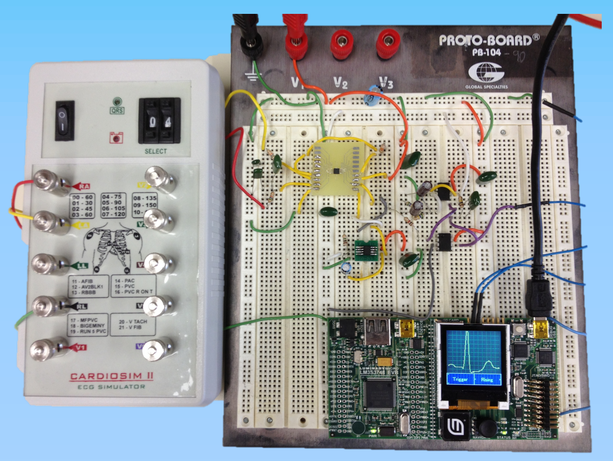
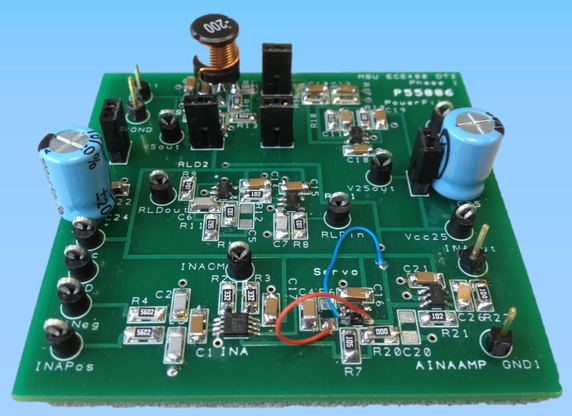
MICHIGAN STATE UNIVERSITY

Electrocardiograph Demonstration Board

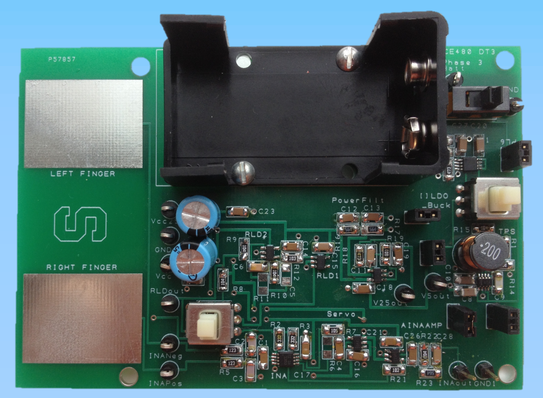
TEXAS INSTRUMENTS



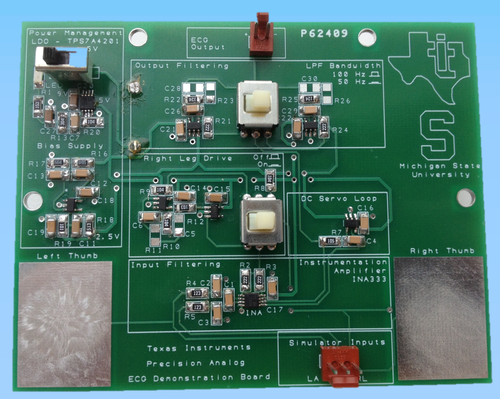
Prototype



Phase 1



Phase 2

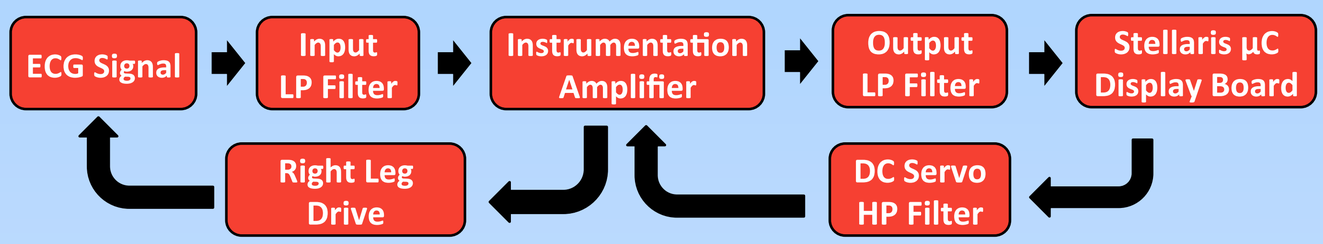


Phase 3

Project Description

The project challenge for the semester was to research, design, fabricate, and test the analog circuitry needed to develop an electrocardiogram (ECG) demonstration board for Texas Instruments (TI). The precision analog group sponsored the project's development throughout the semester. Texas Instruments intends to use the demonstration board to showcase the INA333 instrumentation amp as well as the OPA378 operational amplifier.

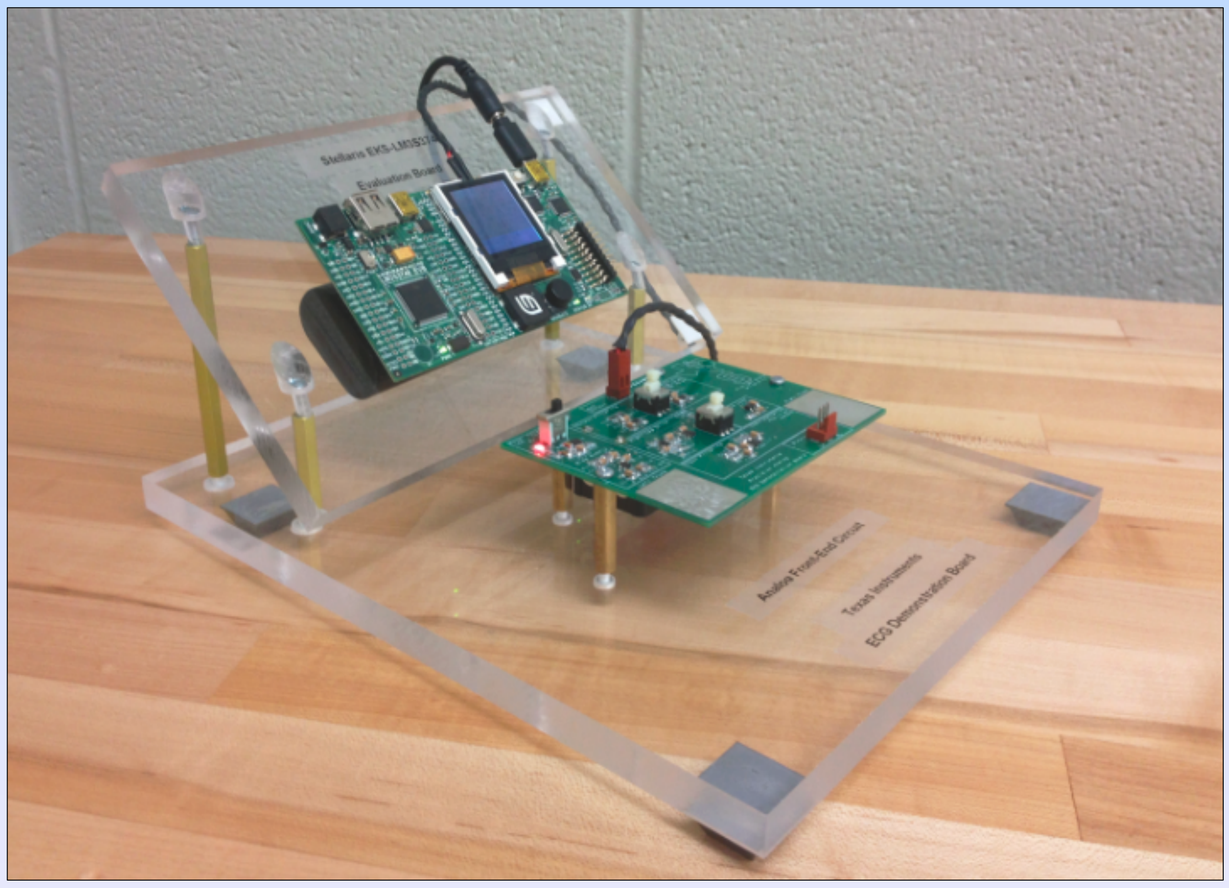
System Block Diagram



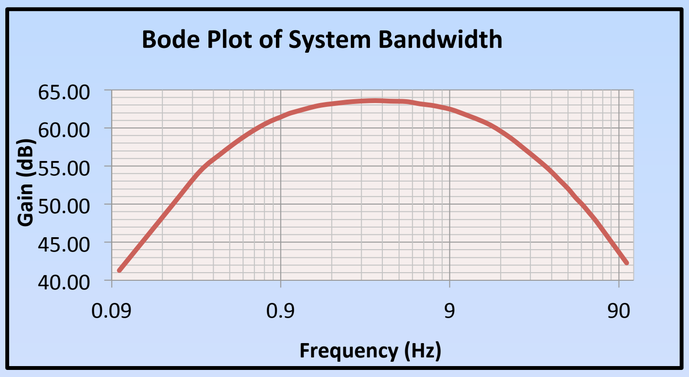
Project Requirements

- Design and fabricate the analog front-end (AFE) circuitry
- Select a TI power management integrated circuit to utilize a 9V battery
- Measure the ECG signals from the CardioSim II (simulator)
- Condition the analog ECG input signals for accurate display
- Interface the AFE with a Stellaris Oscilloscope evaluation board (EVB)

Final ECG Demonstration Board Solution



Project Results



System Bandwidth:	**0.7 Hz - 50 Hz**
Passband Gain:	**64.3 dB**
Battery Life:	**211 hours**

Summary of Results

The final PCB combined with the acrylic display fulfills and exceeds the project requirements. The final demonstration board successfully filters and amplifies an input ECG signal from the CardioSim II simulator and can display the signal on the Stellaris EKS-LM3S3748 LCD screen using the oscilloscope application. The design team successfully implemented the analog circuitry needed to capture a live ECG signal from a user's fingers tips. Texas Instruments plans to use the board to showcase the performance of their precision analog components.

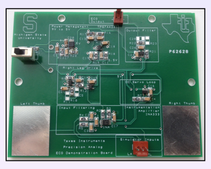
System Components

CardioSim II ECG Simulator:



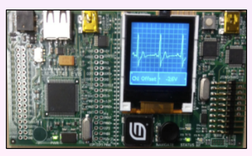
Provides realistic chest electrode ECG signals as inputs to the system

Analog Front-End Circuit:



Amplifies and filters the noisy input ECG signals to output a clean signal for display

Stellaris EKS-LM3S3748:



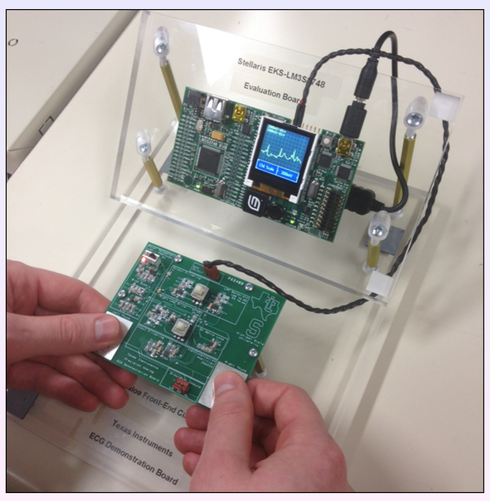
Displays the filtered ECG signals using a programmed oscilloscope application

TI Integrated Circuits Featured:

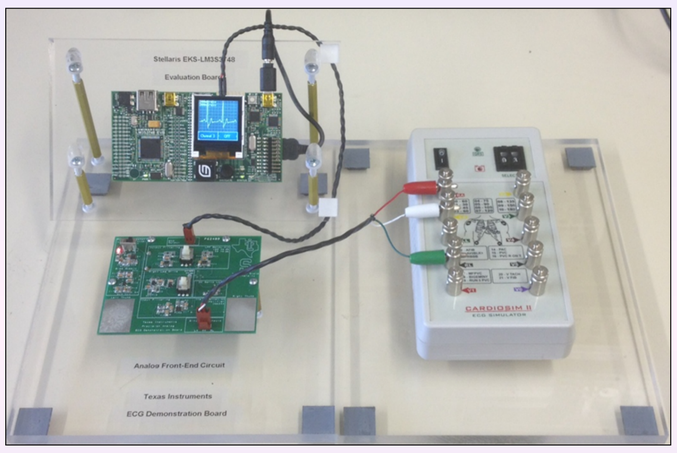
- OPA378 Low-Noise Op-Amp
- INA333 Instrumentation Amplifier
- TPS7A4201 Linear Dropout Regulator

Cost Table

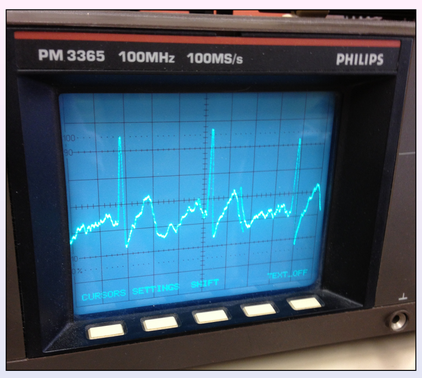
Item	Cost
Acrylic Display	$45
Battery Pack for Stellaris EVB	$30
Stellaris Evaluation Kit	$0
Analog Front-End PCB (4)	$220
PCB Passive Components	$96
PCB Integrated Circuits	Free
Accessory Components	$70
Active ECG Finger Sensors	$ 24
Total	**$485**



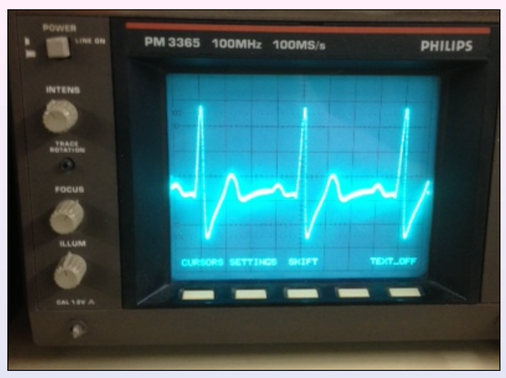
Successful live ECG measurement



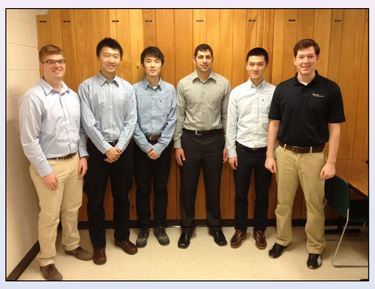
CardioSim II output through final AFE system



Output from AFE Circuit (Live)



Output from AFE Circuit (Simulator)



Faculty Advisor

Dr. Ramakrishna Mukkamala

Project Sponsor

Peter Semig
Texas Instruments Precision Analog

Design Team 3

Mike Mock, Xie He, Yuan Mei
Nathan Kesto, Chaoli Ang, Justin Bohr