White Paper

Purpose
The purpose of this paper is to evaluate the advantages and disadvantages between three separate HVAC systems: a fixed speed compressor system, a Smart Compressor Control (SCC)/Variable Frequency Drive (VFD) retrofitted compressor system, and a DC inverter compressor system.

Scope
The scope evaluates three different systems. This exercise has monitored data of all systems and evaluated the behavior and electricity consumption of each system working independently, cooling the room to the exact set temperature of 17°C/62.6°F. An Eyedro Real-Time Electricity Monitor with three-phase current readings was attached to each unit and used to collect real-time data.

System One: a fixed speed HVAC system
Midea/Carrier Model No: KFR-91YSR with a capacity of 9 kW (36,000 Btu/Hr)
System Two: a fixed speed HVAC system retrofitted with the SCC/VFD combination
Midea/Carrier Model No: KFR-91YSR with a capacity of 9 kW (36,000 Btu/Hr)
Falkonair Smart Compressor Control (SCC)
Invertek OptiDrive VFD
System Three: a DC inverter high specification system
Midea/Carrier Model No: MSMADU-36HRFN1 with a capacity of 9 kW (36,000 Btu/Hr)

Falkonair Innovation: Smart Compressor Control (SCC)
This innovation was created to provide an energy-efficient, cost-effective, and reliable solution for the HVAC/R market to save money. The biggest power consumer of the HVAC/R market is the compressor. The Smart Compressor Control (SCC) optimizes the operation of the compressor by introducing a soft start and continues to modulate the compressor dependent on the demand of the system. The Smart Compressor Control (SCC) software partners with VFD manufacturers' hardware to provide this solution. The Smart Compressor Control (SCC) operates within the DC inverter software technology parameters.

How Falkonair Does it
The Smart Compressor Control (SCC) consists of two sensors. Sensor one connects onto the suction line of the compressor and sensor two connects to the discharge line of the compressor. The Smart Compressor Control (SCC) gathers the temperatures of these two sensors' points and inputs this data into the SCC's algorithm. Using this data, the software works out what speed and what compressor capacity is needed for the whole system. While working on lower frequency for long periods of time there is an oil return sequence designed to bring the oil back to the compressor to protect it. It helps limit short cycling and maintains a normal discharge temperature. The Smart Compressor Control (SCC) controls the VFD attached to the compressor via Modbus communication, controlling the VFD voltage, frequency and electrical current sent to the fixed speed compressor. The Smart Compressor Control (SCC) has multiple dip switch settings that can be switched dependent on the

compressor type whether it is a reciprocating or scroll. The Smart Compressor Control (SCC) also has settings to control the fan motor whether it is a condenser or evaporator fan motor. The SCC works with any type of refrigerant and in-line with any controls already installed on the system. By utilizing temperature sensors rather than pressure transducers, there is no need to cut into the refrigerant line.

The following data tables show the differences in running patterns and consumption between the three different systems.

Figure One

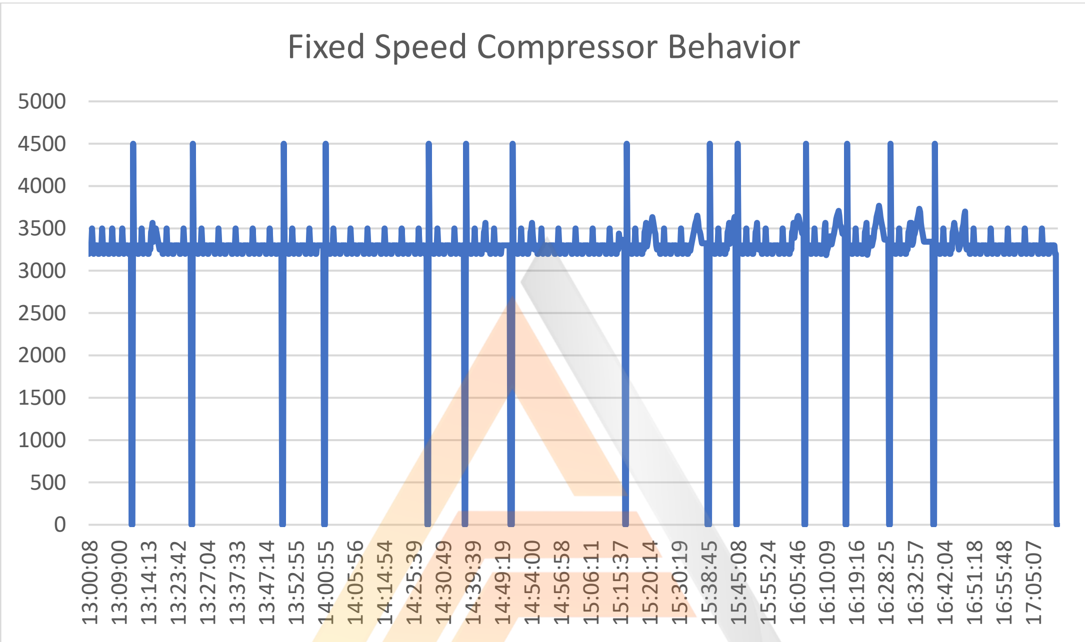


Figure Two

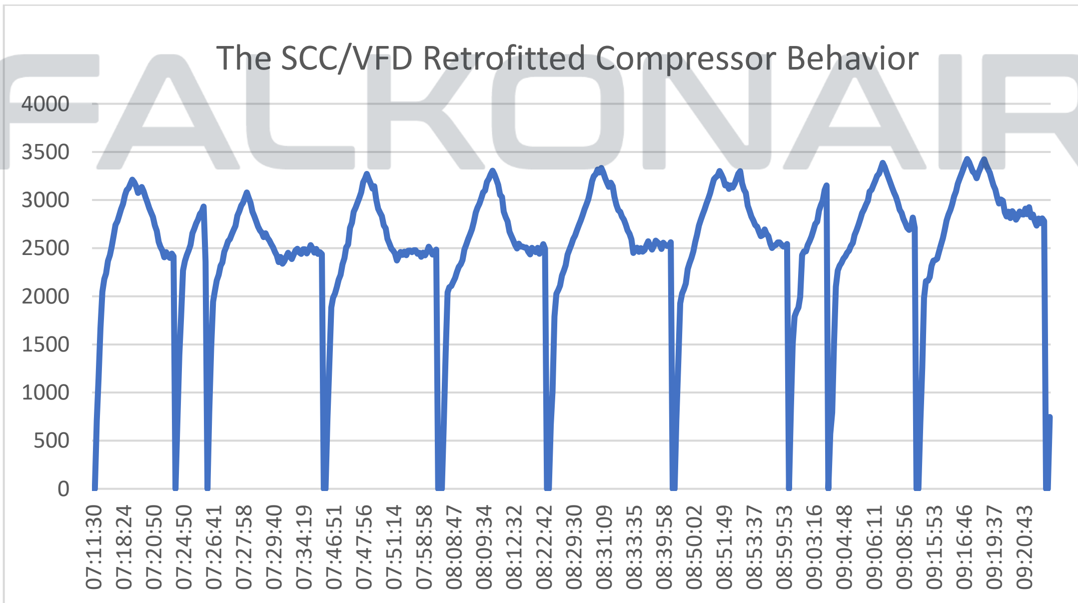
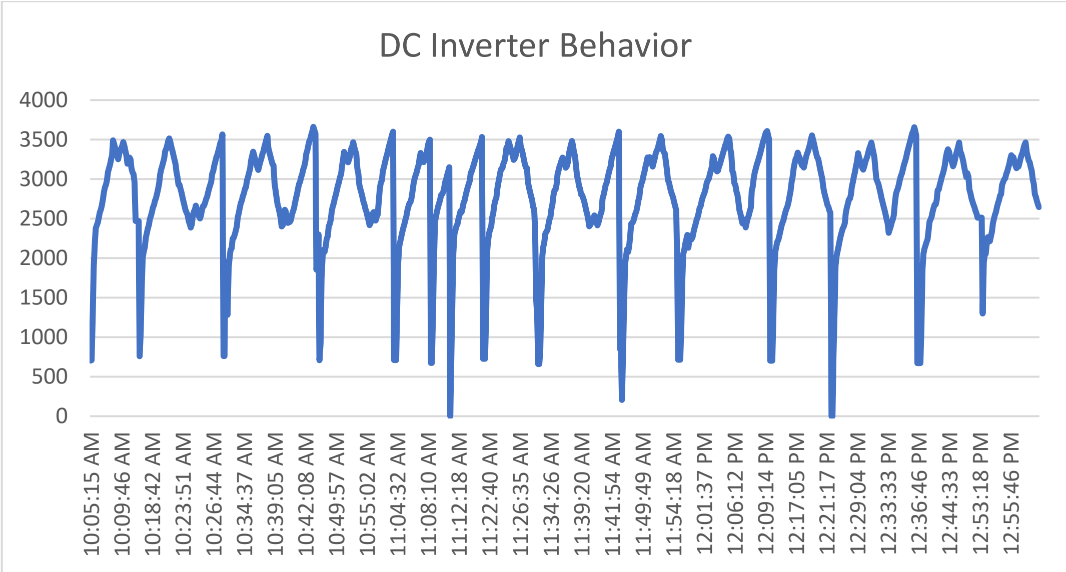


Figure Three



Explanation of the Data

Figure One – Fixed Speed Compressor Behavior

The graph shows the compressor starts with a high current in amps, also known as Locked Rotor Amps (LRA), up to 4.5 kWh and drops down to its Run Amps (RLA) at 3.4 kWh until the temperature set point is reached and shuts off.

Figure Two - The SCC/VFD Retrofitted Compressor Behavior

The graph shows the retrofitted compressor soft starts into its highest amperage at 3.4 kWh and starts to modulate down to an average of 2.5 kWh just before it shuts off.

Figure Three - DC Inverter Behavior

The graph shows the inverter compressor soft starts into its highest amperage at 3.5 kWh and starts to modulate down to an average of 1.8 kWh, but can run as low as .75 kWh, never completely shutting off.

Efficiency Analysis

- Figure Two - The SCC/VFD retrofitted compressor is **approximately 28% more efficient** than Figure One - fixed speed compressor
- Figure Three - DC Inverter is **approximately 40% more efficient** than Figure One - fixed speed compressor
- Figure Three - DC Inverter is **approximately 15% more efficient** than Figure Two - The SCC/VFD retrofitted compressor

When there is a continuous load (as in Figure One and Figure Two) the fixed speed compressor system and the SCC/VFD retrofitted compressor system switched off completely for intervals of three minutes at a time. Meanwhile, the DC inverter system slows down to levels as low as .75 kWh but does not completely shut off.

Compressor Systems: Advantages and Disadvantages

Cost

The cost of installing a DC inverter system in comparison to a fixed speed system can be between 50%-100% more expensive to purchase and maintain. Replacement parts when needed can be extremely costly compared to inexpensive replacement parts on a fixed-speed compressor system.

This information was collected from European HVAC mechanical companies that have been installing DC inverter systems since they were first introduced in 1997. This became law across Europe to install DC inverter systems from 2015 onward for comfort cooling.

Reliability

When it comes to reliability, fixed speed systems are considered more reliable due to containing less complicated controls that come with the high-efficiency DC inverter systems. Fixed speed systems typically have a 10 to 20-year lifespan. Compare this lifespan with DC inverter systems that have lifespans as low as seven years due to the lack of expertise when it comes to troubleshooting and expensive replacement parts.

The reasons for this are as follows:
Reliability and repair costs can be a potential issue. A DC inverter system's reliability is difficult to predict. The system is controlled by multiple PCBs, with each PCB having its own function(s). These functions typically include:

1: Main control board
2: IPM module
3: Rectifier board
4: Power board

Some more complicated DC inverter systems might also have more PCBs included. All of the boards are needed to deliver the DC inverter efficiency operation.

Efficiency

DC inverter systems are the most efficient systems on the planet today. They can be 40-50% more efficient than any fixed speed system.

Environment

The DC inverter system produces the least amount of CO_2 emissions, but still have a detrimental effect in landfills. This is due to the shorter lifespans and 30% of the same system being non-recyclable. This is why fixed speed systems with the SCC/VFD retrofitted compressor is a more environmentally friendly solution.

Conclusion

This white paper provides information comparing and contrasting DC inverter and fixed speed systems. Utilizing over twenty years of experience in the field, repairing and maintaining these systems, as well as extensive involvement in monitoring them for energy-efficiency, Falkonair concludes that The Smart Compressor Control (SCC) provides the best cost-effective, reliable, retrofit solution available today. This solution cuts peak demand charges first and provides additional compressor safety features for fixed speed systems. The SCC/VFD technology is a new way of saving energy and protecting compressors with the benefit of energy efficiency savings on an average of 28%.

This white paper was prepared and written by the Falkonair technical team.

The data was collected and recorded from February to December 2020 under controlled ambient conditions.

Market Research

The market research utilized demonstrates the global VFD market in 2020 to be worth approximately $24 billion and growing at a compounded growth rate of 6.5%.   Please see https://www.grandviewresearch.com/press-release/global-variable-frequency-drive-vfd-market for more information.

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