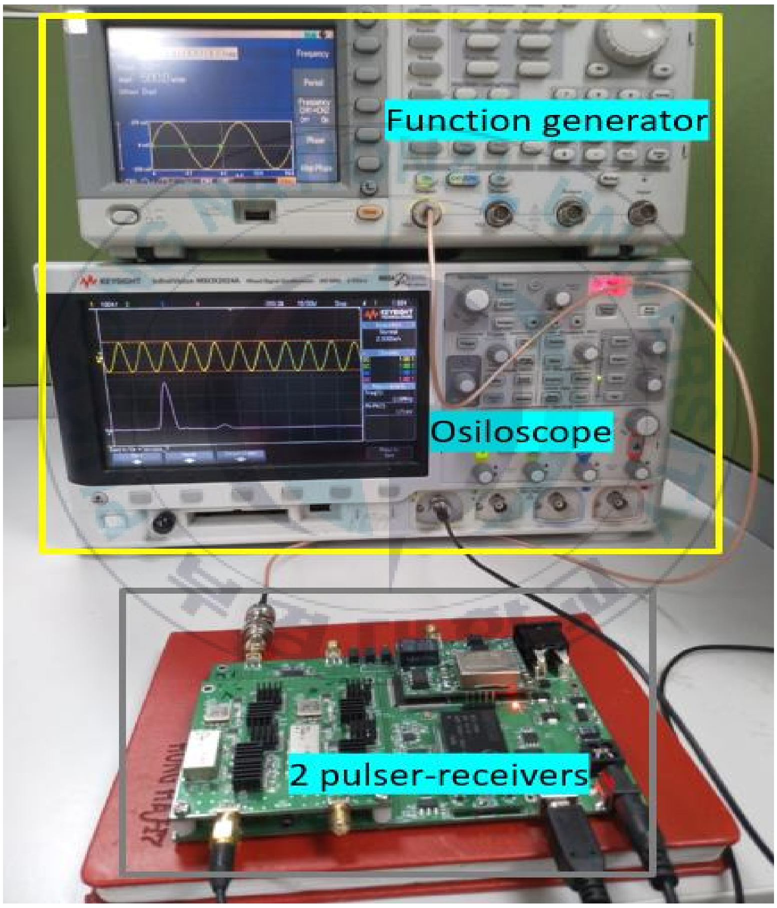

Figure 29: Setup the experiments measurement equipment

2.1.2.2 The result of the experiment 2

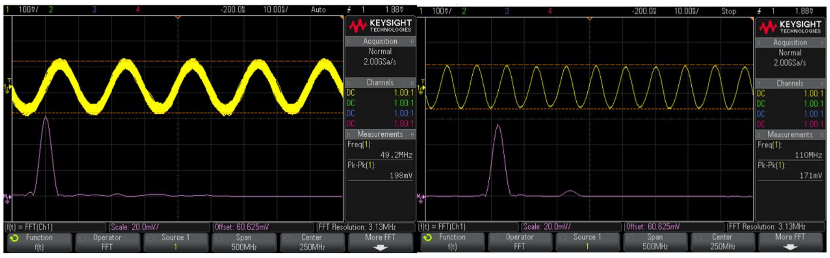

Figure 30: Signal come out from pulser-receivers with input 50MHz (left) and input 110MHz (right)

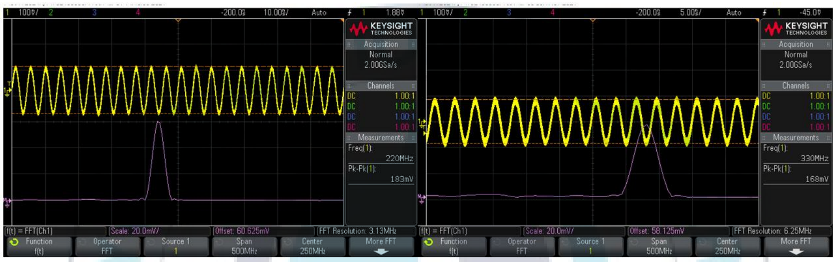

Figure 31: Signal come out from pulser-receivers with input 220MHz (left) and 330MHz (right).

From figure 30 and figure 31, the yellow signals were the sine signal in a time domain and the purple was the sine signal in the frequency domain. The signals with the frequency 50, 110, 220, 330MHz come out pulser-receiver not changing about the frequency value on frequency domain in an oscilloscope. They had not the distortion, the amplitudes of different signals had not so much changed. And although they had the decrease due to attenuate on component and signal path they could increase by the amplifier onboard.

In conclusion, the pulser-receiver has the ability to allow signal pass through in the bandwidth 300MHz.

2.2 Result from S.A.M system using Robot Arm

2.2.1 Introduction about S.A.M system using Robot Arm

At this project, the primary goal is to inspect the round cylinder metal by non-destructive testing (NDT). The system includes a lot of elements and there are main parts: stepper motor, motor trigger board, robot arm, digitizer, ultrasonic transducer, pulser-receiver, and monitor.

The system requires a robot arm to support a portable pulser-receiver for moving to determined positions. The robot arm is manufactured in South Korea, it is named RB5-850 with a payload of 5kg, range of 850mm.

Figure 32: The specification of rainbow robot: RB5-850

The process that scans a round cylinder metal happens as follows. Firstly, a trigger from the P/R device (internal trigger) creates to trigger digitizer for A-scan data acquisition. The screen will display an echo signal on LABVIEW software. After observing the signal, the operator will adjust the robot arm's position to fulfill the scanning requirement or can be called:" Align transducers". Next, when the echo signal is satisfied, the trigger from the motor trigger board is generated to synchronize the working of the P/R device and digitizer. The pulse rate frequency (PRF) of the P/R device now follows the trigger frequency of the motor trigger board. The round cylinder metal is rounded, and the robot arm goes alongside the metal bar to inspect. Finally, the whole image of the phantom is displayed LABVIEW screen.

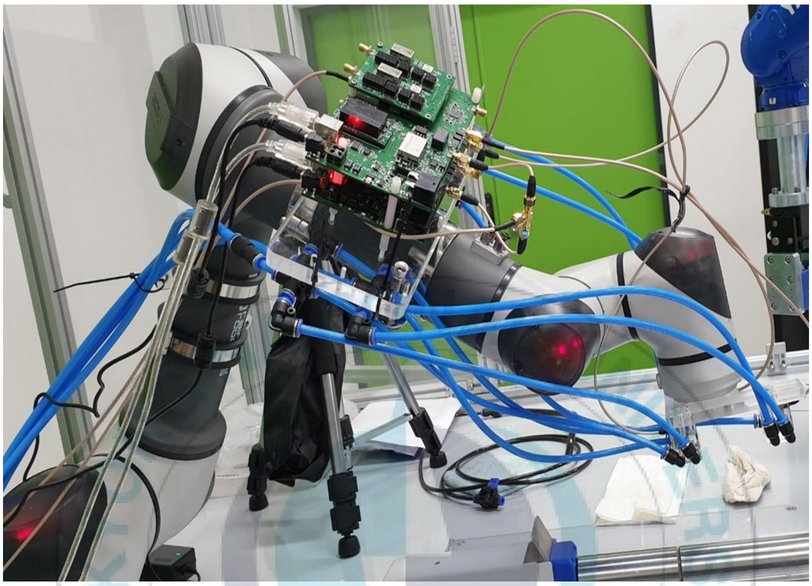

Figure 33: 2 ultrasound P/R devices attached on RB5-850

2.2.2 Acoustic imaging result from robot scanning system.

Figure 34: The aucostic imagining result of metal bar

The above figure shows the acoustic imagine after 2 minutes scanning. The back color inside circle expresses that the acoustic wave goes through without reflection, while the red color shows us that acoustic wave is reflected back to transducer or indicate the cracks of sample.

Chapter 3 : Discussion and conclusion

In previous chapters, a design of portable, costly digital-controlled ultrasonic pulser-receiver 2 channels has been presented and been applied in S.A.M system using a robot arm. Currently, the device has 2 channels along with the maximum exciting voltage is under 100V, and the bandwidth of the device is 300MHz; the device has gained from -11 to 51dB, selectable low pass filter 300MHz vs 100MHz, and selectable high pass filter 0MHz vs 2MHz. With the developing orientation of the device in the future, we hope to enhance exciting voltage up to 300V and more alternatives for filters in both high pass side and low pass side and using more advanced ICs having low power consumption and low noise.

Ultimately, a digital-controlled ultrasonic pulser-receiver 2 channels is developed and tested in a real S.A.M system practically. While scanning process, transducer is excited with proper pulse width and high voltage, reflected signal onboard is filtered and adjust suitable gain based on MCU, FPGA with control panel software on PC.

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Korean Abstract

휴대용 2 채널 디지털 제어 초음파 펄스 수신기 설계

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요약

초음파는 사람의 청각 한계보다 높은 주파수를 가진 음파로 의학, 제품 또는 구조의 비파괴 검사 시스템 등과 같이 여러 분야에서 사용된다. 초음파 시스템의 가장 중요한 부분 중 하나는 초음파 펄스 수신기로, 이는 비파괴 검사 (NDT) 응용 프로그램과 같은 범용 초음파 검사 뿐 아니라 초음파 이미징을 위해 설계된 장비다. 펄서는 나노 초에 최대 81V 의 고전압을 생성할 수 있으며, 수신기는 초 저잡음, 가변 이득 제어 증폭기 및 고역 통과 필터 (HPF) 및 저역 통과 필터 (LPF)를 모두 포함해 선택 가능한 필터를 포함하는 300MHz 대역폭을 가진다. 본 연구에서 언급하는 장치는 장시간 사용을 위해 PC 의 소프트웨어에 의해 디지털 제어되는 휴대용 경량으로 설계되었다.