

Ultrasound Brain Imaging System

Group Dec13-01 Members:

Zach Bertram

Michael McFarland

Maurio McKay

Jonathan Runchey

Client/Advisor:

Dr. Bigelow

Project Overview

- Pulse Echo Ultrasound for brain imaging
- Cheap and portable alternative to fMRI
- Ability to send pulses over 512 channels
- Ability to increase gain to view different regions of the brain
- Viewable image from PC

Our Mission

- 8 channel transmit/receive PCB
- Interfaceable with NI PXI system
- Usable with transducer
- Scalable to 512 channels

Functional Requirement

- Generate 1 MHz pulses
- Send +/-50 V pulses to transducer
- Transmit : 8 channels
- Receive : 8 channels
- LNA gain of 40 dB
- Protection circuit that limits output voltage to 2 V_{pp}

Nonfunctional Requirements

- Board size below 60 in²
 - In order to reduce cost
 - To reduce complexity
- Well documented PCB design
 - For easier troubleshooting and repair

Challenges

- No previous experience soldering high pin density SMT parts
- High individual IC costs
- No previous PCB design experience

National Instruments System

- Will be computer interface for system
- Not yet ordered

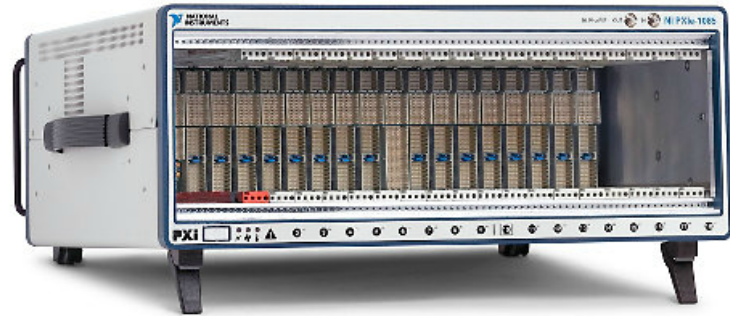
NI PXI-7811R



NI 5752

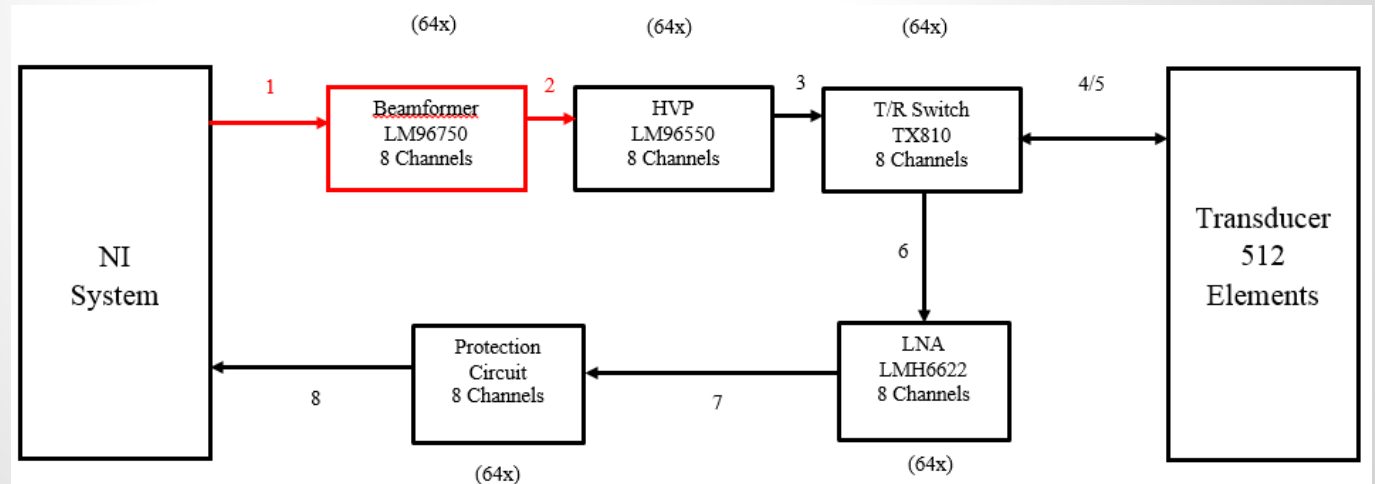


18 Slot NI PXI Chassis



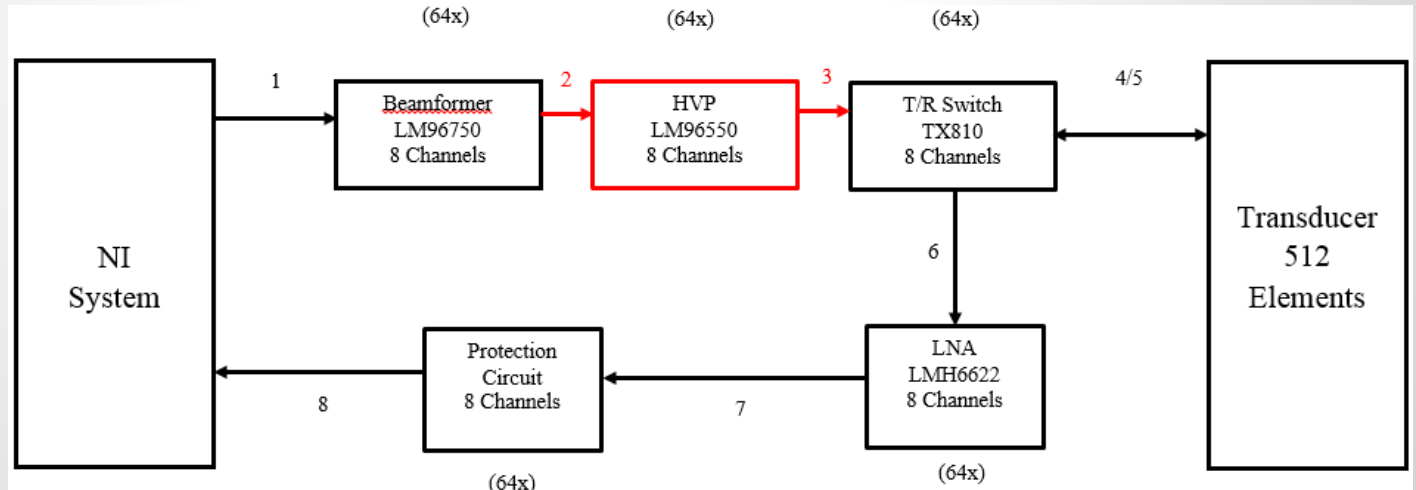
Beamformer(LM96570)

- Provides a serial interface to control the high voltage pulser
- Reduces required Input channels to control pulser from 18 to 9



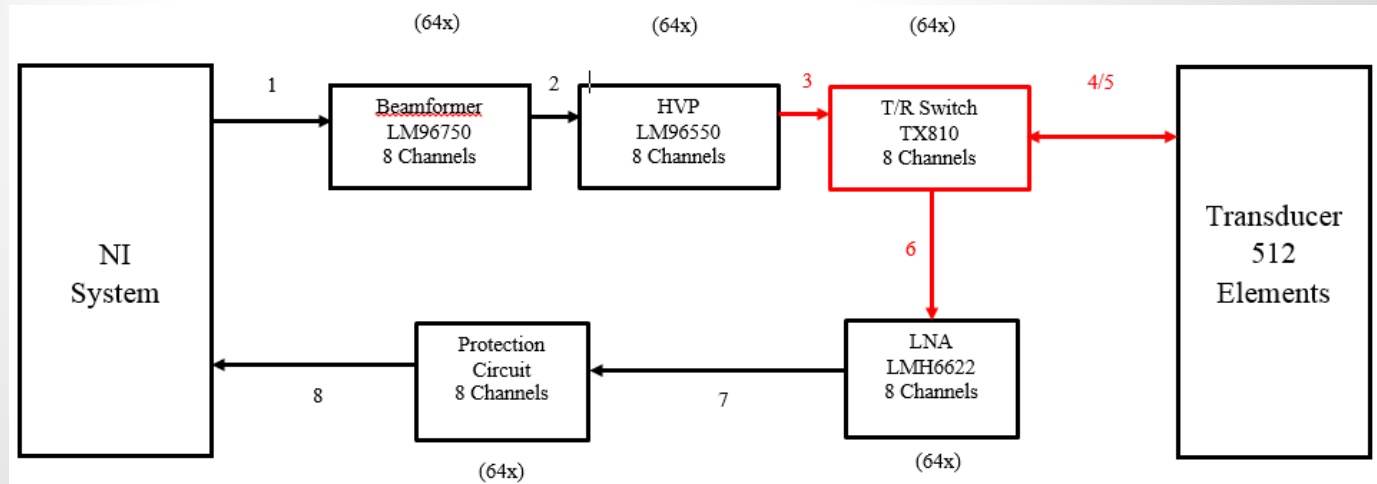
High Voltage Pulser(LM96550)

- Controlled by the Beamformer
- Sends +/-50 V pulses to transducer



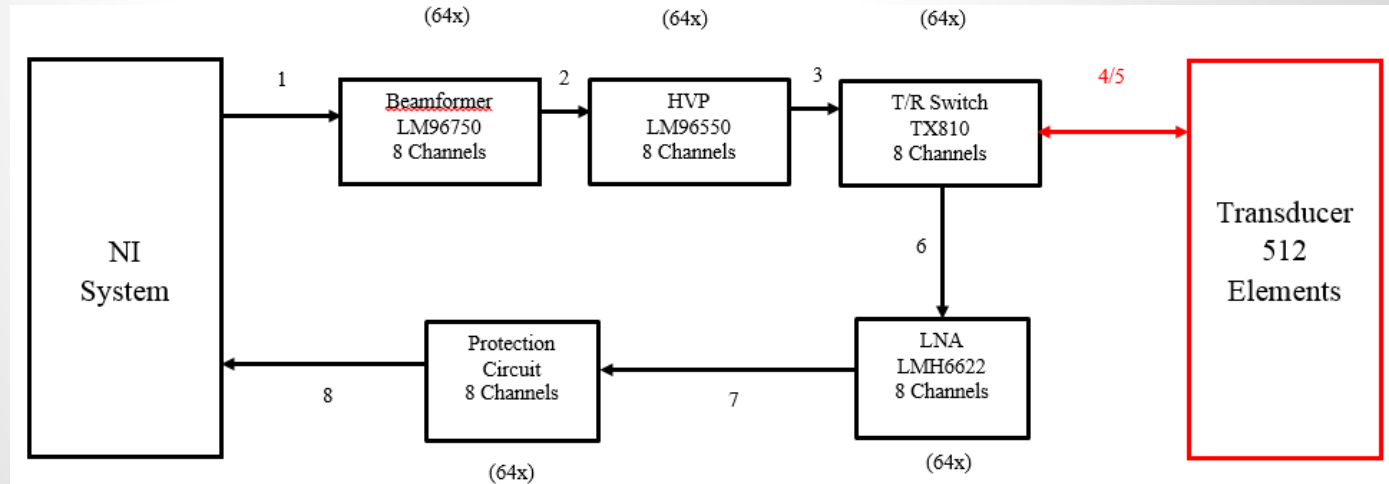
T/R switch(TX810)

- Protects receive circuitry from 50 V pulses
- Output voltage limited to 2 Vpp



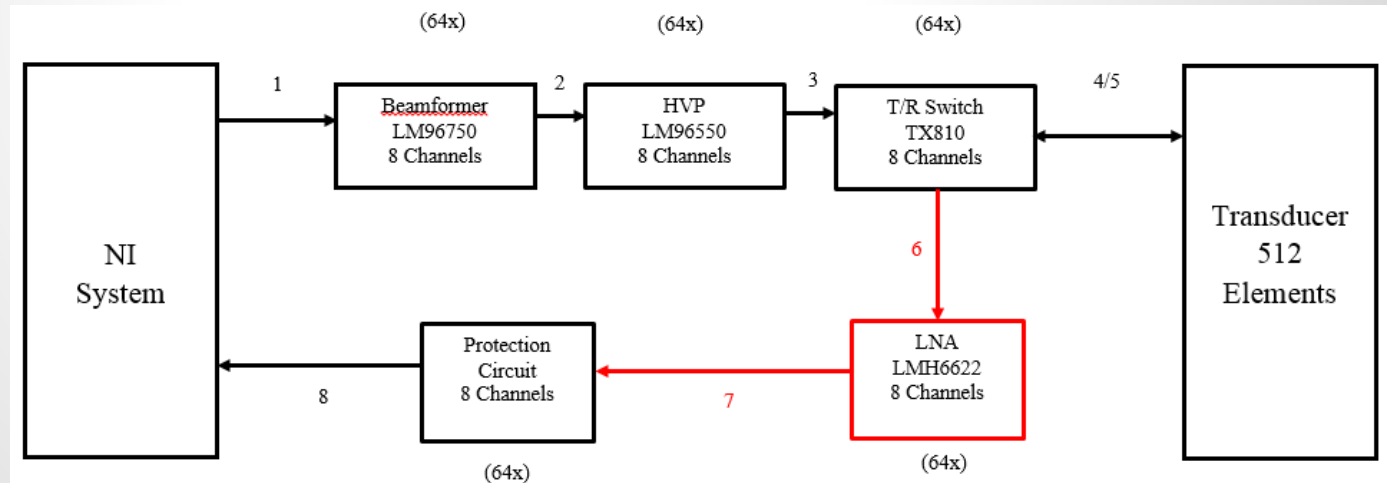
Transducer

- 512 Linear Array
- Converts high voltage pulses(± 50 V) to ultrasonic waves to transmit into body



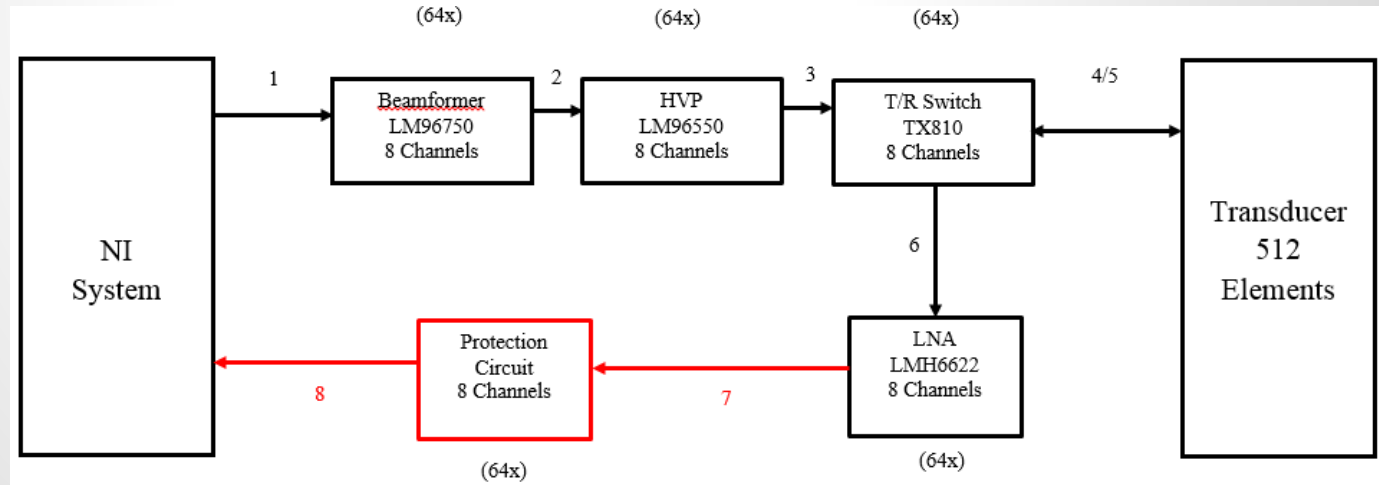
Low Noise Amplifier(LMH6622)

- High Gain Bandwidth (160 MHz)
- Low noise floor ($1.6 \text{ nV-Hz}^{-1/2}$)



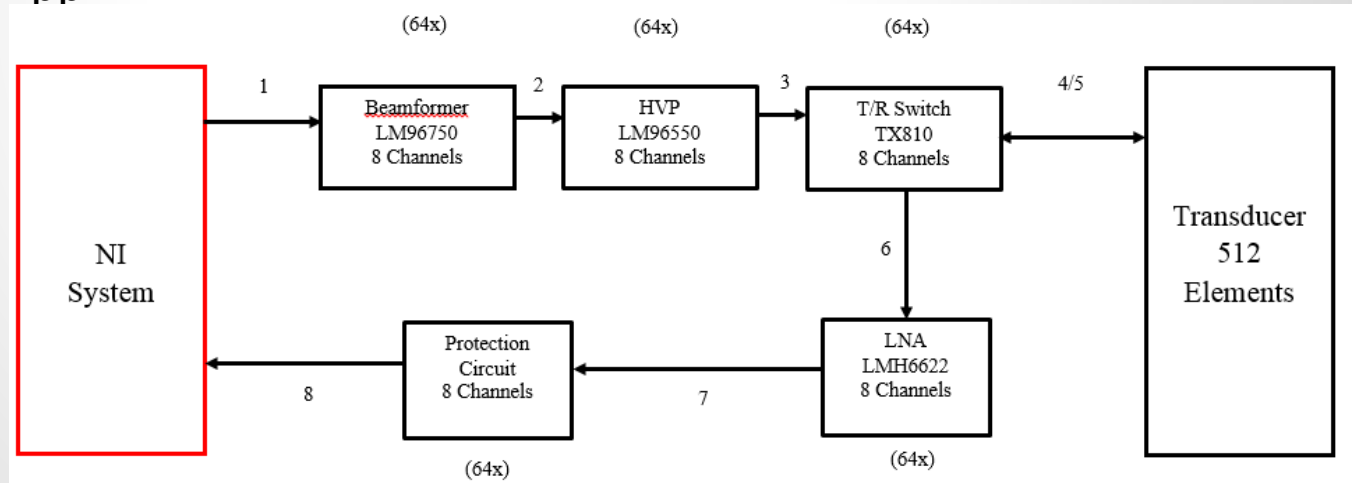
Op Amp Protection Circuit

- Limit output voltage to 2 Vpp
- Lets signals under 2 Vpp pass unattenuated



NI-5752 Module

- 32 Analog receive channels
- Contains TI-AFE5801 analog front end
 - Variable gain range -5 dB-31dB
 - 12-bit A/D converter
- Max input 2 Vpp

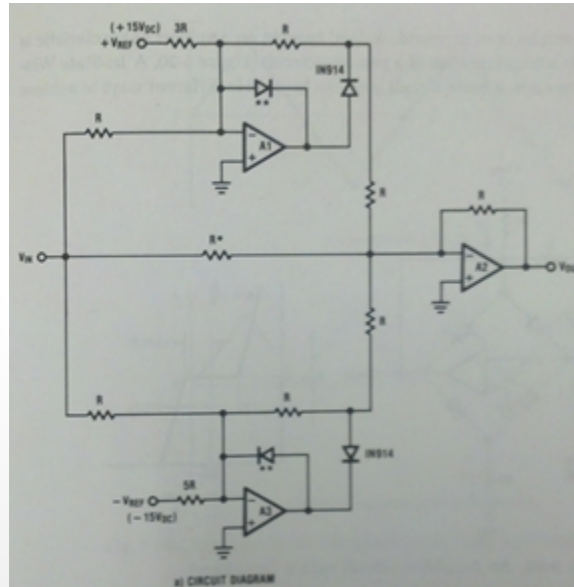


Protection Circuit

- At the start of this semester our client requested we make a protection circuit
 - To protect the NI-5752 module
 - Limits voltage to 2 Vpp

Protection Circuit Solution

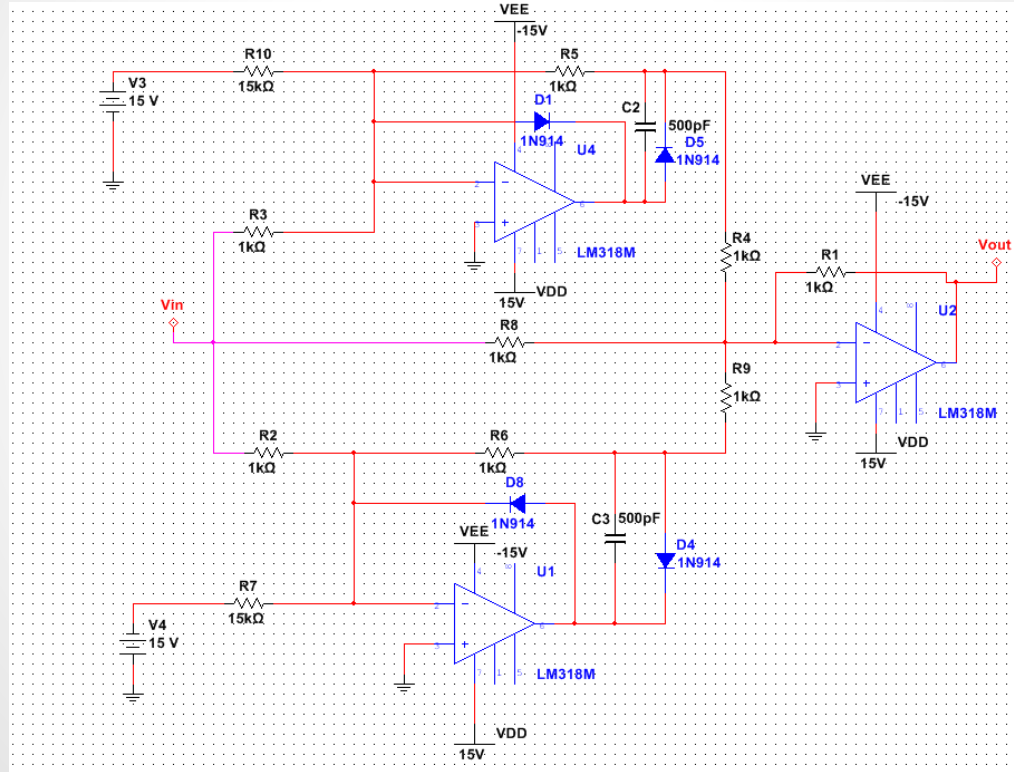
- Decided to use the following bounding circuit:



Protection Circuit Challenges

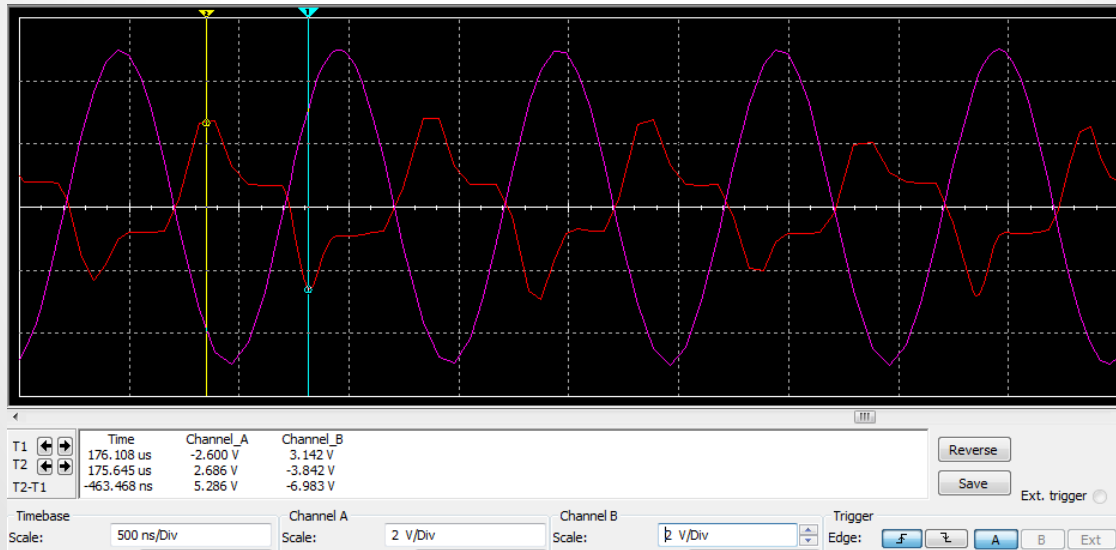
- Difficulties in analysis of the circuit
- Unexpected behavior in simulation
 - Resolved by reducing diode capacitance
 - Added a capacitor to bypass diode at high frequencies

Protection Circuit



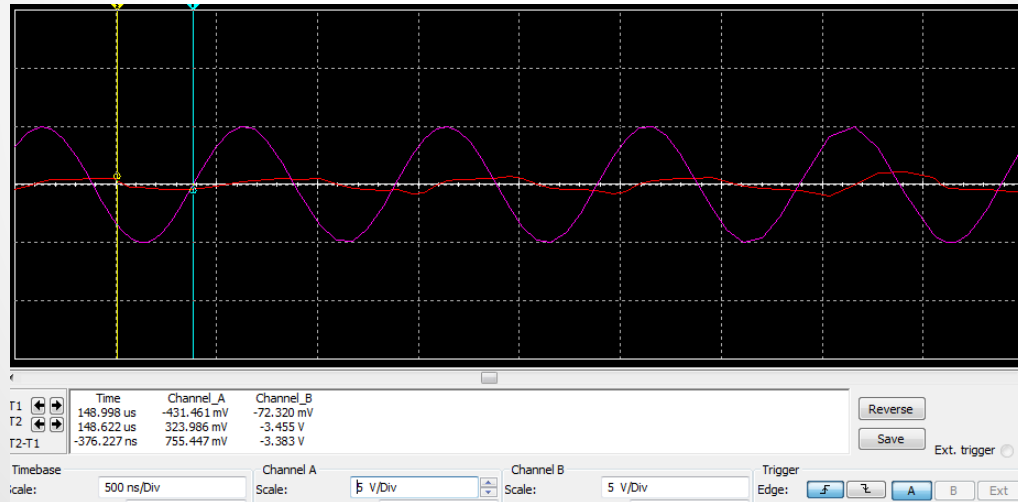
Simulation Results: Non-Working Model

- Input 5 Vpp
- Output exceeds 2 Vpp

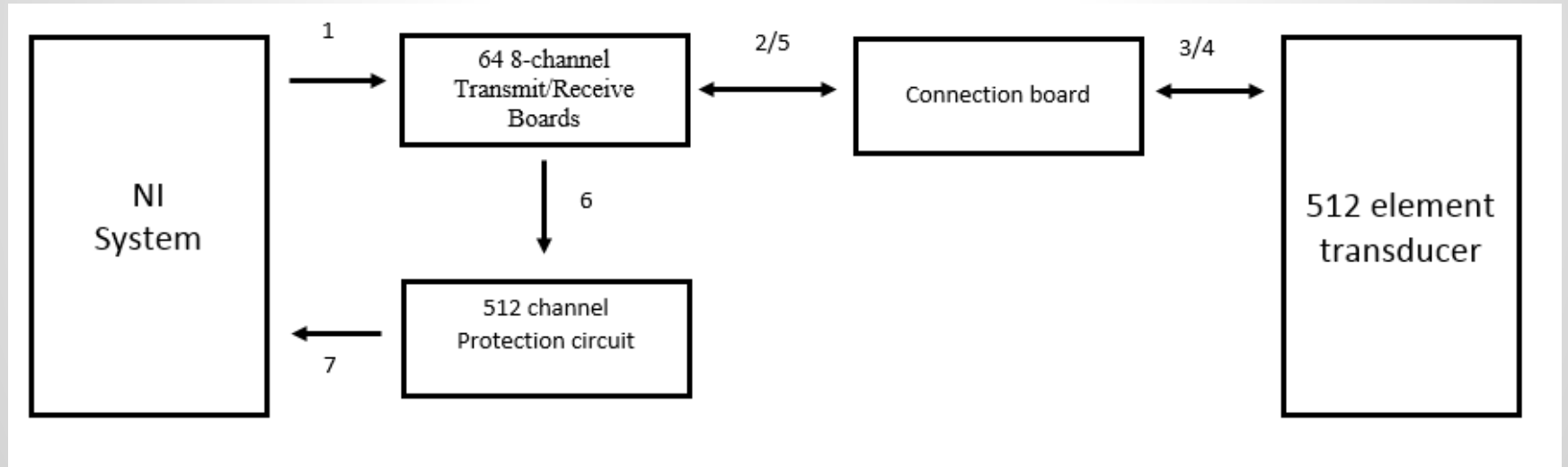


Simulation Results: Working Model

- Input of 5 Vpp
- Output never exceeds 2 Vpp

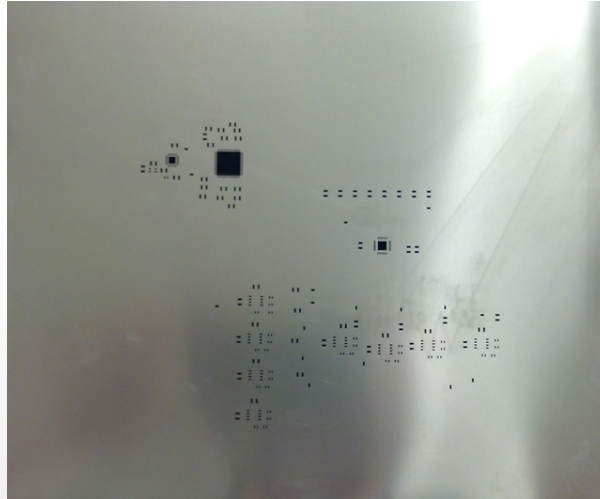


Final Board Layout



PCB soldering

- PCB was ordered with solder mask
- Consulted with electronics tech on how to solder a parts heavy board



PCB soldering

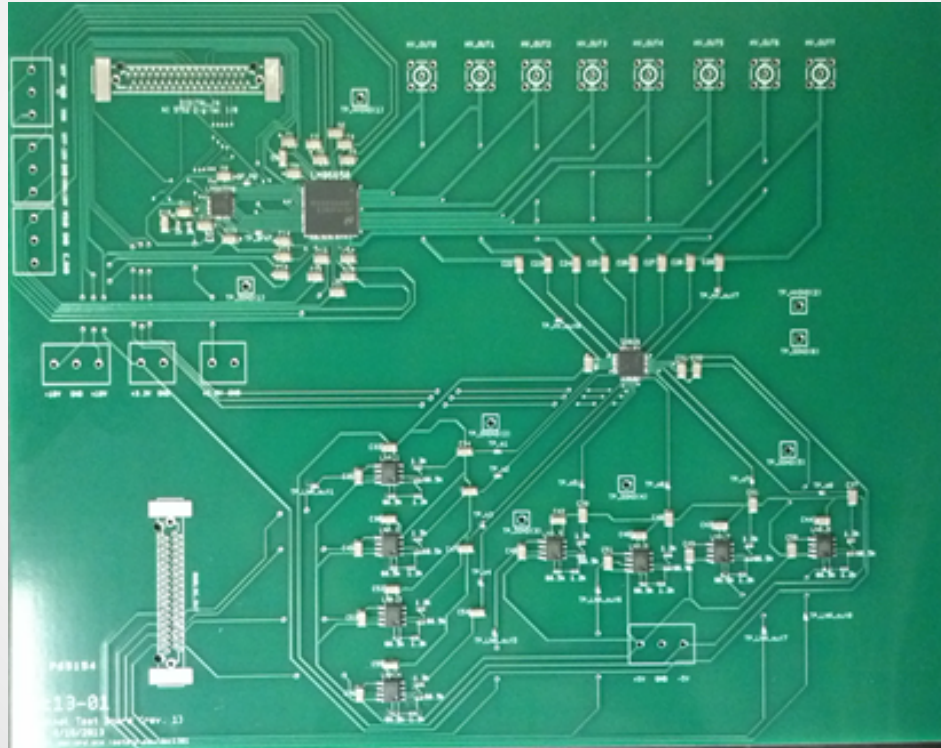
- Board soldered with a preset oven profile and tested



PCB Soldering Challenges

- Challenge
 - LNA, HVP, Beamformer pins were bridged due to high pin density
- Solution
 - Removed by hand with solder wick
 - Increased size of pads for 2nd and 3rd boards

Soldered Test Board



Test Plan

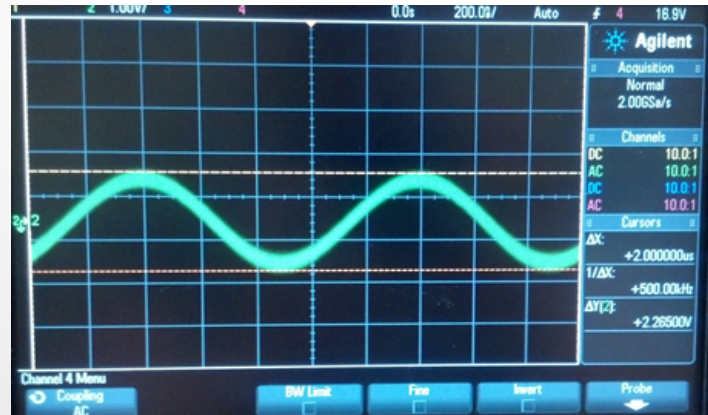
- Start testing 8-channel board
- Testing order:
 - LNA circuit
 - Check for correct gain (40 dB)
 - Verify that the noise level is acceptable
 - Protection Circuit
 - Make sure it limits the output voltage of the LNAs to below 2 Vpp
 - Tx810
 - Make sure the device limits the voltage at its output to 2 Vpp
 - LM96550(HVP)
 - Check that we are able to send a pulse to the SMA pins
 - LM96570
 - Unable to be tested this semester
 - requires NI-PXI system

Test Results Revision 1 PCB: LNA

- LNAs gave unexpected output:
 - Expecting a Gain of 10 V/V
 - First Stage gave an attenuated sine wave output
 - Second stage gave no output

LNA Breadboard Test

- Decided to test on breadboard using test PCB
 - Switched to non-inverting configuration at clients request
- Able to get proper signal on breadboard with a gain of 10 V/V for each stage for the new non-inverting design.
- Input Voltage: 20 mVpp Output voltage: 2.26 Vpp



Test Results Revision 2 PCB: LNA

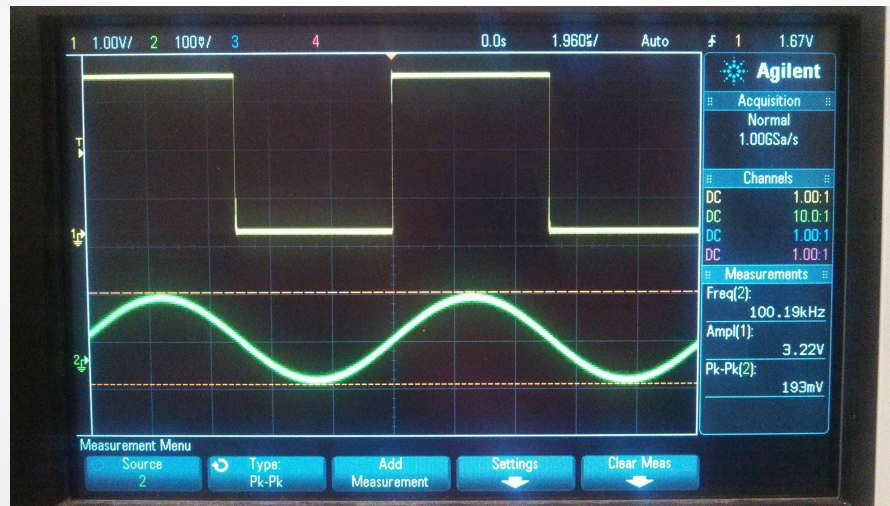
- LNA tests for non-inverting output:
 - Expecting a Gain of 10 V/V
 - No signal at first stage output
 - Upon further investigation found a DC output of -4.07 V
 - No signal at second stage output
 - Same -4.07 V DC output
- Same for all LNAs on the second revision boards
 - Conclusion: error with PCB or soldering procedure

Test Results Revision 1 PCB : TX810

- Worked as expected
 - Limited peak to peak voltage output to 2 V
 - Output waveform retained amplitude for lower voltages
 - Small distortion
 - Output waveform had lost small phase change
- Tx810 burned while trying to test the LNA circuit
 - Most probable cause is a short circuit while trying to resolder and test the LNAs
 - Unable to obtain pictures before we burned the device

Test Results: TX810

- Second stage of testing resulted in proper waveform output.



200mv input wave at 1 MHz

Test Results: TX810

- Successfully working TX810



5v Wave attenuated to ~2 Vpp at 1 MHz

Test Results: LM96550 (High Voltage Pulser)

- Testing of HVP stopped due to chip damages
- All 3 testing phases resulted in burnt chip
- Potential reasons for damage:
 - Unknown PCB error
 - Improper soldering
 - Improper start up sequence

Q & A

Budget for both semesters

Spring Semester 2013					
date purchased	part	part number	quantity	unit price	extended price
4/8/2013	10kohm resistor	P10KGCT-ND	10	0.1	1
4/8/2013	11kohm resistor	P11KGCT-ND	10	0.1	1
4/8/2013	11.5kohm resistor	P11.5KHCT-ND	10	0.1	1
4/8/2013	sma connector	ACX1231-ND	15	3.87	58.05
4/8/2013	High Voltage Pulser	LM96550	5	30.25	151.25
4/8/2013	Beamformer	LM96570SQX/NOPB	5	9.91	49.55
4/12/2013	female connector to transducer	1003-1647-ND	1	265.5	265.5
4/12/2013	VHDCI Connector, 68-Pin, Vertical, PWB Through Hole Mount	780389-01	2	21	42
4/12/2013	1.2kohm resistor	P1.2KGCT-ND	50	0.0092	0.46
4/12/2013	66.5kohm resistor	P66.5KHCT-ND	50	0.0138	0.69
4/18/2013	PCB		1	33	33
4/18/2013	mask		1	130	130
4/26/2013	10kohm resistor	P10KGCT-ND	40	0.1	4
4/26/2013	15kohm resistor	P15KGCT-ND	20	0.1	2
4/26/2013	20kohm resistor	P20KGCT-ND	20	0.1	2
4/26/2013	30kohm resistor	P75KGCT-ND	30	0.1	3
4/26/2013	100kohm resistor	P100KGCT-ND	10	0.1	1
4/26/2013	150kohm resistor	P150KGCT-ND	30	0.1	3
4/26/2013	200kohm resistor	P200KGCT-ND	10	0.1	1
	total				749.5
Fall Semester 2013					
date purchased	part	part number	quantity	unit price	extended price
10/31/2013	low noise op amps	LMH6622MA/NOPB-ND	20	3.195	63.9
11/11/2013	PCB		2	33	66
11/11/2013	mask		1	130	130
11/21/2013	connectors	A34097-ND	6	4.23	25.38
11/21/2013	cables	AE9863-ND	3	5.83	17.49
	total				302.77
	total both semesters				1052.27

Test Board PCB

