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# HVAC Failure Modes

**HVAC Equipment Failure Modes and Potential Solutions**  
**ELECOMP Capstone Design Project 2017-2018**

## **Sponsoring Company:**

### **Bosch Thermotechnology Corporation**

65 Grove Street

Watertown, MA 02472

<http://www.boschheatingandcooling.com>

## **Company Overview:**

In North America, Bosch Thermotechnology is a leading source of high quality heating and cooling systems, water heating systems and comfort heating systems. In particular, the company offers BOSCH tankless water heaters, floor-standing and wall-hung boilers, air-source and water-source heat pumps, as well as controls and accessories for every product line.

Bosch Thermotechnology is committed to reinventing energy efficiency by offering smart products that fit together and work together as integrated systems which enhance the quality of your life in an ultra-efficient and environmentally friendly manner.

The Bosch Group has been a leading global supplier of technology and services in the areas of Automotive, Industrial Technology, Consumer Goods and Building Technology for over 100 years. The company was founded in Stuttgart, Germany, in 1886 and today has more than 300 subsidiaries in over 150 countries.

Every Bosch product is built with one goal in mind; to enhance the quality of your life every day by providing solutions which are both innovative and truly beneficial.



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## Technical Directors:

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Senior Controls Lead Engineer

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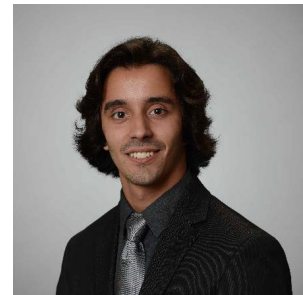
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## Consulting Technical Director:

**Mike D. Smith**  
Founder and Principal Designer  
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*Some of the work may need to be completed at the Bosch facilities in Watertown, MA. Students interested in the project must have a means of transportation to and from the facility.*

## Project Motivation:

The residential and commercial HVAC industries use various components to design their heating and cooling systems. Over the years, systems have evolved to include more and more electrical and software based components (on top of the numerous mechanical components necessary for good heat transfer). Due to the increased number of components within an HVAC unit, there is an increased number of parts that can fail in the field. Bosch is a company devoted to quality



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and the brand **Invented for Life**; therefore we pride ourselves in having reliable, high quality products. Our customers purchase our solutions because of our reliable products and low failure rates. The purpose of the project is to determine why today's HVAC components fail, how they fail, and propose solutions to extend the life of these components in the units (specifically Air Source Split Air Conditioning Units, and Water Source Heat Pumps).

### **Anticipated Best Outcome:**

- Develop a HW/SW system to monitor the various components inside HVAC equipment
- Determine which components of an HVAC system are responsible for most system failures
- Monitor the failure modes for this equipment
- Log and report on these failure modes
- Propose solutions to these failure modes
- Improve HVAC system design

### **Project Details:**

Expectations for April 2018 is to have the team present a working prototype of that covers the following details:

- Develop a monitoring system for the HVAC equipment to track selected component operation
- Develop a means of acquiring trending data for selected components
- Conduct FMEA studies on selected components with corresponding reports for each
- Provide validated data on component failure rates and propose design improvements to extend component life
- Provide schematics for all proposed design improvements and prototype where applicable and feasible
- Devise test cases for hardware verification of any designs for improving components in the HVAC system to include (but not limited to):
  - Blower/Fan motor
  - Compressor
  - Electronics
  - Run/Start Capacitors
  - Reversing valves
  - Thermal Expansion Valves (TXV)
  - Heat exchange coils
  - Water Pumps (where applicable)
  - Pressure switches

## Overall System Concept

Two heat pump systems will be considered for this project.

### 1. Inverter Ducted Split (IDS) Air Source Heat Pump

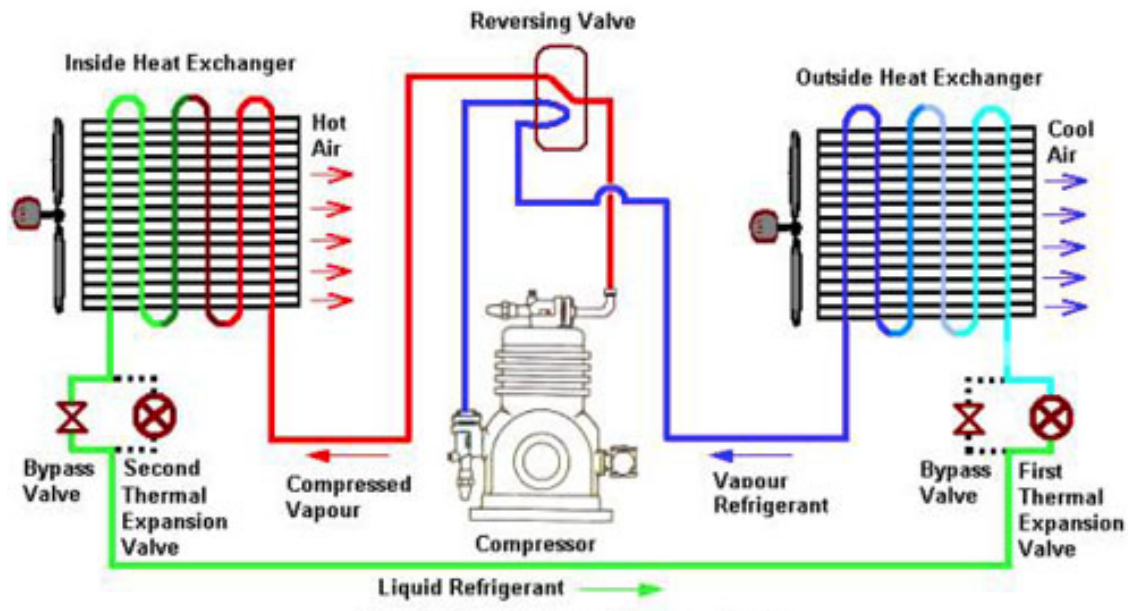
These high-efficiency, robust and quiet Inverter Ducted Split system heat pumps are available in four sizes ranging from 2 to 5 ton capacity. The system boasts a variable speed inverter drive which adjust the speed of the compressor to optimize comfort, while keeping sound levels to a minimum and utilizing just the right amount of energy to achieve maximum efficiency.

### 2. Water-to-Air-Geothermal Heat Pump

Bosch geothermal heat pump systems are some of the most energy and cost efficient on the market, as well as the greenest technology for heating and cooling your home. The technology utilizes the constant temperature of the earth which makes it extremely efficient all year long in virtually any climate.

## Block Diagram

### Basic Heat Pump Operation/Concept



*\*Sampled web image*



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### Hardware/Electrical Tasks:

- Devise/Propose means of measuring and tracking how various aspects of heating/cooling systems affect unit operation including (but not limited to):
  - Refrigerant temperature
  - System pressure
  - Power (Current, Voltage)
  - Air flow
  - RPM
  - Vibration/noise
  - Ambient temperature/humidity
  - Electrical noise
- Create requirements document for proposed hardware improvements
- Determine system architecture and update existing diagrams to include proposed solutions
- Provide documentation on all changes and improvements to system performance
- Devise test cases for hardware verification

### Firmware/Software/Computer Tasks:

- Propose/Develop software for monitoring HVAC system component functions
- Propose/develop algorithms for tracking a reporting component failures
- Propose/develop graphics interface for monitoring system performance
- Software verification and testing
- System Integration testing
- Documentation/Reports

### Composition of Team:

2 Electrical Engineers and 1 Computer Engineer



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## Skills Required:

### Electrical Engineering Skills Required:

- Knowledge of digital and analog circuits
- PCB design and layout
- Design specification
- System/Integration testing

### Computer Engineering Skills Required:

- Proficient in C (or similar) object-based programming language
- Experience with graphic user interface design
- Mobile/Web app development experience
- Networking experience
- Familiarity with Building Automation Systems a plus
- Familiarity with HVAC systems a plus

## Anticipated Best Outcome's Impact on Company's Business:

Completion of this project will be a huge bonus to the Bosch team to gain deep insights into field failure rates. In today's world, heating and cooling solutions are necessities to homeowners, renters, and all of humanity. As an HVAC equipment producer, we need to understand our field failures to better ensure that our customers never go without heating and cooling. This necessity is especially true in New England winters and southern summers. The students participating in this project would receive valuable hands-on engineering experience as well as contributing to a great brand and quality products.

## Broader Implications of the Best Outcome on the Company's Industry:

As with any quality engineered product, this information will allow Bosch to continue developing quality products and ensure that our units never fail while in the field. As our competitors in the space continue to grow, we as Bosch must continue to grow as well to stay competitive with the market.