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1 INTRODUCTION

The goal of this design is to develop a reliable energy efficient stationary eTRU. Modifications will be considered in the future to transition from stationary to mobile applications and battery powered units. One theme of this design is to eliminate as many mechanical components as possible and replace them by electronics and software. This will improve reliability and reduce maintenance. In addition, features can be quickly added to the eTRU by simply adding software algorithms with no changes to the hardware. This allows for a quick time to market.

A laboratory will be setup to investigate various proprietary energy efficient algorithms and ideas which will contribute to IP of the company and be incorporated into the design.

The initial temperature control software design will seek to optimally bring the temperature of a loaded trailer to the desired set point in minimum time using the minimum amount of energy and simultaneously maintain a temperature variation within the compartment of 5 degrees or less. While doing this, an attempt will be made to prevent frost buildup of the evaporator coils, since defrost reduces the energy efficiency considerably. All pressures and temperatures will be accessible by the Controller for diagnostic, fault detection and remote monitoring purposes. A self test of the system will always run in the background.

Frost buildup and defrosting have a large detrimental effect on energy efficiency since the heat used to melt the ice must be taken out. Any optimal control strategy should include preventing of the tendency of frost build up on the evaporator coils. As a result, frost detection and prediction techniques should be investigated. At a minimum the defrost cycle should be short and infrequent as possible.

Energy efficiency optimization can be performed by

- Using direct drive fan motors (also increases reliability and maintainability)
- Choosing optimal motor control and electronic commutation algorithms
- Choosing efficient fan geometries
- Using an Electronic Expansion Valve (EEV) instead of a mechanical TEV
- Choosing an energy efficient defrost algorithm and approach
- Unloading the compressor (if available)

Improved energy efficient control software include

- Use of FOC (field oriented control) algorithm to power 3 phase motors
- PID control of Compressor speed
- PID control of Evaporator Fan(s) Speed
- PID control of Condenser Fan(s) Speed
- PID control of EEV
- Feedback, Feed Forward and Adaptive Control of temperature and temperature variation
- Minimize number of defrost cycles and reduce defrost time

Sensors used to measure

- Return Air temperature
- Discharge Air temperature
- Ambient Outside Temperature by Condenser
- Condenser temperature (or use Head pressure)

- Current or Power usage
- Humidity (TBD)

Pressure sensors used to measure

- Head pressure
- Suction pressure

Motor Speeds

- Evaporator motor speed depends on Treturn – Tdischarge
- Condenser motor speed depends on Tcondenser – Tambient, where Tcondenser>Tambient or controlled by Head Pressure. It also depends on the refrigerant used. A lookup table of pressure vs temperature for the given refrigerant will also be used to determine speed.
- Compressor motor speed depends on Treturn – Tsetpoint.

Except for the Controller, another goal of this design is to use off-the-shelf readily available parts in the USA whenever possible. This will allow customers to easily order a replacement part and give them more confidence when buying our unit.

2 HARDWARE ARCHITECTURE DESIGN

Figure 2.1 shows a block diagram of the hardware interfaces to the Controller. With the hardware in place, software and control algorithms can be developed to investigate different stable, energy efficient control strategies that will be used in controlling the refrigeration system.

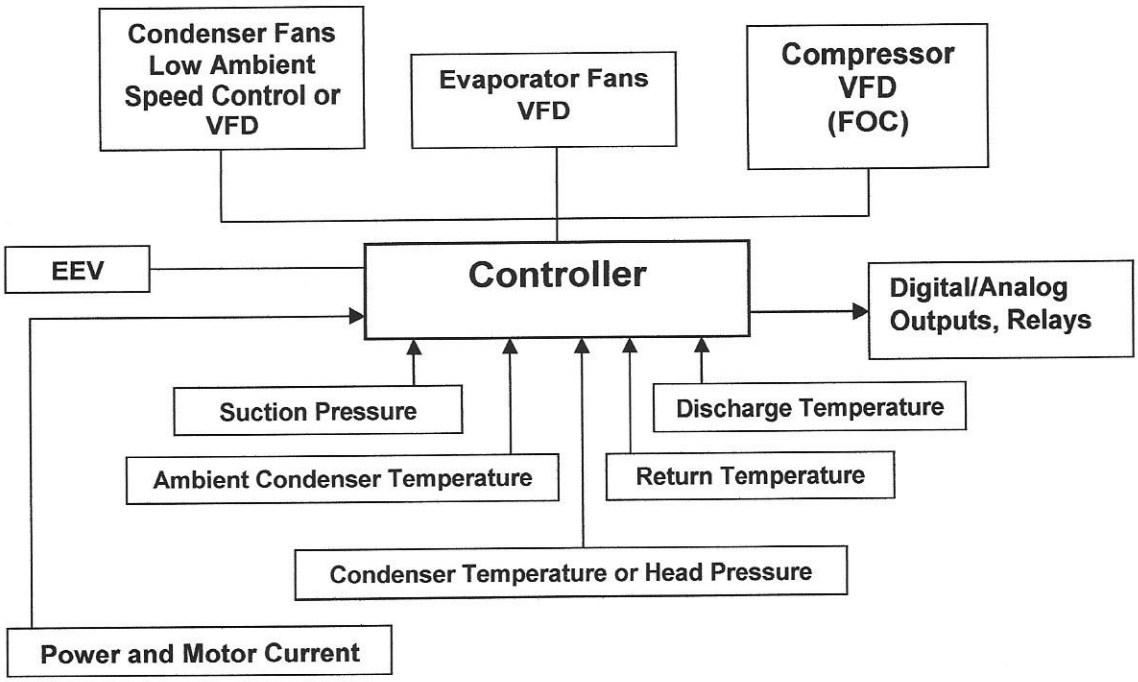

Figure 2.1 – Controller Interfaces

3 EXAMPLE OF ENERGY EFFICIENT APPROACH