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Understanding Compressor Electronics

The key to better system performance, increased profitability and more satisfied customers.



Chapter 1: Introduction to Compressor Electronics

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Introduction to Compressor Electronics

Executive Summary

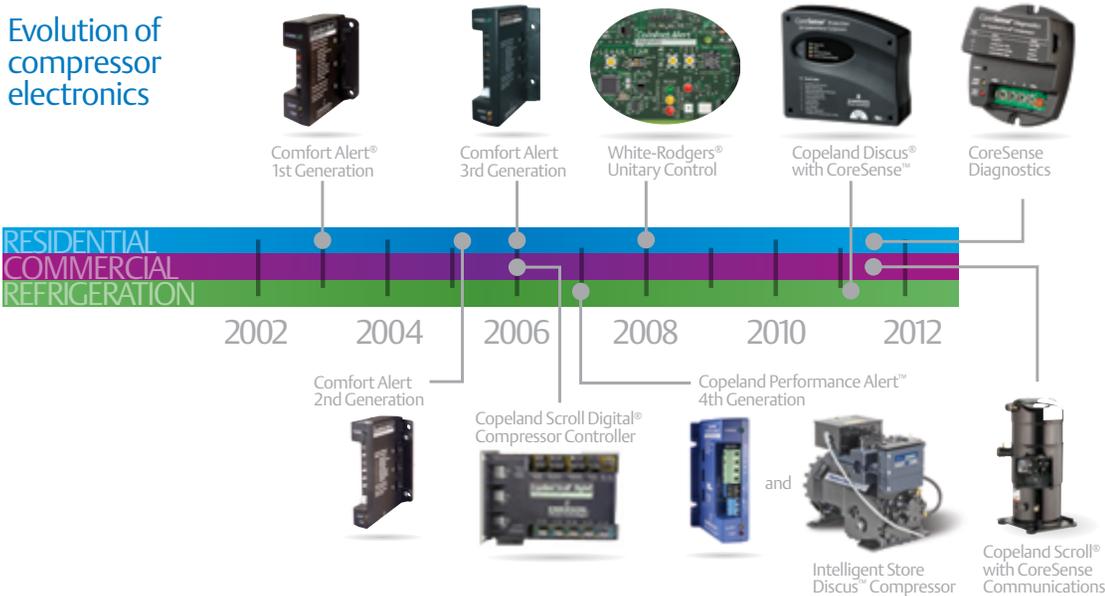
As a worldwide provider of heating, air conditioning and refrigeration solutions for residential, industrial and commercial applications, Emerson Climate Technologies is leading the industry in the development of compressor electronics. As the technology continues to present new possibilities and capabilities, it is important HVACR contractors and professionals understand how compressor electronics work and how they can be employed to provide better system performance, increased profitability and more satisfied customers.

This e-book is designed to help educate contractors and end-users of the value of compressor electronics and its impact on their overall business. The eBook series will contain a total of four chapters with this first chapter providing a general overview on electronics in the HVACR industry. The second chapter will explain why compressor electronics are needed by addressing some of the key issues our industry is facing. The third and fourth chapters will then cover other key items including, how compressor electronics work and the key benefits they deliver. The eBook will also provide examples of this technology and its success in the field today with real-life scenarios.

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Evolution of compressor electronics



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Emerson Climate Technologies first introduced compressor electronics to the HVACR industry in 2003 with the launch of its Comfort Alert[®] diagnostics module. Today, the technology has evolved into commercial and refrigeration applications and is now referred to as CoreSense[™] technology.

Introduction to Compressor Electronics

HVACR Electronics

We are constantly surrounded by data. Many of the appliances and equipment we encounter in our personal and professional life now contain some level of electronics and diagnostic technology that gathers usage and operational data.

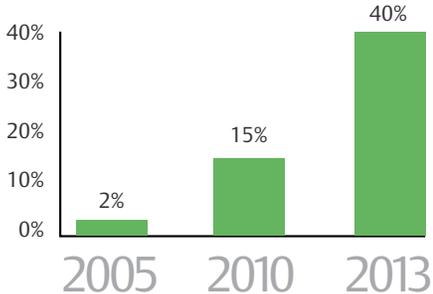
From cell phones and UPS systems to forklifts and coffee makers, products across markets and industries are becoming smarter. Within the last few years, we've seen an increase in the technology available that enables us to better manage and analyze that data, transforming it into actionable information that we can effectively use to improve performance, increase reliability and cut costs.

For example, through embedded electronics, sensors and diagnostic technology, we can find out exactly how our car is performing, pinpoint a faulty part and identify proven preventive maintenance steps that can be taken to prevent future issues. The HVACR industry is no exception. For a number of years, electronics have been integrated into commercial and residential furnaces that perform self-diagnostics through an [integrated circuit board](#), which continuously monitors the furnace's operational performance. Furthermore, electronic supervisory controllers in commercial refrigeration have managed systems to optimize performance while preserving food quality.

As technology and diagnostic capabilities continue to evolve, it is a natural migration that electronics are now being introduced in air conditioning and refrigeration systems. According to a recent article from [HVACR Distribution Business](#), the number of air conditioning systems with embedded electronics is significantly increasing. The article points out that the outdoor unit electronics market has expanded exponentially in the last five years. From less than two percent of the market in 2005, it has grown to more than 15 percent in 2010 and is projected by many to be as high as 40 percent by 2013.

With electronics becoming more common in air conditioning and refrigeration systems, they are now being integrated into the heart of these systems – the compressor.

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By 2013, outdoor units with compressor electronics is expected to grow to nearly 40% of the market.

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Introduction to Compressor Electronics

Why Compressor Electronics?

In today's economy and competitive landscape, solid, reliable performance is key, whether for HVACR systems and components, or service technicians. There is a need in the HVACR industry for equipment that can diagnose and protect itself from costly failure until a qualified contractor arrives for service. This smarter equipment would help lower maintenance costs and system downtime, and save contractors valuable time by enabling faster, more accurate diagnoses and ultimately reducing callbacks.

Electronics for HVACR systems have been around in control boards for many years, but a number of significant developments in compressor technology through the years has paved the way and laid the groundwork for a smarter compressor enhanced with compressor electronics.

At its core, compressor electronics enhances compressor and system performance by sensing, monitoring and interpreting electrical and mechanical information within the compressor to provide advanced capabilities, such as system diagnostics, protection, verification and communication. We will discuss these advanced capabilities in more detail in Chapter 4 of this eBook series.

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Introduction to Compressor Electronics

Conclusion

While compressor electronics is a fairly new category, many of the appliances and equipment we encounter in our personal and professional lives contain some level of electronics and diagnostic technology. And, in the case of HVACR, compressor electronics can address key issues that will help minimize downtime and increase productivity.

Stay tuned for the next chapter in our eBook series “Understanding Compressor Electronics”. In Chapter 2, Emerson Climate Technologies outlines some of the key issues facing the HVACR industry, including the inefficiencies of replacing “No Fault Found” compressors, the gap between the number of trained technicians retiring and those joining the industry, and the pressures facing facility managers to reduce costs and downtime, along with efficiency and profitability challenges facing manufacturers and contractors.



“With compressor electronics, I now have a way to draw more information from the compressor, helping me achieve the reliability and costs savings I need, which is good for my business.”

– HVAC contractor



Click to watch an overview of compressor electronics

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Chapter 2: Addressing Key Industry Issues

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Addressing Key Industry Issues

Executive Summary

In the last chapter, we introduced the concept of compressor electronics by discussing how electronics have been used successfully in other industries. From smartphones to cars with diagnostic capability, electronics have been key in helping to shape and improve product performance and reliability. And, although electronics are new to air conditioning and refrigeration systems, they are proving valuable in helping contractors and end-users alike keep systems up and running.

In this chapter, we will review some of the key issues our industry is faced with and how compressor electronics help address these key issues.

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Addressing Key Industry Issues

High Number of Costly 'No Fault Found' Warranty Returns

One of the most important industry issues driving the need for compressor electronics is the high rate of compressor warranty returns that are classified as 'No Fault Found' (NFF). It is estimated that approximately 30 percent of all air conditioning and refrigeration compressors returned under warranty are NFF. This is creating major inefficiencies and adds unnecessary cost throughout the supply chain.

'No Fault Found' warranty returns are not a new issue. They have existed for many years and have become an accepted part of the warranty and maintenance process. No level of contractor training and experience can completely eliminate misdiagnoses; and unfortunately, many misdiagnoses lead to costly replacement of a good compressor.

Common Compressor Misdiagnosis
Compressor sound – the defrost and start-up sound make the homeowner think something is wrong or that the system is unreliable
Electrical – the technician measures an open circuit because of component failure and internal overload has tripped; therefore he assumes windings are open
No Pump – the reversing valve doesn't shift and the compressor looks like it isn't pumping

Sometimes it can be as simple as a contractor replacing the compressor because they detect a strange noise, which might be due to vibration. Other times, it might be that other controls in the system are preventing the compressor from starting. Regardless of the reason for the misdiagnosis, it is a major expense for everyone involved. The ability to improve diagnostic accuracy would not only aid contractors with faster, more accurate diagnoses, it also would help to reduce cost throughout the entire channel by significantly reducing the number of compressors returned with NFF.



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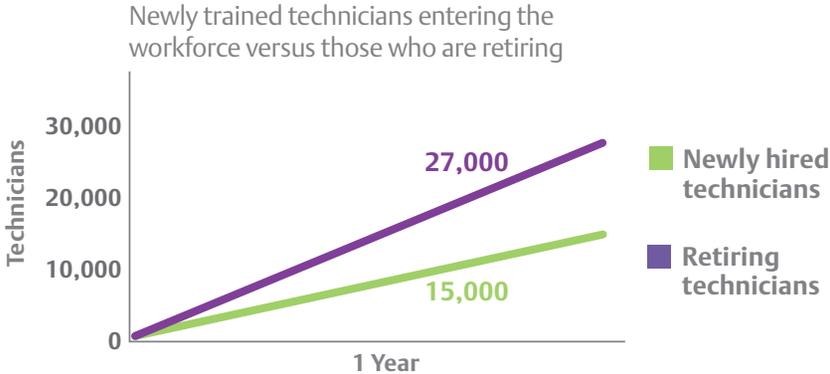
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Addressing Key Industry Issues

Shortage of Experienced and Properly Trained Technicians

The HVACR industry has been dealing with a growing shortage of experienced and properly trained technicians for many years. Industry organizations such as North American Technician Excellence (NATE) have been drawing attention to the issue and working to find solutions since the early 2000s.



According to the United States Department of Labor – Bureau of Labor Statistics, only 15,000 trained technicians are entering the workforce annually. A recent ACHR News article estimated that more than 27,000 skilled technicians are projected to retire annually. This combination of not enough new technicians entering the industry and too many experienced technicians retiring is not only shrinking the pool of HVACR technicians, but also resulting in the loss of valuable experience and trouble-shooting expertise. With compressor electronics, contractors can maintain productivity levels even with fewer or less experienced technicians. That’s because systems equipped with these electronics help guide technicians to the problem quickly and accurately, so they can move on to the next job.



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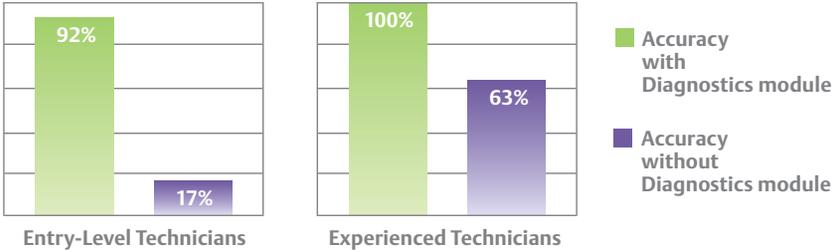
Addressing Key Industry Issues

Operational Pressures Facing End-users

Residential and commercial end-users are both facing pressure to reduce costs, eliminate waste and increase efficiencies across their homes and facilities. As they look for areas to make improvements, they invariably focus their attention on the number one source of energy consumption, their air conditioning or refrigeration system.

A contractor’s reputation is the most valuable asset they have. Unfortunately, if contractors don’t have the experience and training needed to properly diagnosis and repair problems as quickly as possible, they can put their reputation at stake. The ability to utilize advanced technology to quickly and accurately diagnosis problems will save costs, eliminate call-backs and keep intact their valuable reputation. It also will mean that contractors can possibly schedule more service calls.

A study conducted by Emerson Climate Technologies at a local JVS (joint vocational school), found that HVAC students had a troubleshooting accuracy of 17 percent without the use of a diagnostics module. When these same students used a diagnostics module, their accuracy improved to 92 percent. That same study was also conducted with experienced technicians, whose accuracy with compressor electronics improved to 100 percent.



End-users want to ensure that their systems continue to operate at the optimum performance level. If there is a problem with the system, they want it quickly and accurately repaired without any unnecessary costs or callbacks. For commercial end-users, any unplanned downtime of the system can result in the loss of perishable food, negatively impacting their business.

Between 20 and 40 percent of our food is wasted before it reaches the family dinner table. Much of that waste hits supermarket, convenience store and other foodservice retail operators, who have a significant investment in refrigeration equipment and perishable inventory.



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Profitability Challenges Facing Manufacturers, Contractors and Facility Operators

Throughout the channel, manufacturers, contractors and end-users alike are looking for ways to be more profitable. Original equipment manufacturers (OEMs) want to enhance their systems with components and technologies that improve the overall reliability of their systems. With value-add features, like compressor electronics, manufacturers can now provide more efficient and reliable equipment saving everyone both time and money.

In the case of contractors, time spent on callbacks is costly. Not only do callbacks affect profitability, they also affect reputation. Although all callbacks are not avoidable, many can be avoided through proper diagnosis. In systems equipped with compressor electronics, technicians are able to quickly and accurately pinpoint the root cause of the problem the first time, thus avoiding costly callbacks and possibly losing a customer.

Supermarket, convenience store and other food retailer operators ultimately want to improve their bottom line. When it comes to refrigeration equipment, operators are faced with costly installations, perishable inventory, maintenance costs, and overall energy costs. By utilizing systems with compressor electronics, retail operators can be assured of quality installations, system uptime, reduced maintenance costs and tighter control of energy consumption.

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Retailers spend on average 1.5 percent of sales on energy. The cost to operate the refrigeration equipment is 65 percent of total store electricity.

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Conclusion

With many of the issues our industry is facing, whether it is warranty returns, lack of qualified technicians, operational and productivity challenges, compressor electronics has been proven to help address them head on.

Compressor electronics provides:

Industry Issue	Compressor Electronics Benefits
Warranty Returns: No Fault Found	<ul style="list-style-type: none"> • Better System Diagnostics • Reduced NFF Warranty Costs • Improved Productivity • Reduced Callbacks
Lack Of Qualified Technicians	<ul style="list-style-type: none"> • Improved Productivity • Intuitive Troubleshooting • Better Customer Service • Reduced Callbacks
Operational Pressures	<ul style="list-style-type: none"> • Reduced Callbacks • Improved Productivity • Tighter Energy Control • Increased System Uptime • Accurate Diagnosis
Profitability Challenges	<ul style="list-style-type: none"> • Improved Productivity • Accurate Diagnosis • Quality Installations • Increased System Uptime • Tighter Energy Control • Reduced Operational Costs

Download the next Chapter in our eBook series to learn about the technology behind compressor electronics and how Emerson-developed software algorithms can identify both performance issues that need attention and the escalating patterns leading to catastrophic faults.

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Chapter 3: Inside How Compressor Electronics Work

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Inside How Compressor Electronics Work

Executive Summary

In [Chapter 2](#), we addressed some of the key issues facing our industry and how they are driving the need for compressor electronics that help ensure solid, reliable performance from HVACR systems. One of the most important of these issues being the high rate of compressor warranty returns that are classified as “No Fault Found,” which are creating major inefficiencies and adding unnecessary costs throughout the supply chain.

Armed with this background information, you are now ready for Chapter 3. In this chapter, we will dive a little deeper into the details, giving you a better understanding of how compressor electronics actually work.

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Inside How Compressor Electronics Work

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Inside How Compressor Electronics Work

Using the Compressor as a Sensor

If you have ever serviced or repaired HVACR systems and compressors, the chances are good that you have heard this analogy at least once: “The compressor is the heart of the HVACR system.” But have you ever stopped to really think about this comparison? It turns out, this analogy provides an easily understandable foundation for helping you understand just how compressor electronics work.

Much like the human heart, the compressor is the central organ that keeps the system running. Its primary function is to pump “life blood” (i.e., refrigerant) through the system to ensure optimal and efficient performance. In the human body, problems that occur with other organs will often manifest themselves through the heart, causing it to work harder and potentially stop functioning. This is also true for the compressor and its HVACR system.

It is for this reason that the compressor makes an ideal sensor for which to gauge the health of the entire system. Similar to an EKG monitoring the heart, we can monitor the “signals” or “information” provided by the compressor to detect symptoms that are causing less than optimal performance.



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By using the compressor as a sensor, compressor electronics monitors system data and proactively shuts down the system if conditions exist that could damage the compressor.

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Gathering Key Operating Information

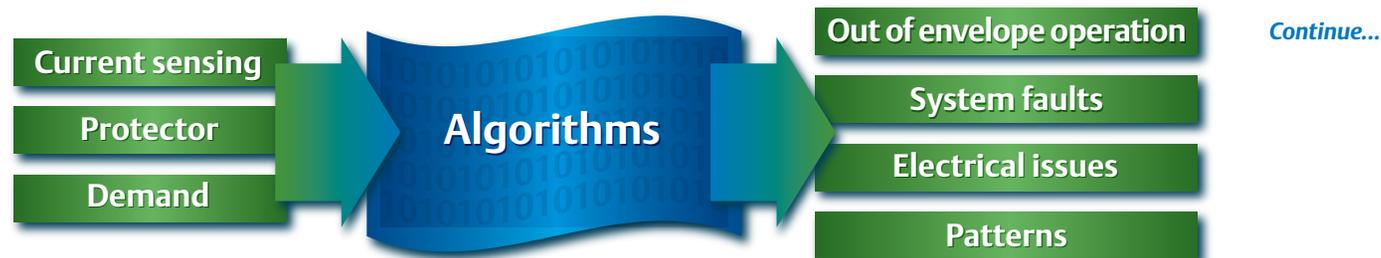
By sensing, monitoring and interpreting electrical and mechanical information from within the compressor, compressor electronics allow you to basically monitor the HVACR system as a whole on an ongoing basis. The detailed compressor and system information it delivers enables you to quickly and accurately identify performance issues for greater reliability and cost savings, giving you freedom to refocus time and money on other priorities.

Compressor electronics gathers three primary types of operating information:

1. Current signature of the compressor
2. Compressor protector behavior
3. Presence / absence of demand

This information is then interpreted by established software algorithms that are rooted in many years of compressor testing, teardown and operating experience. These software algorithms use the information to identify:

- Conditions leading to out of the envelope compressor operations
- System faults
- Electrical issues
- Escalating patterns leading to catastrophic faults



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Inside How Compressor Electronics Work

Directing Attention to the Root Problem

Once the information has been gathered and problems have been identified, compressor electronics directs you to the root cause of the problem, giving you the information you need to quickly and accurately diagnose and optimize the system. In many cases, providing you with detailed information at the right time allows you to diagnose system-related problem areas or performance issues even before they occur.

Without compressor electronics, service technicians would typically have to rely on years of technical experience, critical system measurements, good judgment and after-the-fact analysis when troubleshooting a unit. They may be able to run the system and duplicate the problem, but might never know with certainty what caused the issue. They might even replace the compressor or other components, when in fact the root cause of the problem is elsewhere in the system.

With compressor electronics, LED indicators now direct you to the root cause of the problem. Utilizing the key inputs and the defined software algorithms, fault conditions can be quickly and effectively presented through industry standard LED flash codes. These flashing LED codes serve as your first source of troubleshooting information during a service call. The number of flashes correlates to a common fault condition, which are typically system or electrical related.

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LED Indicators on a Diagnostics Module

	Module has power and indicates normal operation
Solid Yellow	
	Flashes to indicate fault code
Flashing Yellow	
	Compressor is in a tripped state and locked out for repetitive fault condition
Flashing Red	

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Inside How Compressor Electronics Work

Common HVACR Faults

The most common system and electrical faults that plague an air conditioning or refrigeration system, and that can be detected through the use of compressor electronics, are listed below. By addressing these concerns, you can help ensure the long-lasting reliability of the compressor and system.

Fault	Description
Compressor Trips	Compressor is in a tripped state, a Y demand signal is present, but the compressor is not running
Pressure Switch or Thermostat Cycling	Compressor is running only briefly
Discharge Pressure	Pressure is out of limits or compressor is overloaded
Locked Rotor	Low line voltage or seized compressor bearings
Long Run Time	Indicative of low capacity due to a system low-side fault
Low Voltage	Low line voltage or overloaded transformer
Low Oil Pressure	Improper oil circulation
Missing & Reverse Phase	Three-phase wiring of utility issue
Welded Contactor	Compressor always runs
Motor Trip	Motor temperature or voltage outside limits
Open Circuit	Bad capacitor or wiring issue
High Discharge Temperature	The head temperature probe has detected a temperature greater than specification

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[Click to watch a summary of common compressor faults.](#)

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While the technology behind compressor electronics is advanced, the basic premise is quite simple: recognizing that the compressor truly is the heart of the HVACR system and capitalizing on that fact to use the compressor as a sensor to monitor the system and diagnose performance. At the end of the day, the compressor is basically alerting you to any possible problem areas or performance issues within the entire system.

Stay tuned for the next chapter in our eBook series “Understanding Compressor Electronics”. In Chapter 4, “Advanced Capabilities Delivered by Electronics”, Emerson Climate Technologies discusses some of the key benefits, features and attributes compressor electronics can offer.



“The diagnostics capability delivered by compressor electronics is simple...it takes the guess work out of troubleshooting.”

– Refrigeration contractor

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Advanced Capabilities Delivered by Compressor Electronics

Executive Summary

In Chapter 3, we explained how compressor electronics work from a theoretical standpoint. We pointed out that they use the compressor, the heart of the HVACR system, as a sensor to monitor, interpret, and diagnose performance within the compressor. By sensing electrical and mechanical information from within, compressor electronics allow you to monitor the entire system on an ongoing basis.

In the final chapter we will focus on the key features and benefits provided by compressor electronics. We will help you understand how the technology will give you the freedom to refocus time and resources on other pressing priorities by presenting real-world scenarios and proven results. The primary benefits provided by compressor electronics can be broken into three categories: Diagnostics, Protection and Communication. The following sections provide more information on the three areas.

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Advanced Capabilities Delivered by Compressor Electronics

Diagnostics

Compressor electronics make today’s HVACR systems and contractors more efficient and smarter. Available technology delivers a range of fault codes that can help contractors identify the root cause of a problem. (See Chapter 3 for a list of common fault codes.) Sophisticated algorithms and capabilities, presented via LED indicators and extensive fault history, allow technicians to diagnose the past and present state of the system.

Tests conducted by Emerson Climate Technologies at a local vocational school provide insight into how much compressor electronics can improve problem-solving accuracy. Results of the test, which focused on troubleshooting air conditioning system faults, showed that the technology improved troubleshooting accuracy of an entry-level technician from 17 percent to 92 percent. Experienced technicians who were tested saw an improvement to 100 percent accuracy when assisted by the technology.



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Protection

Commercial and residential end users have a significant investment in their HVACR equipment and need assurance that their equipment will not go down, costing them valuable time and money. And in the case of commercial end users such as supermarkets, there is also the significant risk of perishable inventory.

By monitoring conditions within the system and proactively shutting down the compressor to prevent system damage, electronics technology can make compressors and systems more reliable than ever. It offers critical safeguards against conditions like insufficient oil pressure, high motor temperature, or high discharge line temperature.

When the compressor electronics sense a fault that indicates the compressor is running in an unsustainable condition, it responds with active protection by shutting down the compressor to avoid imminent damage. Based on fault severity, the compressor will then either reset itself when the condition is cleared or require a technician to trouble shoot the fault before restarting. A failure to properly identify and address the root cause of the system fault may result in a repeat event and almost certain callback as the proactive nature of the technology will once again shut down the system.



80% of all compressor failures could be avoided with regular maintenance and proper diagnostics.

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Advanced Capabilities Delivered by Compressor Electronics

Communication

When you're in the field making service calls, it's important you have the right information at the right time to make the right decisions. And wouldn't it be nice if you were able to understand the failure mode and possible cause of a system failure, before arriving at the work site or climbing on the roof only to realize you are lacking an essential tool or spare part. Compressor electronics gives you that information and heads-up by establishing real-time communication.

Compressor electronics stream real-time diagnostic information on compressor operation directly to the system controller. By using the compressor as a sensor, the technology allows valuable insight from inside the system to be accessed and monitored in real time by the controller. This enables technicians to quickly diagnose and prepare for the job in advance; increasing the number of service calls they can fit into a day.

Along with providing real-time information such as temperatures and pressures, compressor electronics can also provide you with historical information. Faults that might have occurred in the past week or even over the entire life of the compressor are easily available with a push of the button. Having this information allows you to know exactly what the system is experiencing. This means shorter and fewer site visits, saving technicians and end users time and money.



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Advanced Capabilities Delivered by Compressor Electronics

A/C Contractor Relies On Electronics To Keep Texas Family Cool In The Heat Of Summer

Application

13 SEER Residential A/C

Customer

Family of four in Austin, Texas

Situation

Mid-July, 99 degrees and the customer's air conditioning system is not cooling properly.

Solution

Leveraging the compressor electronics LED indications found in the electrical box of the air conditioning system, the contractor quickly identifies a locked rotor condition and accurately pinpoints the problem as a failed run capacitor, which is then replaced.

Result

The contractor was able to troubleshoot the problem in less than 10 minutes and the homeowner's system was up and cooling in less than 30 minutes.

The contractor quickly assigned to the next service call.



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Refrigeration Contractor Helps Store Owner Avoid \$5,000 Repair Costs With No Loss of Product

Application
Commercial Refrigeration System

Customer
Small grocery store in Detroit, MI

Situation
Store was experiencing repeated callbacks on one of their refrigeration systems.

Solution
The manager of the store upgraded all of his systems to compressors with electronics. The next time the system had an issue, the service technician called to the job was able to diagnose the problem quickly and accurately.

Result
From the LED visual warning, the technician discovered a failing contactor. On another call, a high motor temp warning was displayed and the technician was able to easily fix the simple problem before it caused a major failure.

Two compressor failures were averted, resulting in \$5,000 in savings.



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Scenario 3

Grocery Store Chain Saves Money By Getting Connected

Application

Refrigeration Parallel Racks

Customer

A 100-store regional grocery chain in southern California

Situation

The store's locations are spread throughout the region and they are experiencing shrinking profit margins and increased competition.

Solution

The grocery store chain installed compressor electronics and network capability to all 100 stores.

Result

85% of service calls diagnosed remotely
Overall contractor fees reduced by 20%
Annual product loss savings of \$100,000



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Advanced Capabilities Delivered by Compressor Electronics

Conclusion

This brings us to the conclusion of our “Understanding Compressor Electronics” eBook. Throughout these chapters we tried to give you a better understanding of compressor electronics and explain how they provide better HVACR system performance and help solve challenging industry issues such as the high rate of compressor warranty returns classified as ‘No Fault Found.’

As technology and diagnostic capabilities continue to evolve, the compressor is truly becoming the heart of the HVACR system; not only as the “central organ” keeping the system running but also as an ideal sensor for which to gauge the health of the entire system and through which to gather key operating information.

With the valuable in-depth system information provided by compressor electronics, technicians can make faster, more accurate decisions resulting in improved compressor and system performance and reliability, as well as reducing the amount of expensive repairs and costly callbacks due to improper diagnosis. In certain cases, compressor electronics can even proactively shut down the system to prevent costly damage.

Armed with a better understanding of how compressor electronics work and how the innovative technology provides diagnostics, protection and communication benefits, you are one step closer to properly utilizing the technology to give your customers peace of mind and enjoy the freedom to refocus your time and resources on other pressing priorities.



Savings

Actively shuts down the system, saving valuable time and money.

Reliability

Peace-of-mind knowing systems with compressor electronics will work without catastrophic failure or costly repairs.

Information

By using the compressor as a sensor, electronics provides new levels of diagnostics, protection and communication.



Scan or [click here](#) for more information about compressor electronics from Emerson Climate Technologies.

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