APPLIANCE & HVAC REPORT

Reaching Design Engineers at the OEM Level

July 2023 www.appliancehvacreport.com VOLUME 5 ➢ NUMBER 3

9 FEATURES COVERING

- CONVERSION
- CORDLESS TOOLS
- DECARBONIZATION
- POWER RELAYS
- REFRIGERANTS
- SEMICONDUCTORS
- SAFETY
- SENSORS

TIPS

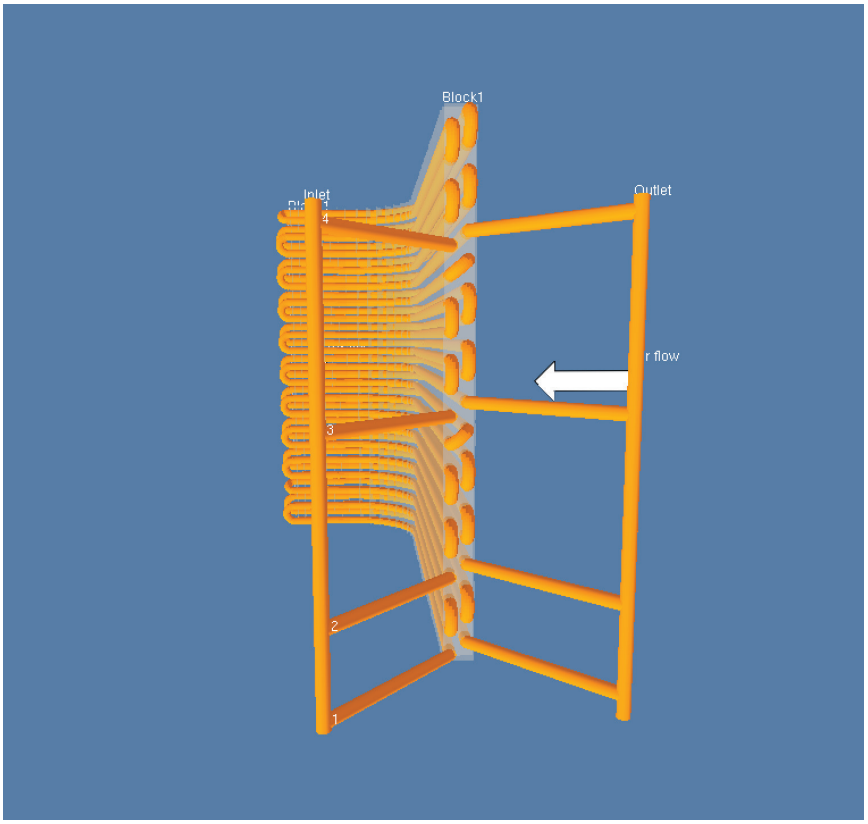
DESIGNING ROBUST AND EFFICIENT CORDLESS POWER TOOLS & CHARGERS

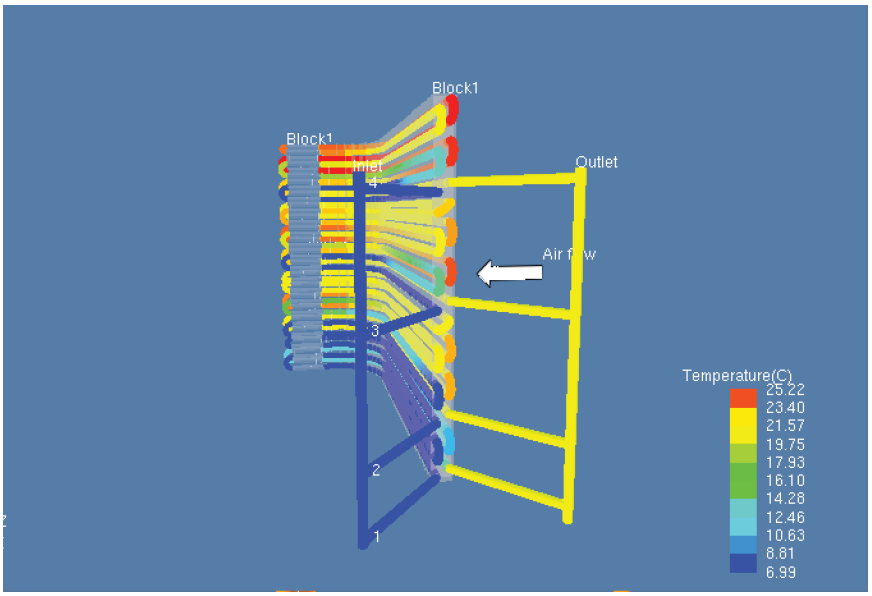
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FOUR REASONS TO REPLACE A REED SWITCH WITH AN MR SENSOR



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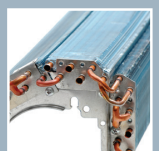
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Welcome to Our Third Issue of 2023!



As we head into the summer months, we've been on the road a fair amount. First we exhibited at the Electrical Wire Processing Technology Expo (EWPTE) in Milwaukee and saw friends from Etco, Vitrek and others.. Second, attended the AMERICAN SOCIETY of GAS ENGINEERS (ASGE) annual meeting in Las Vegas. We are a Platinum Sponsor of ASGE.

And while we normally are at the combined Foam and Adhesive/Sealants Expo and The Battery Show, both in Novi, MI we will only be able to attend the latter this year. It was jammed last go-round.

Getting back to EWPTE, we had an interesting meeting with Jeffrey Buchoff, regarding his dad Leonard S. Buchoff, who is still going strong at 96. I love hearing about people like this.

They are with the LB Connector Co. They were awarded a patent last year, describing a compliant compressive connector pad capable of connecting fine pitch land grid arrays, and its associated method of manufacture. LBC has developed prototypes demonstrating the invention and because of having an inventor still living and born the year Lindbergh crossed the Atlantic and Babe Ruth hit 60 homers, I thought I'd mention it to our audience. His dad is the inventor and has a resume about 8 pages long!

Anyway, both EWPTE and ASGE were well attended, ahead of last year, as the trend of people traveling again has come full circle to pre-pandemic levels. And right or wrong, rare was it to see a mask (though a person next to me on a plane was wearing one).

Close to home (Cleveland, OH) I was struck to see a news item about a local suburb, Cleveland Heights. They are offering a program to residents who will exchange their gas-powered lawn mowers, still functional, for brand new electric ones. More than 100 residents wanted to proceed with the swaps, exhausting the Cleveland Heights supply. Yep, the gas industry is under attack.

Plenty of great information in this issue. Thank you CertifiGroup (now part of Eurofins), Chemours, Honeywell Sensing and Safety Technologies, HongFa America, Littelfuse, S.A. Armstrong Ltd. and The Building Decarbonization Coalition.

Also, a special thanks to our friends at Semiconductor Digest, who shared some very interesting sales and market share information and allowed us to publish it.

Stay well one and all.

Brad

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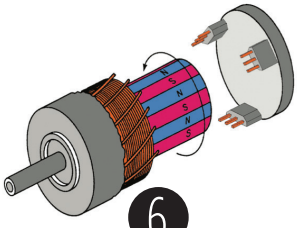
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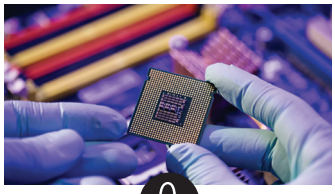


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by Victor Verissimo

One way to help ensure efficiency is by selecting the correct bipolar latching Hall-effect sensor integrated circuit for electronic commutation in BLDC motors.



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Semiconductor Revenue Grew 1.1% in 2022

by Gartner

The market in 2022 for semiconductors was about $602 billion (that's billion with a B) last year, a 1% increase from 2021 at $595 billion.

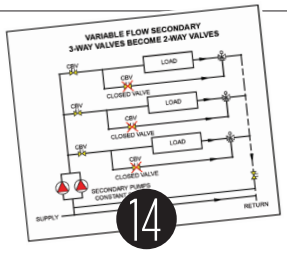


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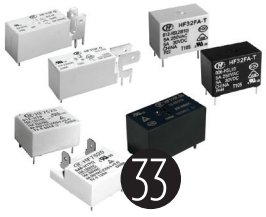
The power tool market is growing, with a compound annual growth rate of more than 6%.



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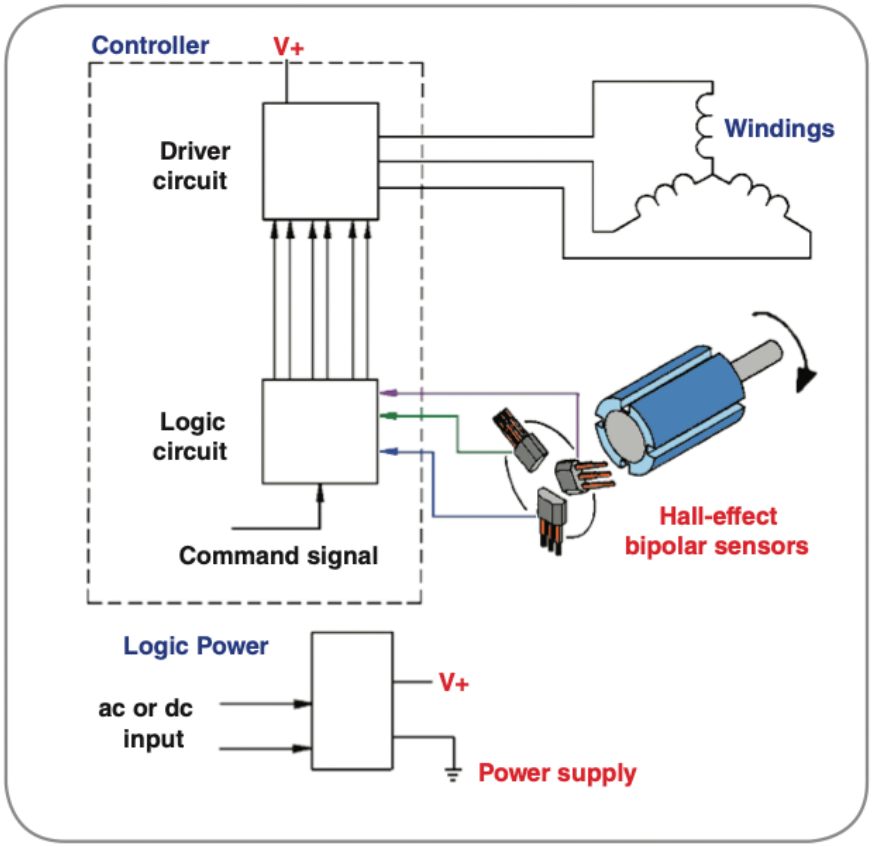
As the U.S. phasedown of high global warming potential (GWP) hydrofluorocarbon (HFC) refrigerants continues, the industry can draw on past events to predict, plan, and protect itself.

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Bipolar Hall-effect sensors are used in BLDC motors to detect the position of the rotating magnet. In this example, an eight-pole motor with a three-phase winding uses three bipolar latching Hall-effect sensors.

How to Select Hall-Effect Sensors for Brushless DC Motors

BY VICTOR VERISSIMO

As energy and cost savings continue to be a concern for designers of electronic devices, brushless DC (BLDC) motors need to operate efficiently. One way to help ensure efficiency is by selecting the correct bipolar latching Hall-effect sensor integrated circuit for electronic commutation in BLDC motors. These tiny integrated circuits play a big role in motor efficiency, which can significantly affect the reliability and performance of many critical applications which all call for a highly efficient and quiet motor, including robotics, portable medical equipment and HVAC fans.

BLDC motors use electronic instead of mechanical commutation to control the power distribution to the motor. Latching Hall-effect sensors, mounted in the motor, are used to measure the motor's position, which is communicated to the electronic controller to spin the motor at the right time and right orientation. These Hall-effect sensors are operated by a magnetic field from a permanent magnet or an electromagnet, responding to South (operate) and North (release) poles. These magnetic sensors determine when the current should be applied to the motor coils to make the magnets rotate at the right orientation.

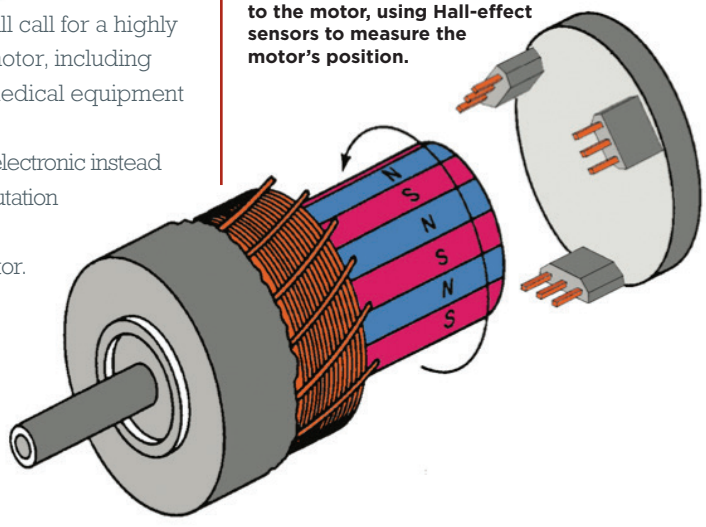
There are several design characteristics that BLDC motor manufacturers should evaluate when selecting a bipolar latching Hall-effect sensor to commutate the motor so it can operate as efficiently as possible. These include sensitivity, repeatability, stability-over-temperature and response time.

Sensitivity

A magnetic field is required to activate a Hall-effect sensor. Sensitivity level is based on the placement of the sensor to the magnet, the air gap, and magnet strength. Product datasheets should indicate the magnetic field strength (measured in Gauss), required to make a bipolar Hall-effect sensor change state (operate and release).

A high sensitivity sensor, typically rated at less than 60 Gauss, compared

BLDCs use electronic commutation to control the power distribution to the motor, using Hall-effect sensors to measure the motor's position.



to a less sensitive sensor allows for the use of smaller magnets or less expensive magnetic materials, which is increasingly important as the prices for rare earth magnets continues to increase. High sensitivity also allows for a wider air gap, which means the sensor can be placed further away from the magnet and still be very reliable, while providing some design flexibility. Or given the same air gap, the sensor is more sensitive, thus delivering higher reliability and repeatability. This means a Hall-effect sensor with high sensitivity or a low magnetic switch point delivers improved motor efficiency.

As an example, Honeywell's SS360ST, SS360NT, and SS460S high sensitivity bipolar latch Hall-effect sensors operate from only 30 Gauss typical at 25 °C, and 55 Gauss maximum over the full operating temperature range of -40 °C to 150 °C. This allows for the installation of lower-cost commutation magnetics and the design of smaller products than if a less sensitive sensor were used.

Repeatability

Repeatability refers to the Hall-effect sensor's latching time. When the sensor output turns on, it directs current through the coil windings in the stationary part of the motor. This current produces a magnetic field that interacts with the field from the permanent magnets on the shaft and causes the shaft to spin.

As the magnet rotates past the sensor, a highly repeatable sensor changes state at the same angular position each time the magnet passes by. For example, one complete revolution of the motor shaft is 360 degrees. If the sensor turns on at five degrees when the shift spins the first time, does it change state at five degrees at the next rotation? A highly repeatable sensor is one that has a consistent response time, which will maintain all of the angular measurements very close to the same value. In this case, at five degrees.

Why is this important? To produce the maximum amount of torque on the shaft, the timing between current flowing through the coil and the position of the shaft must be as accurate as possible. If there is a delay in the sensor's response to changes in the magnetic field, this slow response can lead to low bandwidth and accuracy errors. Any error in the switching point of the Hall-effect sensor will reduce the torque of the motor, which hinders motor efficiency.

Stability

Similar to repeatability, stability refers to how much the angular position changes, but in this case, versus temperature or voltage. For example, if the sensor output changes state at five degrees at 25 °C, where does it change state at 125 °C? The Gauss level required to turn a part on at 125 °C needs to be as close as possible to the Gauss level required to turn a part on at 25 °C. So, if a part operates at 30 Gauss at 25 °C, does it operate around 30 Gauss at 125 °C, or does the operate point shift to, for example, 50 Gauss or 5 Gauss?

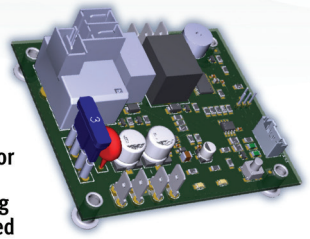
Honeywell's SS360ST, SS360NT, and SS460S high sensitivity bipolar latch Hall-effect sensors have operate-and-release points that are nearly

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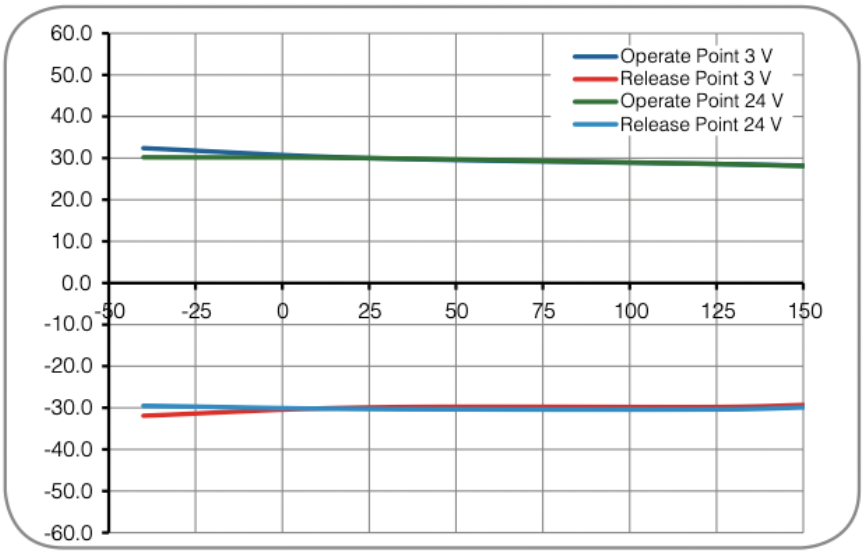




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The Honeywell SS360ST, SS360NT, and SS460S bipolar latching Hall-effect sensors offer reliable switching points over its operating temperature range of -40 °C to 150 °C.

magnetically symmetrical over the operating temperature range. This means a sensor operating at positive 30 Gauss will release at approximately negative 30 Gauss.

This is important because stability-over-temperature, coupled with high sensitivity, is needed for precise position detection. Magnetic stability also helps improve jitter performance, which is critical for BLDC efficiency, and reduces speed variation.

Response Time

Response time is the time it takes for the output of the sensor to change state. For example, if a sensor has an operating point of 30 Gauss, and a 30 Gauss magnetic field level is applied to the sensor, the response time is measured from the point when the 30 Gauss field is applied to when the output changes state.

A fast response time to a change in the magnetic field delivers efficiency in commutating a BLDC. If a sensor switches at a different magnetic field level than what is required due to slow response or delay, this could result in accuracy errors.

Motors need to switch at a very specific point to achieve the highest efficiency. Mis-commutation results in lower effective torque constant and higher torque ripple that can cause additional noise as well as impact efficiency and system performance.

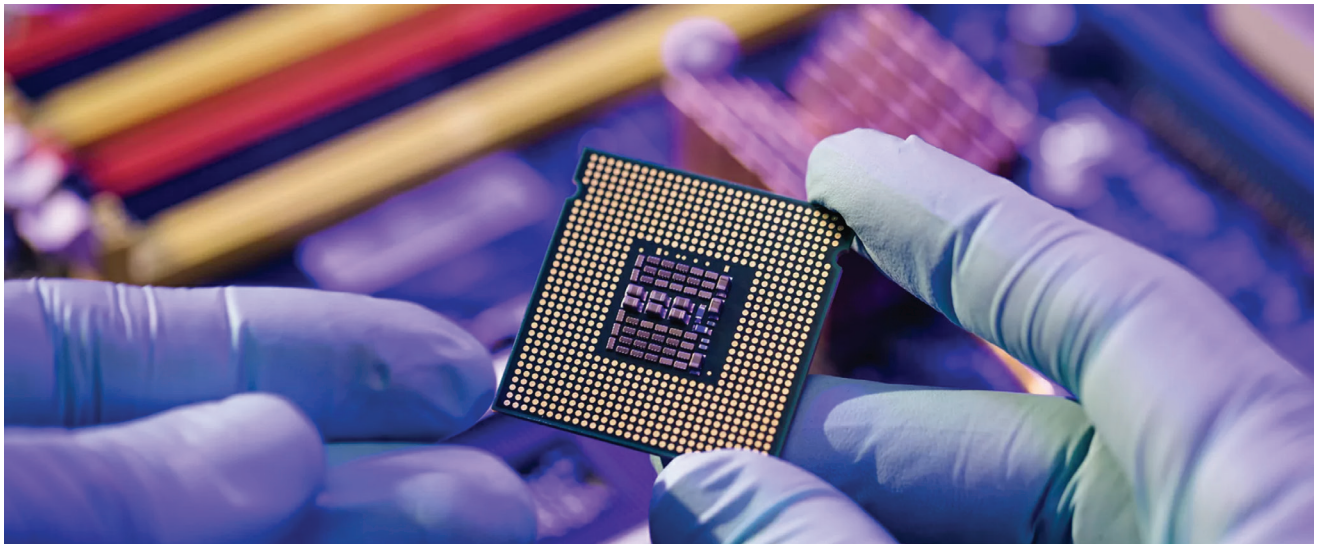
It's also important to note that sensor manufacturers have achieved high sensitivity and stability-over-temperature by using a technique called chopper stabilization. This results in a highly repeatable and stable sensor over the operating temperature range using single or dual Hall-effect sensing elements. However, this technique can negatively affect motor efficiency due to several disadvantages, including slow response time and increased electrical noise.

Honeywell's sensors eliminate the need for chopper stabilization by using a quad Hall-effect sensor, instead of a single or dual Hall-effect element, together with proprietary software, to account for any drift in the switch point. These sensors also exhibit a fast response time, reduce sensitivity to packaging stresses, and produce less noise, resulting in improved motor efficiency.

Don't underestimate the value of Hall-effect sensors in BLDC designs. These tiny devices shouldn't be an afterthought during the design process as they have a big impact on motor efficiency. Designers should look closely at several specifications including sensitivity (60 Gauss rating or less), repeatability (changes state at the same angular position each time the magnet passes by), stability (operate and release points virtually symmetrical over the temperature range), and response time (switching as close to the change in the magnetic field level). ●



Victor Verissimo *joined Honeywell in 2019 and is currently the General Manager for Honeywell Sensing & Safety Technologies. Victor has over 30 years of experience transforming and leading strategic business teams. Prior to joining Honeywell, he was the Vice President of Marketing and Pricing for Nvent Electric Plc and before that, he served as the Senior Director of Marketing for Flowserve Corp. Victor has a BSEE from the University of Johannesburg, South Africa and a MBA from the IMM Graduate School of Marketing in Johannesburg, South Africa.*



Gartner Says Worldwide Semiconductor Revenue Grew 1.1% in 2022

BY GARTNER, INC. AND SEMICONDUCTOR DIGEST

Top 10 Worldwide Semiconductor Suppliers by Revenue
2022 vs. 2021 in Millions $ / Market Share Listings

Company	2022 Revenues	2022 Market Share %	2021 Revenues	2021 Market Share	2022 vs 2021 Sales Growth %
Samsung Electronics	65,585	10.9%	73,197	12.3%	-10.4%
Intel	58,373	9.7%	72,536	12.2%	-19.5%
SK Hynix	36,229	6.0%	37,192	6.3%	-2.6%
Qualcomm	34,748	5.8%	27,093	4.6%	28.3%
Micron Technology	27,566	4.6%	28,624	4.8%	-3.7%
Broadcom	23,811	4.0%	18,793	3.2%	26.7%
AMD	23,285	3.9%	16,299	2.7%	42.9%
Texas Instruments	18,812	3.1%	17,272	2.9%	8.9%
Mediatek	18,233	3.0%	17,617	3.0%	3.5%
Apple	17,551	2.9%	14,580	2.5%	20.4%
Other	277,501	46.1%	271,749	45.7%	2.1%
TOTAL MARKET	**601,694**	**100.0%**	**594,952**	**100.0%**	**1.1%**

Source: Gartner (January 2023)

Semiconductors are used in thousands, even millions of applications, including in appliances and HVAC products. So with some help from my friends we thought we'd publish sales statistics on this industry.

The market in 2022 for semiconductors was about $602 billion (that's billion with a B) last year, a 1% increase from 2021 at $595 billion. It's highly fragmented however compared to many industries. The Top 10 suppliers worldwide account for less than half of total revenues, while the Top 25 last year accounted for 77.5% of the industry.

Samsung and Intel are the leaders, with a combined share of about 21%, but that fell from 24% in 2021. Apple moved into the Top 10 in 2022 after ranking 11 the year before.



U.S. Department of Energy Secretary Jennifer Granholm and Rep. Katie Porter tour an all-electric home in Irvine, California, in 2022.

The U.S. has become a global leader in the movement to eliminate pollution from buildings

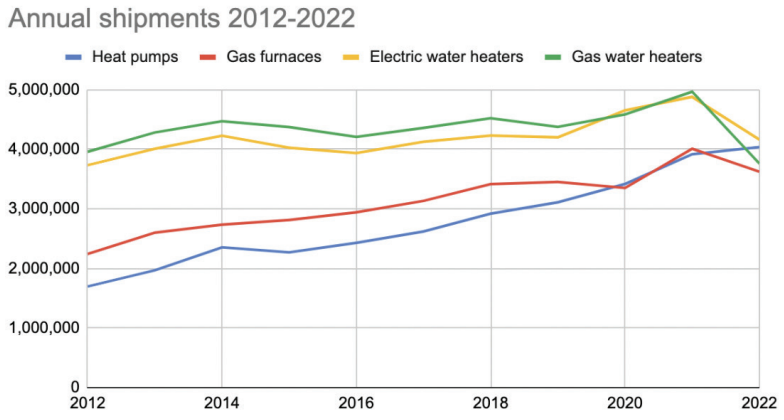
BY PANAMA BARTHOLOMY

The Building Decarbonization Coalition unites critical stakeholders on a path to transform the nation's buildings through clean energy, using policy, research, market development and public engagement. Working alongside members including policymakers, appliance manufacturers, utilities, and many more, the coalition is charting the course to eliminate fossil fuels in buildings to improve people's health, cut climate and air pollution, prioritize high-road jobs, and ensure that our communities are more resilient to the impacts of climate change.

In less than four years, a movement to eliminate pollution from buildings in the U.S. by switching from fossil fuel appliances to highly efficient electric alternatives has prompted changes from coast-to-coast while spurring new innovations in clean energy technologies such as heat pumps and heat pump water heaters. This has forever changed how Americans are heating, ventilating, and cooling the spaces where they live, work, and play to be safer, healthier, more comfortable, and with lower energy usage and utility bills. A new report published by the Building Decarbonization Coalition offers a comprehensive analysis of how and why these transformations have taken place.

According to data published in February, heat pump shipments in the U.S. outpaced gas furnaces in every month of 2022. For the first time in the nation's history, it was reported in 2022 that more homes use electric heating than gas. Thirty years ago, only 25% of homes used electric heating. That number is surging thanks to heat pumps' explosion in popularity and advanced efficiency compared with older electric heating options. The

For the first time, heat pump shipments outpaced gas furnaces in every month of 2022.



Source: Air-Conditioning, Heating, and Refrigeration Institute shipment data

U.S. now ranks second in the world in growth of heat pump sales, trailing only Europe.

All of this has happened before the billions of dollars in the Inflation Reduction Act have rolled out. Despite polarized political debate on the topic, the report finds that the U.S. has emerged as a global leader in the movement to eliminate pollution from buildings as the building sector has embraced the shift.

One in every five Americans now lives in an area that has passed a policy requiring or encouraging building electrification. 100 municipalities and four states have adopted these policies, and more are in the progress of doing so this year. Four years after Berkeley, Calif., became the first city in the U.S. to require 100%-electric new construction, change is happening astonishingly fast. Millions of residents will be able to tap into incentives to electrify their homes passed in the landmark federal climate law, the Inflation Reduction Act of 2022, starting this year.

Coast-to-coast, from L.A., to New York City, to the Pacific Northwest, to Washington, D.C., Maine and up near the crest of the Rocky Mountains — in Crested Butte, Colo. — cities, states, corporations and other private entities are reshaping every building type imaginable to be all-electric: apartments, homes that are brand new and more than a century old, retail stores, schools, restaurants, offices, and skyscrapers. In the entirety Washington state, the vast majority of every new building will be all-electric starting in June 2023. In New York State, all new buildings will be all-electric beginning in 2026.

The Electrification Marketplace is Ramping Up Quickly

Innovative companies are responding to these market signals. New technologies like cold-climate heat pumps and battery-powered induction stoves are rolling out and solving some of the most challenging aspects of making buildings 100% electric. Because they deliver unmatched efficiency and are pollution free, electric appliances lower energy usage and save money on bills, while making buildings healthier, safer, more comfortable, and with better indoor air quality. All-electric buildings create a better quality of life for Americans while slashing a massive portion of U.S. greenhouse gas emissions.

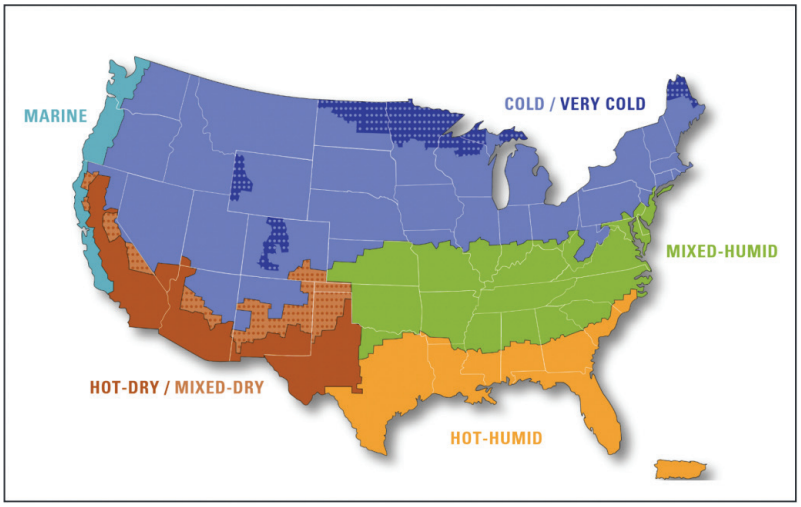
A growing body of scientific research has also exposed the concerning health risks of living in homes with gas appliances like stoves and furnaces, and added greater urgency to the building decarbonization movement. Studies have shown that gas appliances leak toxic chemicals and carcinogens such as benzene even while turned off, and pollution from gas stove use is attributed to one in every eight cases of childhood asthma in the U.S. Because methane is an extremely potent greenhouse gas, leaks in the delivery system also compound climate change impacts.

To meet the explosion in consumer demand, the report finds that manufacturers are scrambling to ramp up production while innovators are rolling out new technology for household electric appliances. In 2022 we saw significant technological advances in water heating that allow for easy plugin and avoid costly electrical upgrades. We also saw a proliferation of heat pumps that are able to store energy while electricity is plentiful on the grid, and reduce electricity demand while the grid is under stress. This type of innovation will only continue to grow as states like California implement plans to stop selling fossil fuel heating appliances before 2030.

Cold climate heat pumps have been crucial in expanding building electrification in the U.S. 50% of residential gas consumption in the U.S. occurs in nine cold-climate states, and heat pump adoption has historically been weakest in these states because older technologies struggled in cold climates. That's no longer the case. Existing models of cold-climate heat pumps are performing exceptionally well in extreme winter storms, but technological breakthroughs are keeping homes comfortable when it's below 20 degrees Fahrenheit outside. The shift to cold climate heat pump use is exemplified by Maine's goal of installing 100,000 heat pumps by 2025, which is set forth in state law—

Breakthroughs in cold-climate heat pumps

Advancements and innovations in cold-climate heat pump technology is now enabling these systems to keep homes and buildings warm and comfortable in regions of the U.S. known for their extreme, bitterly cold winters.



Source: U.S. Department of Energy

In the hot-humid areas of the Deep South, 30% of homes use heat pumps. In the mixed-humid areas of the Upper South, 22% of homes use heat pumps. It's less than 10% in the marine areas of the West Coast and less than 5% in the Northeast, Midwest, and Mountain West.

and they are on track to meet. From Colorado to the Canadian border, cold climate heat pumps were put to a major test during an extreme winter storm in December 2022. They passed—these systems kept homes warm as temperatures remained well below zero degrees day and night.

Other Recent Heat Pump Innovations

- Last year, heat pump manufacturer Lennox was the first company to complete the U.S. Department of Energy's Cold-Climate Heat Pump Challenge, and has developed an air-source model that delivers 100% heating at -15 degrees, and 70- to 80% heating at -23 degrees. The company hopes to bring the product to markets in 2024. Trane is field-testing its own model of cold-climate heat pump as part of the DOE challenge.
- Other types of heat pump technology are being adapted for cold climates. Manufacturers Johnson Controls and SpacePak produce a mini-split system and air-to-water system, respectively, that work effectively in bitterly cold conditions. SpacePak's system performs well at -22 degrees.
- This technological innovation isn't limited to extreme winter weather, either. For the first time in North America, in 2021 Manufacturer Daikin began selling a ducted heat pump system called Atmosphera that uses a refrigerant with one-third of the global-warming potential of commonly used refrigerants in HVAC systems. Last year, Rheem began selling a heat-pump water heater that works with buildings' 120-volt electrical systems, helping some homeowners avoid costs of upgrading to 240-volt electrical panels.
- Startup heat pump company Harvest Thermal has created a system that shifts its performance for times of day when there's lower demand for electricity, helping balance the power grid—which is critically important as operators navigate more extreme heat waves every summer. The system is able to store energy while electricity is plentiful on the grid, and reduce electricity demand while the grid is under stress.

Similar to how innovations helped drive down costs for electric vehicles, companies are rushing to develop solutions to remove cost cost barriers for electric HVAC appliances, improve customer experiences, and bring new products to market. With heat pump sales already surging and billions of dollars of incentives for home electrification about to be made available through the Inflation Reduction Act, innovators see this as an opportunity to do for electric homes what they did for the electric car.

The startup accelerator Y Combinator has dozens of companies engaged on home electrification, and expects even more to join as tech layoffs drive an increasing number of entrepreneurs into the climate tech space. Innovations include companies developing battery-powered induction stoves that plug into 120V outlets, and heat pumps with batteries that can operate when the power goes out and contribute to lower energy bills, smart electrical panels with AI built in, to companies intent on improving the customer experience in engaging electrification contractors and making it easier to use Inflation Reduction Act rebates at point of sale.

American households' preference for heat pumps extends beyond a basic decision not to use gas. They're choosing heat pumps over other traditional electric HVAC options suchas resistance heating, because heat pumps deliver superior performance, unmatched efficiency, lower energy

bills, and keep homes comfortable year-round. Heat pumps use 50% less energy than resistance heating. Nationwide heat pump sales grew by 15%. in 2021, which places the U.S. behind Europe's 35% sales growth but ahead of China and Japan's 13%.

In 2020, 18 million homes in the U.S. used heat pumps for space heating and cooling, a 34% increase from 2015, according to the most recent data from the U.S. Energy Information Administration. Heat pump adoption differs by geographic region, primarily due to variability in climate and development patterns. Because of their mild year-round climate, states in the Southeast have historically had the highest number of heat pumps.

This has begun to change, as states like California lead a charge in transitioning buildings away from fossil fuel appliances, and major cities like New York implement their citywide electrification policies. This shift spotlights the need for contractors in every state—and training programs that will build their knowledge and skill-levels for heat pump installations.

A Year of Historic Federal Action in the U.S.

2022 marked two historic firsts—it was the first time Congress passed a major law aimed at addressing climate change, and it was also the first time a U.S. president touted the benefits of getting a heat pump in an official address.

According to modeling, the Inflation Reduction Act could cut annual emissions enough to close two-thirds of the remaining gap for the U.S. to reach its 2030 climate target (50% below 2005 levels). Building decarbonization will be a key part of the law's aims to slash emissions from the building and power sectors. The IRA's tax credit program is estimated to spur installation of 7.2 million heat pumps in the U.S. in the next decade. While this investment is significant, the IRA alone cannot transform the market to the extent needed for mass-scale building electrification. It will, however, accelerate progress in numerous states and sound a starting gun in others.

The intensifying threat of climate change is making storm patterns and natural disasters more extreme, presenting enormous challenges to energy systems. Safely maintaining and upgrading fossil fuel delivery systems requires enormous amounts of time and money. These investments would be best spent evolving the electric and thermal network systems we need to sustain a renewable energy future. A fully electric energy system, powered by renewable energy, will do everything that fossil fuel systems can do, but better, more efficiently, and more affordably for consumers.

How quickly this happens will have drastic consequences for our future, because the world is building at a rapid pace. Across the globe, the squarefoot equivalent of an entire New York City is projected to be built, every month, until 2060. Every new building with gas hookups will one day require expensive retrofits to be all-electric, demonstrating the importance of building all-electric from the start.



Panama Bartholomy *is the Executive Director of the Building Decarbonization Coalition.*

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Conversion From a Constant Flow System to a Variable Flow

BY TONY EGAN

How to Save Pumping Energy in Hydronic HVAC Systems

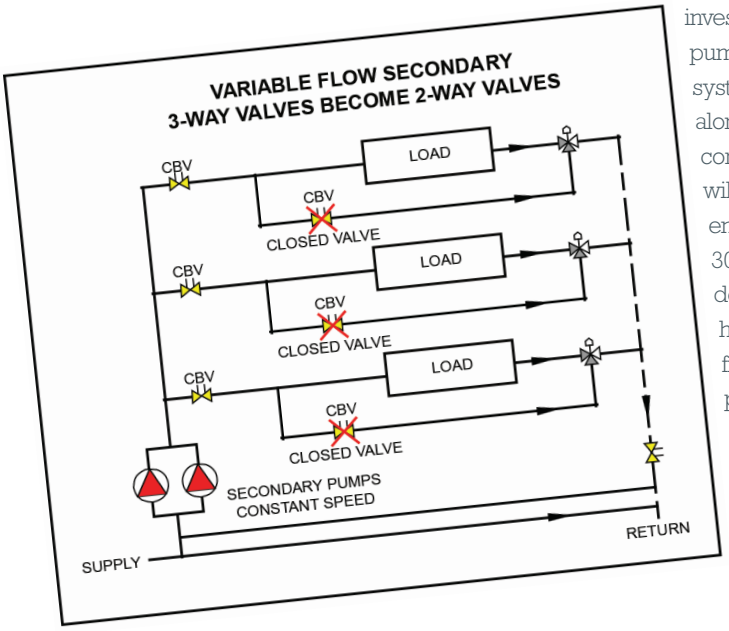
Hydronic HVAC equipment is typically oversized; even for design day conditions. De-sign day conditions are the design flow and head losses necessary to meet system heat loss calculations based on the listed highest design and lowest temperature periods for the geography. Many times equipment is oversized by design to lessen the risk of an equipment redesign being necessary due to system calculation errors and/or building changes during construction.

Constant Flow System to a Variable Flow System

To reduce power costs, it may be decided to change the system from a Constant Flow type to Variable Flow. With 3-way valves installed there is no opportunity to reduce the pump flow, as the valve bypass port is designed to open as the load is reduced; resulting in constant pump flow. Should the bypass line valve be closed, the 3-way valves would effectively become a 2-way valve. As the valve then modulates closed to reduce a load coil flow on mild days, the excess flow would no longer be bypassed; thus the loop differential head would increase as the control valve throttles the flow. As this throttling reduces the system flow, pumping power needs are reduced.

The Value of Variable Speed Pumps in Variable Flow Systems

There are two major decisions to be made to derive full benefits from variable flow systems. The first is whether to make the system design suitable for variable flow and the second is to understand the value of investing in variable speed pumps. Converting the system to variable flow alone while retaining constant speed pumps will save pumping energy; typically 20% to 30%. This energy saving does not come easily however. As the flow from constant speed pumps is throttled by 2-way valves the pressure across the pumps and the control valves increases. This leads to some reduction in the pump life due to higher bearing loads and, perhaps more importantly, makes the conditioned spaces temperature harder to maintain. As the pressure across control valves increases the valves must close to a greater extent to allow a given amount of water to pass through the load. With higher differential pressures a small change in the valve lift results in a large change in the flow; this can cause 'hunting' of the valve stem position resulting in loss of effective control with fluctuating conditioned space temperatures.



Variable speed pumps, combined with a control system that recognizes current system conditions, will reduce pump speed during part-load periods, reducing pressure in the system to a value that satisfies the current load flow requirements with mini-mum over-pumping. This will reduce pumping energy use to a minimum, extends the life of the pumps and motors and increase the effectiveness of the control valves by reducing the differential pressure across them.

Benefits From Converting Constant Flow Systems to Variable Flow With Variable Speed Pumps

- Reductions in absorbed pumping power that are realized when a heating or cooling system runs under 2-way control with variable speed pumps
- Reduction in total operating costs, which can often payback the change costs expended in the first year. If the payback is in the first year, then no new capital is required and the conversion costs can be expended out of the revenue budget
- Armstrong have published an easy to use Opportunity Calculator for easy return on investment calculations which is used to demonstrate to the user/operator in a transparent way the cost savings and payback time for the

new equipment

- Reduced water borne noise, as water velocity is reduced
- Longer product life, as it is no longer operating at full speed
- No check valve chatter, as the pumps work on soft start and soft stop under the variable speed control
- In the UK a newly converted system may help the building qualify for a higher grade Energy Performance Certificate. If the modified building is run through the SBEM energy model software, a reduced input power will be evident
- In North America a newly converted system will help the building achieve a desired LEED certification

Armstrong is able to supply a unique Sensorless control, for duty standby systems, integrated within Vertical In-Line pumps, where the pumping unit will react to the needs of the system without the resources required to acquire, install and wire a re-motely mounted system feedback sensor. The pump curve data is mapped into the control software which can precisely place the operating position on the pump curve by monitoring the motor power and speed. This enables the unit to react to system condition in precisely the same manner as conventional controls react to a remotely mounted system feedback sensor.

Variable Flow System Conversion–Piping Considerations

A challenge for many hydronic system designers is to correct a misunderstanding by some building owners/operators that a system can be converted to variable speed with all its implied energy and cost savings merely by installing an adjustable frequency drive onto the pump motor.

In reality the system piping inside and/or outside of the Plant Room may require modifications. In the following sections 3-way and thermostatic radiator valves are discussed in addition to compensated heating systems with mixing valves, fan coil unit systems and primary pumps. The need for a bypass line on 2-Way valve control systems is also discussed.

Variable Flow System Conversion–Radiator Systems

Radiator heating systems are easily converted to variable flow systems. Many radiators are already fitted with Thermostatic Radiator Valves. (TRV) If not, they can be readily and inexpensively installed. They do not require an electrical supply and can be easily set to provide effective room temperature control. TRVs interrupt the water flow when the room reaches design temperature. A self-regulating variable speed pump such as the Armstrong IVS Sensorless pump will recognize this reduction in water flow demand and reduce speed; saving power and energy costs.

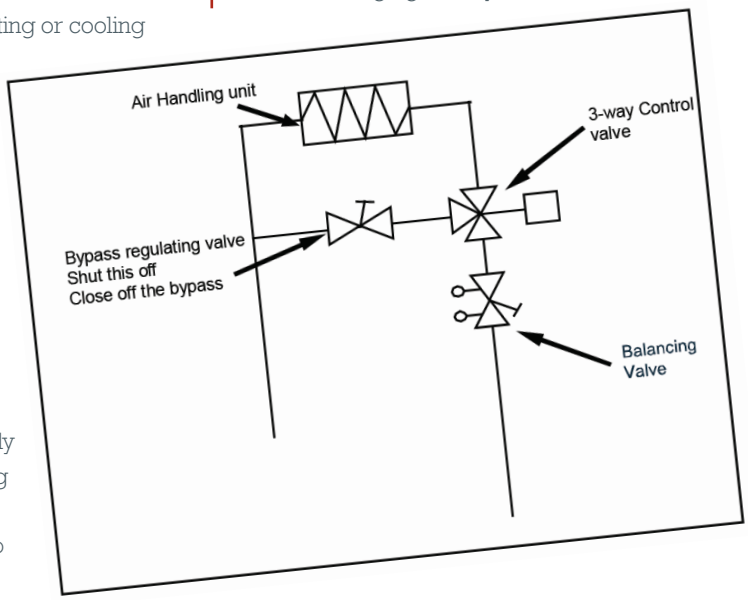
Variable Flow System Conversion–Valve Conversion

3-way valves are the work-horses for heating and cooling control of conventional constant flow systems. Connected through the Building Automation System (BAS) to thermostats located in conditioned spaces, the 3-way motorized valve either directs the heating or cooling water through the coil in the Air Handling Unit (AHU), or, if the space being served is at normal operating temperature, the flow is directed through the bypass line to the return piping. The bypass line is normally fitted with a regulating valve, set so that the bypass pressure drop matches that of the coil in the AHU. Thus, which ever way the water is being directed, the pump sees little change in flow or head and continues to operate at full speed.

Current state of the art variable flow energy saving pumping systems use a 2-way motorized control valve and are installed without a bypass line.

To convert existing 3-way valve systems to 2-way valve configuration is relatively easy. Simply close the regulating valves in the bypass lines. With the bypass closed, when the 3-way valve modulates attempts to divert the flow around the load and through the bypass, it will restrict the flow rate instead. An Armstrong IVS Sensorless pump will sense this deviation from its control curve and reduce speed until the pre-set control curve, the system resistance curve and the pump performance curve at a new speed converge for the new operating point. Thus power is saved and operating costs reduced. Water velocity is reduced, noise is reduced and equipment time between repairs is extended.

This conversion can be applied to most AHUs as they are generally installed with these 3-way valves and have easily accessible bypass lines, fitted with regulating valves. It gets more challenging with systems



feeding Fan Coil Units (FCU) as they are often supplied without motorized valves.

Variable Flow System Conversion– Fan Coil Units

Fan Coil Units (FCUs) are almost smaller versions of AHUs. They are generally located in the conditioned space being served; typically in a ceiling or wall space. An FCU is served by pipes to feed chilled water and heating water and may have duct-work from the HVAC air system. Older FCU are controlled by a room thermostat and control their output by a combination of a multispeed fan and/or a damper which throttles the air flow into the space being served.

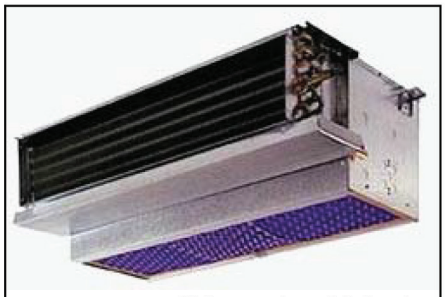
Modern fan coil units may be fitted with 4-way control valves, either the rotary type, or the vertical acting type shown in the picture. Both provide an internal bypass from the supply to the return line.

Converting these valves to 2-way is not simple and involves getting access to the FCU, of which there may be many, opening them up and changing out the valve.

This expense will make the payback period very long. An alternative strategy to convert to variable flow systems is required.

Variable flow system conversion - Control of return temperature for FCUs

One alternative strategy is to leave the FCU and controls in place unchanged and investigate an alternate control opportunity. When the FCU is operating on bypass, the water leaves the FCU at the same temperature that it enters, no heat is being supplied into or taken from the conditioned space as the temperature setting has been reached. This means that pumps can be controlled by measuring the return temperature and can reduce the flow rate/operating speed until the return temperature is back to design return temperature range. To prevent the possibility that certain zones may be under pumped when others zones are satisfied, multiple sensors need be applied to return pipework around the building so that all areas are served. Currently the Armstrong IPS system would serve for pump control for up to 18-zones. Armstrong is further developing a controls package for this application.



Picture courtesy of Actionair

Variable Flow System Conversion– Primary Pumps

Primary pumps typically operate at constant speed to produce a constant flow of water through the chiller or boiler and serve a low loss recirculation header. The secondary pumps take water from this low loss header to circulate through heating or cooling building load heat exchangers. As boilers and chillers need minimum flow requirements; secondary pumps have the highest opportunity for energy savings. On the other hand, many primary pumps are over-sized for the low resistance of the system they serve. As a result many are throttled back, which wastes power and money. One solution is to fit a drive to the motor, open up the throttling valve and manually reduce the pump speed until design flow rate is achieved. No automatic controls are required. Speed is reduced and energy is saved for the life of the system. Noise will be reduced if the throttle valve were noisy. Many modern chillers can accept a variable flow through their heat exchangers. Request minimum flow data from the chiller or boiler manufacturer and any controls advice before proceeding with any changes to primary pumps. Armstrong can supply IVS Sensorless rotating assemblies for existing Armstrong VIL pumps, which will make primary pump energy savings a real possibility with little capital cost.

Variable Flow System Conversion– The Bypass

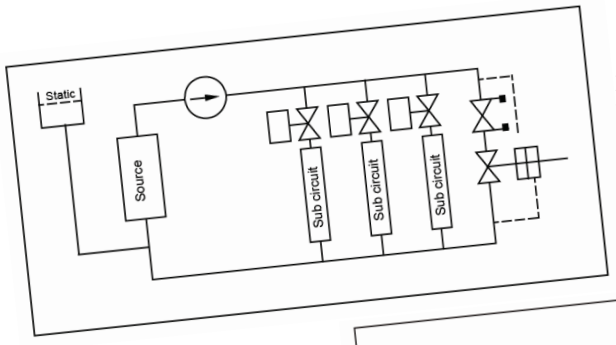
Variable flow HVAC systems converted from 3-way control to 2-way valve control will find certain challenges when all of the 2-way valves are shut off:

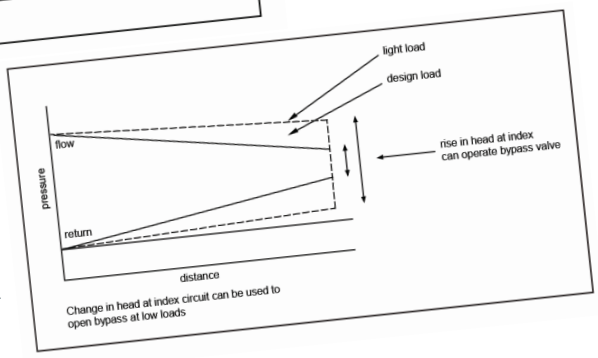
1) The pump may overheat when it continues to run against a closed valve at its minimum speed. This may lead to premature seal failure or thermal shock cracking issues if cold water is suddenly allowed into a hot cast iron casing

2) The temperature of the conditioned water in the headers and remote risers, now stationary, will decay to ambient. This means that when a space eventually requires heating or cooling, there will be a delay as the freshly heated or cooled water from the boiler or chiller finds its way from the plant room, up the riser and along the floor to the terminal. This may cause user discomfort, generating complaints

3) One solution for 2-way motorized valve control systems is to fit a remotely mounted bypass line with a control valve. This, suitably engineered and controlled, will maintain a minimum flow rate in the header, keeping the system pipework at the correct temperature and prolonging pump and pump seal life

4) The bypass flow required is generally between 5 and 10% of a single pump de-sign flow rate. However, as the pump will be operating at the lowest speed required to maintain the minimum system pressure, this flow should be calculated based on minimum speed Best





Efficiency Point (BEP) from the variable speed pump curve

5) Several methods of providing a suitable bypass are discussed in the following sections.

Variable Flow System Conversion–Bypass Control 1

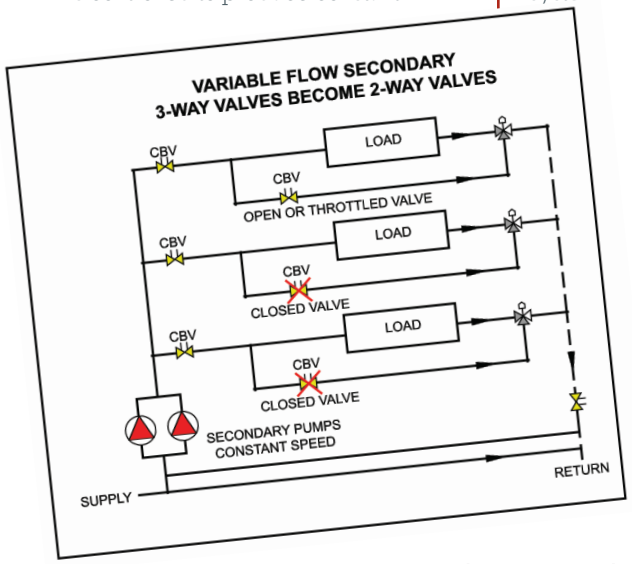
One easy method for bypass control that Armstrong recommends is that, when con-verting a 3-way valve system to 2-way configuration, simple leave the most remote 3-way valve bypass line open on each riser. If there are only few loads in the zone, close the most remote 3-way valve bypass regulating valve 50% so that energy is not wasted with too much conditioned water being returned unused to the chiller or boiler. In this manner, water will only be bypassed when the remote load is satisfied and, as the remote load is typically the least served in the system, this would probably be when all loads are satisfied and bypass flow is required. Other bypass opportunities are discussed in the following sections.

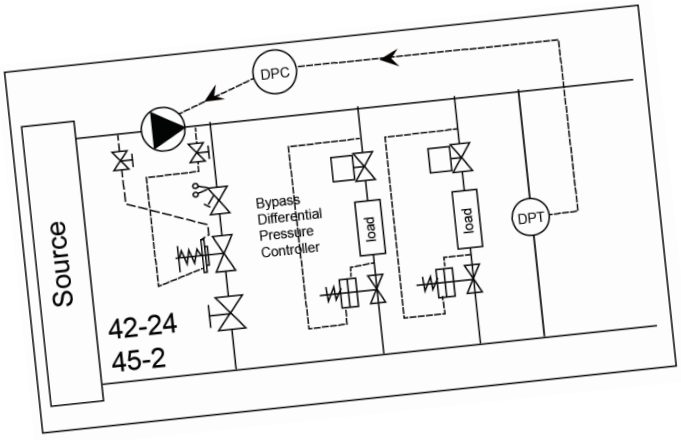
Variable Flow System Conversion–Bypass Control 2

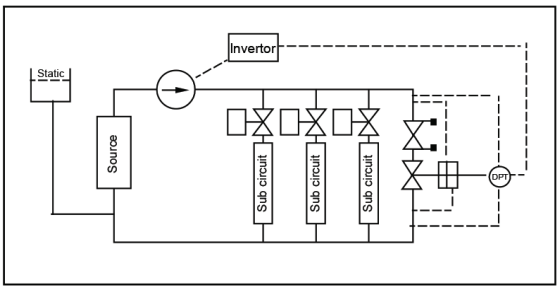
This example shows how a bypass valve is installed and controlled for variable speed pumps where the differential pressure controller is located at the pump. The pump in the picture is controlled to produce constant pressure local to the pump in the plant room. This design does not produce the largest value of energy savings, however it can explain the operation of the bypass easily. The diagram below the system schematic shows how the pressure varies around the system. The pressure is highest across the pump (on the left of the diagram) and then reduces as the water flow passes around the system supply piping. The pressure drops again through the index leg (On the right) and continues to fall as it returns to the pump through the return piping. When all the 2-way valves in the system are open, the water velocity is greatest and the friction / pressure losses are the greatest so that the differential pressure at the index leg is lowest. However, at low load, when all the 2-way valves are closed, the friction loss in the supply and return pipework is reduced, causing the differential pressure at the index leg to increase. This change in pressure can be used by a pressure controlled valve to open and allow water to pass through the bypass line, located at the end of the system. The understanding of where the differential pressure controller is located and the concept of friction loss reducing drastically in the distribution piping at low flows is fundamental in understanding Bypass Control sections II, III & IV.

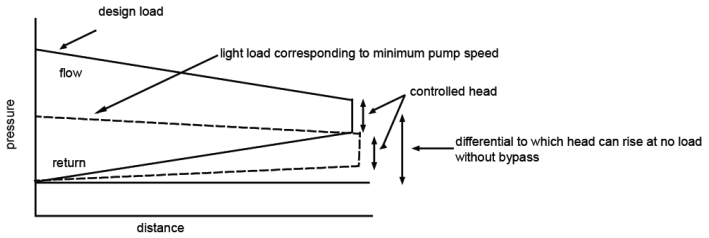
Variable Flow System Conversion–Bypass Control 3

The installation illustrated has a differential pressure (DP) controller mounted on the index circuit for highest energy savings. The pressure will be constant at the remote point and will vary closer to the pump in the plant room as the loads vary and the pump speed adjusts to match the DP setting and the actual friction loss in the distribution piping. The pressure actuated bypass valve is located in the plant room. Normally closed, it senses the fall in differential pressure in a part load situation and opens, allowing









Change in head at index circuit can be used to open bypass at low loads

a minimum flow through the pump. While simple and easy to install, it does not provide the minimum flow needed to keep the water in the distribution piping at the operating temperature.

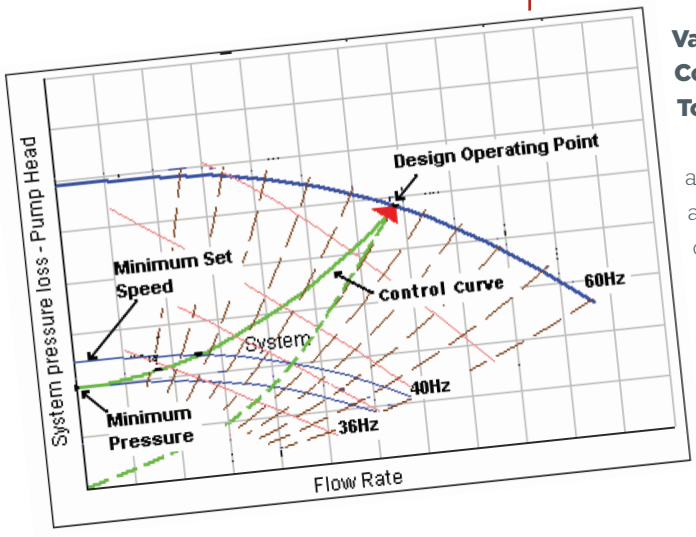
Variable Flow System Conversion–Bypass Control 4

This bypass example provides a good bypass functionality; however the setup is more complicated. In this case both the bypass and the differential pressure transducer are mounted remote to the pump on the index line. This produces the best energy savings and the pipework maintains the required operating temperature.

For this to operate effectively the minimum frequency on the drive control must be set high enough that at low load, where the losses in the distribution piping are small as the flow rate is very low, the pump will operate at its minimum set speed and move left, up the performance curve, increasing the pressure at the index, causing the bypass valve to open. The closed valve pressure of the pump at its minimum frequency must be 25% higher (12% higher frequency) than the control pressure setting of the pressure transducer at the index.

Variable Flow System Conversion–Bypass Control 4–Pump Operation

The above diagram illustrates how the pump performance tracks the load on the system, when set up to open a bypass valve mounted on the index. Be-ginning at the design operating point, the pump will track the quadratic control curve down to the minimum speed setting. As the system 2-way motorized control valves continue to close, reducing the system flow, the controls will not allow the drive to reduce speed further so the operating point must move to the left along the minimum set speed performance curve, causing a rise in pressure as it approaches zero flow rate. This rise in pressure actuates the bypass valve, which will open, permiting the minimum flow to pass through the bypass line.



Variable Flow System Conversion–Pump Topics

If the existing motors are going to be re-used and will be fitted with drives for the first time, checking the suitability of the motor for inverter use with the manufacturer's representative in your area. High voltage spikes from adjustable frequency drives apply more stress to the insulation systems of motors than constant speed application. Motor insulation not suitable for inverter use may break down, causing motor failure. Generally, older motors with Class B insulation may not be suitable for inverter use and modern motors with Class F insulation should be checked also.

Generally the motor manufacturer will need to know the drive carrier frequency set-ting and the cable length between the drive and motor. If in doubt, it makes sense to change out the motor if supplying a new drive. If the pumping unit is an Arm-strong vertical in-line type, a new complete rotating assembly, supplied with Sensor-less Controls can probably be supplied to fit directly into the existing pump casing. Ask your local Armstrong representative for more information.

Variable Flow System Conversion–Electrical Topics

In a plant room, the conversion work involves fitting the new rotating assemblies to the existing pump bodies or supplying stand-alone controls, Sensorless or not, for exisiting pumps. The existing pump control panels and the contactors inside them are now redundant and may now be removed from site. If the owner prefers to retain the existing control panel as is contains other equipment and is already set up for BAS interface, the power cables can be wired into the new drives instead of the old motors. Trying to fit the drives inside a central panel with long cable to the motors is not the best solution. This can lead to

harmonics problems causing noise and motor insulation damage and is to be avoided. Decentralized controls are common today and Armstrong can supply integrated controls on Vertical Inline pumps up to 75hp (55kW)

Variable Flow System Conversion– Control Topics

Once the mechanical and electrical installation is complete, the controls company can if necessary or desired connect the controls to the BAS / BMS. They can monitor the drive status and deliver an enable or disable signal. Armstrong drives are compatible as standard or with optional cards to all the usual communications proto-cols; such as Lonworks, BACnet, Modbus, Metasys N2 or Apogee FLN.

Variable Flow System Conversion– Summary

- *The Variable Flow System* conversion saves money
- The heating / cooling system works better
- Building regulation compliance is enhanced
- Pumps and drives are easily installed - often with no change to pipework
- Control valve changes are easy to do – often closing the bypass line to convert 3-way valve systems to 2-way systems is best done by the building maintenance staff who are familiar with their location.
- The plant room is cleaned up with fewer control panels

Sensorless Pump Technology

Issues relating to sensors:

- For best energy savings the sensor needs to installed remotely
- Mechanical and electrical installation costs incurred
- Exact position for sensor in system is often difficult to determine
- If installed remotely loads closer to the pump may be under-pumped when needing flow and remote loads are satisfied
- Bringing the sensor closer to the pump is expensive and prevents highest energy savings
- Sensors are prone to failure and are regularly damages or installed incorrectly Placing the DP sensor remotely facilitates greater turndown and hence greater energy savings although some capital and installation costs will be incurred by installing the sensor at a location distant from the pump and controls. To save on direct cable runs back to the drive it is possible to put the signal through the BAS / BMS and bring it back out in the plant room; however cost for extra BAS / BMS points will still be incurred. If the sensor is placed across the most remote load leg and remote loads are satisfied and loads closer to the pump need full flow, the pump speed and back pressure in the piping may not be sufficient to supply full flow to the closer loads; resulting in under-pumping. BSRIA in the UK and others recommend that the sensor be placed 2/3rd the way down the system as a tradeoff between energy savings and satisfactory system operation. Sensors are electro mechanical devices and can fail in the system. If you read Benefits of variable speed pumps with Sensorless Control on above you may now know that Sensorless Control can do everything a remote sensor can do, without the cost of supplying, installing and wiring the sensor. Ask your local Armstrong representative for more details.

Variable Flow System Conversion– IVS Opportunity Calculator

The calculator is on-line at: http://www.armstrongpumps.com/ivs/Calculator.html

The Opportunity Calculator helps the user estimate the potential energy savings in the system and how long the payback period will be. A system lifetime cost savings estimate is also detailed. Simply complete the data input on the first screen; including system flow rate, head losses, operational hours per year, pump efficiency and local electricity cost. The cost of the Sensorless pumping unit is entered later on the 'IVS pump cost' screen. This cost would be the incremental cost of the sensorless unit over a constant speed pump for a new system (Constant pump cost entered on the appropriate screen) or the full cost of the sensorless unit if the unit is to pay for itself soley from energy savings (Use constant speed pump cost of zero). The minimum system pressure defaults to 40% of the design pump head and the part-load flow defaults to the ASHRAE 90.1 part load benchmark of 50% of design flow. Each screen takes you step by step through the constant speed continuous power usage and the variable speed power usage under normal part load conditions. Later screens compare the two running costs and calculates the payback.

This calculator is quite conservative and estimates the payback from energy savings only. Sensor costs are not included which could easily remove $2,000 (£1200) from the investment total.

These are exciting times with energy saving fruits low-hanging in many hydronic HVAC systems just waiting to be picked. Your local Armstrong representative will be pleased to help you understand the true value of variable speed HVAC pumping and how it can easily reduce your energy costs and pay for the conversion quickly from your own savings.

***Tony Egan**, Marketing Manager at S.A. Armstrong Limited*



Tips for Designing Robust & Efficient Cordless Power Tools & Chargers

BY PAULIUS JUSKEVICIUS

The power tool market is growing, with a compound annual growth rate of more than 6%. The fastest-growing product sector is cordless power tools, representing about half of all power tool shipments. The market growth is spurring the introduction of new technology into the products. The cordless power tool industry is transitioning to lithium-ion batteries to obtain the advantages of higher power density and longer discharge cycles. Furthermore, the industry is taking advantage of improved reliability, greater longevity, smaller size, and improved output performance from brushless DC motors.

While lithium-based batteries provide more power in a smaller package and longer battery life, these batteries challenge designers to ensure battery safety. Brushless DC motors challenge designers to drive the motor more efficiently.

This article provides recommendations to assist cordless power tool designers make their product designs more robust and efficient. The article includes recommended components for protecting the power tool's battery pack, the power tool itself, and its battery charger. In addition, designers will receive recommendations for improving the efficiency of the power tool and the battery charger.

Ensuring a Robust CordlessTool Battery Pack

A cordless tool battery pack includes the battery pack, battery management circuitry, and protection circuitry to ensure safe operation. Figure 1 illustrates an example battery pack. Surrounding the battery pack are the function blocks performed by the battery pack and the recommended protection components for each function.

Figure 2 shows a block diagram of the battery pack circuitry. The adjacent table lists the protection and sensing components recommended for each circuit. The recommended components include protection from both temperature and electrical hazards.

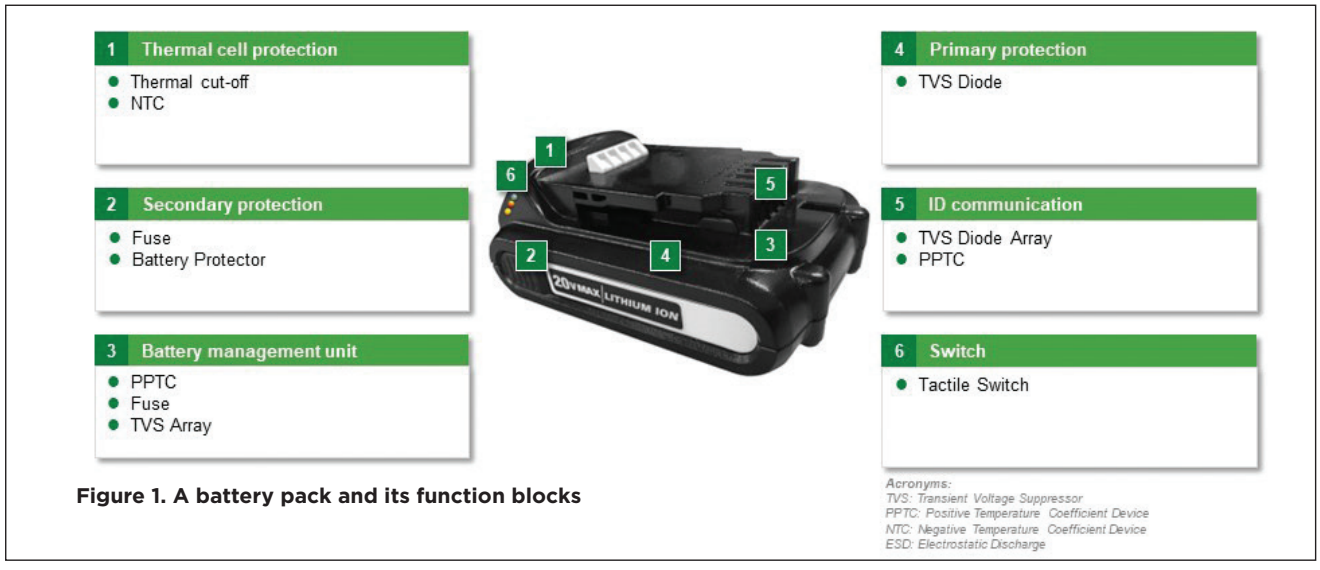
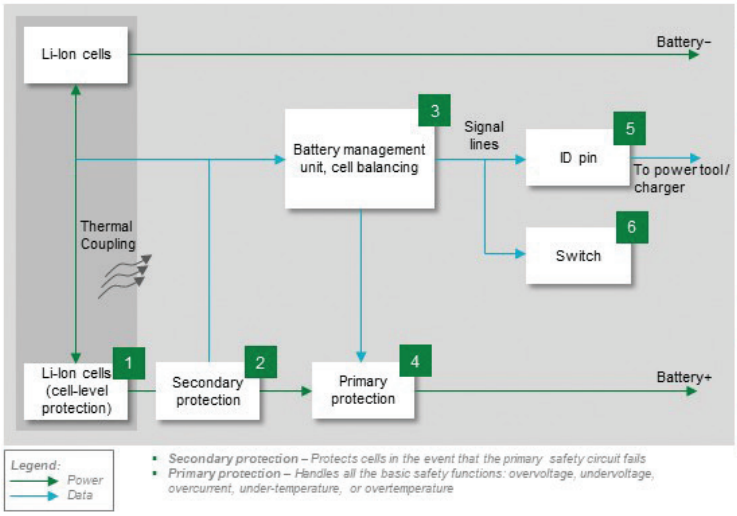


Figure 1. A battery pack and its function blocks

Figure 2. Battery pack circuit block diagram



	Technology	Product series
1	Thermal Cut-off Device	MHP-TAC
	NTC	KC
2	Fuse *OR* Battery Protector	BF1, 881, 688 *OR* ITV
3	PPTC *OR* Fuse	0805L *OR* 458
	TVS Diode Array	SP1003, SC1006
4	TVS Diode	SMF, SMF4L
5	TVS Diode Array	SP3021,SP1007
	PPTC	zeptoSMDC
6	Switch	KSC441J, PTS645V

Li-Ion Cells Thermal Protection Circuit [1]

Lithium batteries, while providing high energy density capacity, can overheat if damaged. Left unchecked, an overheated Lithium battery can erupt in flames. To prevent this failure mode, use a temperature sensor-based monitoring circuit and a temperature-controlled switch to disconnect the battery from the load.

A thermistor, a negative temperature coefficient sensor, can quickly detect a temperature rise with a thermal response of 10 s. With nominal room temperature resistances from 100 Ω to 100 kΩ, the sensor can adapt to a wide range of detection circuit designs. Look for minimal-sized thermistors, such as those with diameters under 0.1 inch, to enable fast thermal response. Also, look for an epoxy coating for high reliability.

Consider a device that directly disconnects the cell from the power tool circuitry to protect individual battery cells. Use a thermal cut-off device, such as one that contains a parallel combination of a bimetal switch with a polymeric positive temperature coefficient (PPTC) device. Figure 3 shows a schematic of a thermal cut-off component. The PPTC device heats up in response to the battery cell temperature and causes the bimetal switch to open. The switch remains open until the PPTC element cools, providing resettable overtemperature protection. Versions of thermal cut-off devices are available with selectable temperature activation ratings.

Secondary Protection Circuit [2]

In the Secondary Protection circuit, a backup for the Primary Protection circuit, a three-terminal Lithium-ion battery protector (see Figure 4), can provide both battery overcharge and overcurrent protection. The three-terminal component includes a distributed embedded fuse and heater elements. The fuse element interrupts an overcurrent condition; additionally, if the monitoring circuitry detects lithium-ion battery parameters outside the designated range, the heater element will cause the fuse to blow.

As a simpler alternative, a high-current fuse provides overcurrent protection. Save space with a surface mount fuse model and simplify compliance requirements with a UL/CSA-recognized component.

Battery Management, Cell Balancing Circuit [3]

Protect the Battery Management, Cell Balancing Unit from overcurrent and electrostatic discharge (ESD). This circuit ensures that all cells individually supply an equal portion of the load current. Protect this circuit from a current overload with either an

Figure 3. Parallel bimetal switch and PPTC thermal cut-off device

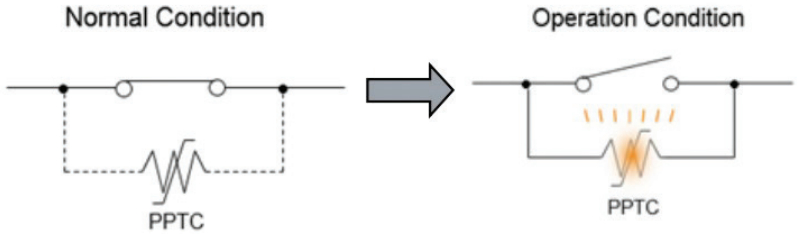
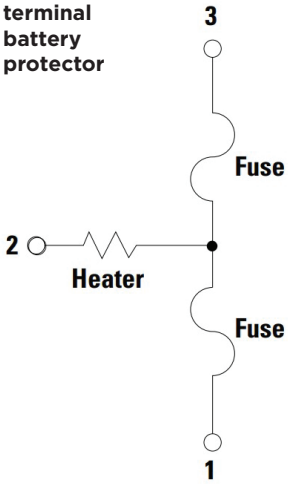


Figure 4. Three-terminal battery protector



inrush withstand fuse or a polymer positive temperature coefficient (PPTC) resettable fuse. Either component is available in surface mount packaging for PC board (PCB) space-saving.

A transient voltage suppressor (TVS) diode is an excellent component for ESD protection of semiconductor components such as those in the Battery Management circuit. Versions of TVS diodes can safely absorb ESD strikes as high as 30 kV from direct contact or through the air with sub-nanosecond response times.

Primary Protection Circuit [4]

The Primary Protection circuit interfaces directly with the battery pack and protects the battery pack from overvoltage, under-voltage, overcurrent, under-temperature, and overtemperature. A problem with the charging process can cause these conditions. A TVS diode can prevent damage to the semiconductors in this circuit. As well as providing ESD protection to 30 kV, TVS diodes can safely absorb 200 W of a transient pulse. A surface mount model can save PCB space. Figure 5 shows bidirectional and uni-directional models of TVS diodes.

ID Pin [5]

The ID Pin circuit ensures that the power tool battery pack can only connect to the proper charger for safe charging of the battery pack. Consider a PPTC resettable fuse to protect the circuit from a current overload and a TVS diode for ESD protection. Look for a TVS diode with two diodes in an anode-to-anode series connection (Figure 6) for bipolar protection.

Switch Circuit [6]

The Switch circuit helps to indicate the status of the charge on the battery. Consider a sealed switch with at least an IP67 rating against moisture and dust ingress. Microminiature switches are available to conserve PCB space. Look for a long life, with a minimum of 100,000 operating cycles. Also, look for a switch with repeatable haptic performance and a short activation distance. All these characteristics enable a reliable switch.

The components presented in the individual circuits will provide protection from hazardous thermal and electrical states. One major element of a cordless power tool, the battery pack, is now more robust and reliable.

Designing a More Robust Cordless Power Tool with Optimum Efficiency

To design a reliable power tool, designers must provide protection mechanisms from electrical hazards and ensure maximum battery life so that the portable power tool can operate through a work shift. Figure 7 illustrates a professional-grade cordless power tool and lists the components needed to protect the tool from current overloads, transient overvoltage, and overtemperature. Furthermore, the power drive circuit has opportunities to optimize the design for efficiency.

Figure 8 shows a block diagram of brushless DC motor circuitry in a cordless electric drill. The brushless DC motor drives the drill bit. The table on the right lists recommended protection, sensing, and high-efficiency control components for use in specific circuits.

DC Input Protection and Battery Communication Circuit [1]

The DC Input Protection and Battery Communication circuit provides overcurrent and overvoltage protection for the brushless DC motor circuitry. The circuit also energizes and de-energizes the motor. Provide overcurrent protection with a fuse. Consider using a:

- A fast-acting fuse
- A fuse that can operate at temperatures up to 150° C
- A surface mount fuse package to minimize PCB space.

For overvoltage protection, use a

Figure 5. Schematic diagrams of two types of TVS diodes

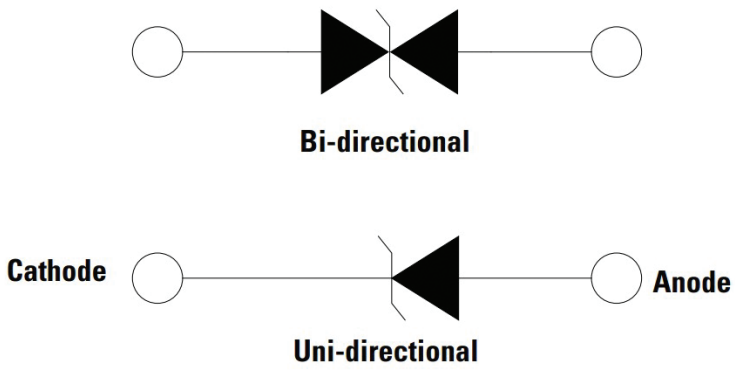


Figure 6. TVS diode array with diodes connected anode-to-anode



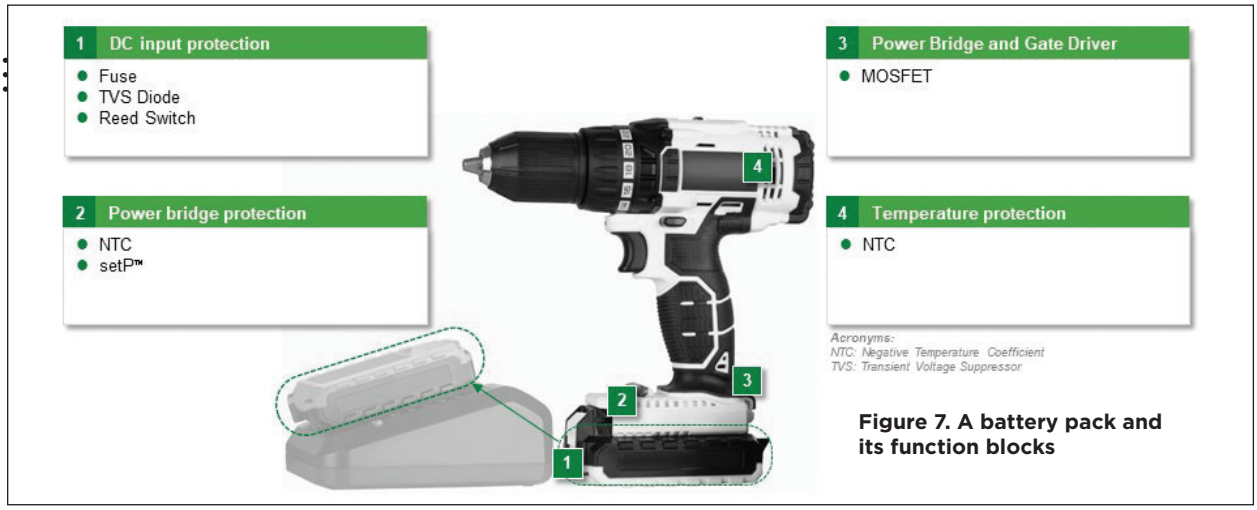
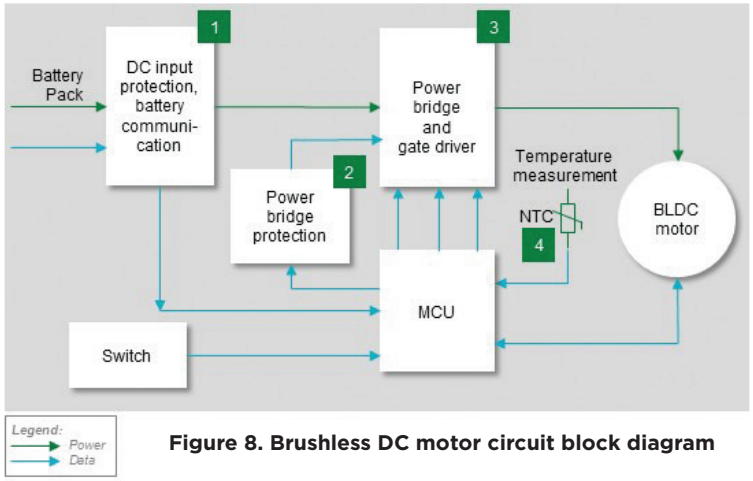


Figure 7. A battery pack and its function blocks



	Technology	Series
1	Fuse	501
	TVS Diode	SMAJ, SMBJ, 5KP
	Reed Switch	MDSR-10, 59166
2	NTC	KC
	Digital Temperature Indicator	setP™
3	MOSFET	Gen2 / Gen4
4	NTC	RB

Figure 8. Brushless DC motor circuit block diagram

TVS diode. Consider a TVS diode that can absorb as much as 400 W of peak power.

Power Bridge Protection Circuit [2]

The Power Bridge Protection circuit block monitors the health of the motor drive circuit. Use an NTC thermistor, such as the one recommended for monitoring battery temperature, to monitor the temperature of the MOSFET driving the motor.

Consider a safety disconnect to reduce the MOSFET's current drive if its temperature rises too high. Littelfuse has a unique component, the setP™, whose resistance increases by six decades when a temperature threshold is exceeded. Figure 9 shows the characteristic of a setP digital temperature indicator. The high resistance change can trigger a control circuit to remove power from the MOSFET, preventing MOSFET thermal runaway. The setP device is integrated into a signal line.

NTC Temperature Measurement Sensor [4]

Monitoring the motor is essential for ensuring a reliable power tool. Use an NTC thermistor to monitor motor temperature and avoid excessive motor temperature due to an internal short or stalled motor. Surface mount NTC thermistors can mount on the motor using wire bonding, epoxy, or solder.

With the cordless tool protected from overcurrent, overvoltage, and overtemperature, the designer can concentrate on maximizing the tool's efficiency. Two circuit blocks offer opportunities to minimize energy consumption.

DC Input Protection Circuit [1]

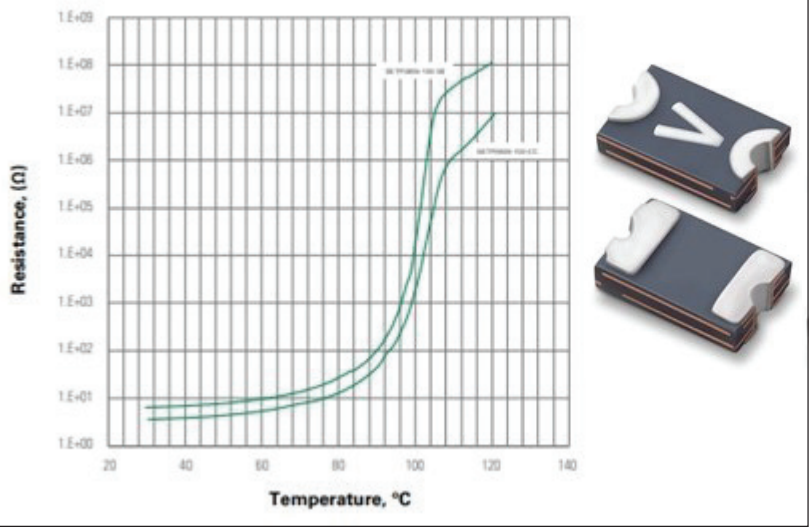
Use a reed switch to detect the state of the battery connection to ensure that the battery can energize the power tool circuitry. Look for a small reed switch with low contact resistance under 120 mΩ for minimum energy consumption. Select a robust switch that can switch up to 0.5 A at up to 10 W of power.

Power Bridge and Gate Driver Circuit [3]

The Power Bridge and Gate Driver circuit uses a high-power MOSFET in the DC-DC converter circuit to allow high-power switching for maximum efficiency and minimum energy consumption. MOSFETs can supply current up to 600 A with RDS(On) values well under 100 mΩ. Low gate-source capacitance below 100 nC and switching times in the 10's of nanoseconds enable high efficiency, high-frequency DC-DC converter operation.

Two significant cordless power tool design elements are now more robust and efficient. The third major element, the power tool charger,

Figure 9. The resistance vs. temperature characteristic of a setP temperature indicator



requires design consideration for circuit protection and high efficiency.

Protection and Efficient Design For The Power Tool Charger

Figure 10 illustrates a power tool battery charger. The function blocks list components that make the circuitry robust to electrical and thermal hazards and optimize the circuitry for efficient operation. Figure 11 details the block diagram and indicates the recommended components for each circuit.

AC Input Primary Protection Circuit [1]

The AC Input Primary Protection circuit interfaces with the AC line and is subject to high current capacity in the event of an overcurrent condition and voltage transients induced in the power line from environmental conditions such as lightning and large motors turning on and off. Use a fast-acting fuse for overcurrent protection. Ensure the fuse has an interrupting capacity of at least a kiloamp level at 125 VAC. Safely absorb overvoltage transients with a metal oxide varistor (MOV). MOVs can safely absorb a current surge from a voltage transient of at least 6 kA with power levels up to 480 J. Select UL and IEC-certified fuse and MOV components to make the product approval process an easier task.

Rectification, High-Frequency Converter, PFC Circuit [2]

Protect the Rectification, High-Frequency DC-DC Converter, and PFC Circuit from portions of transient waveforms that get through the AC Input Primary Protection circuit with a TVS diode. Consider using a TVS diode that can absorb as much as 600 W of pulse power. In addition, verify that the diode provides 30 kV of ESD protection.

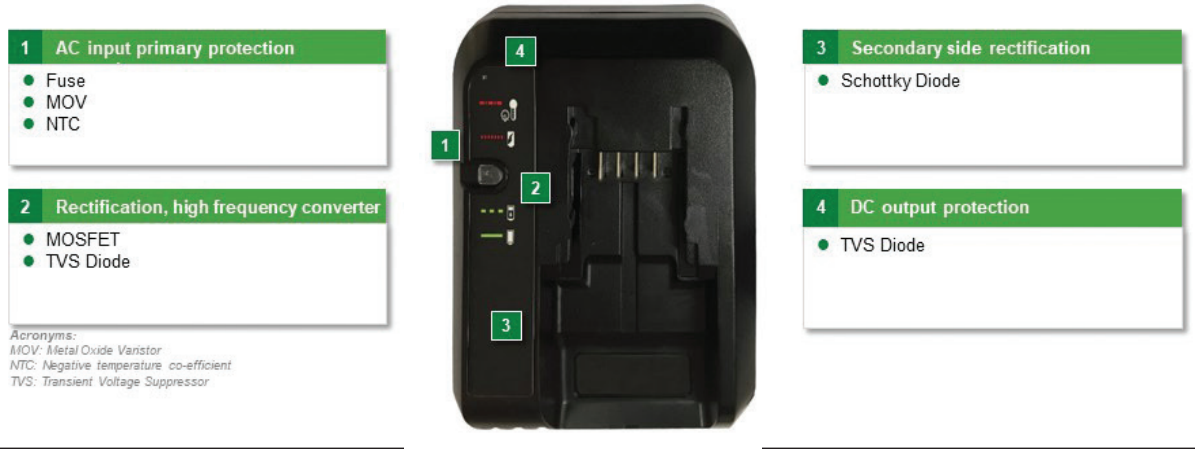
Output DC Protection Circuit [4]

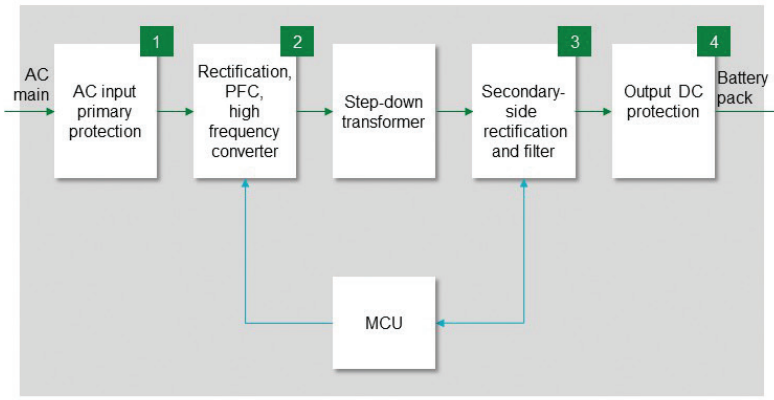
Use a TVS diode for transient and ESD protection on the Output DC Protection circuit. Ensure that the TVS diode used can protect against ESD strikes of at least 8 kV.

Rectification, High-Frequency Converter, PFC [2] and Secondary-Side Rectification and Filter Circuits [3]

Enable The Rectification, High-Frequency DC-DC Converter, and PFC Circuit to generate the DC voltage and to charge the battery pack efficiently. Use MOSFETs which allow the switch-mode circuit to operate at a high frequency. Look for MOSFETs with Low gate charges, low RDS(On), and fast switching times. MOSFETs are available with gate charges as low as 14 nC, RDS(On) under 150 mΩ, and switching times of 50 V/ns.

Figure 10. Example power tool charger





	Technology	Series
1	Fuse	5X20mm Fuse, TR, TE
	MOV	LA, CIII, TMOV
2	MOSFET	X2-class
	TVS Diode	P6SMB
3	Schottky Diode	MBR, DST
4	TVS Diode	SMBJ

Figure 11. Power tool charger block diagram

For efficient operation, consider low forward voltage drop Schottky rectifiers on the Secondary-Side Rectification and Filter circuit.

Schottky diodes can operate at the high frequency of the switch-mode DC-DC converter.

Summary: A small number of components yield robust, efficient performance

The judicious selection of components can provide high protection to the battery pack, power tool, and battery charger. In addition, effective component selection can maximize the power tool's and its charger's efficiency. If designers would like assistance in selecting circuit protection and efficiency components, they can take advantage of a component manufacturer's expertise to save development time and get help with the following:

- Cost-effective component selection
- Compliance with applicable safety standards
- Pre-compliance testing (offered by some manufacturers) to minimize the cost of product certification by a national testing lab.

The result will be a safer, more reliable, and more efficient cordless power tool.

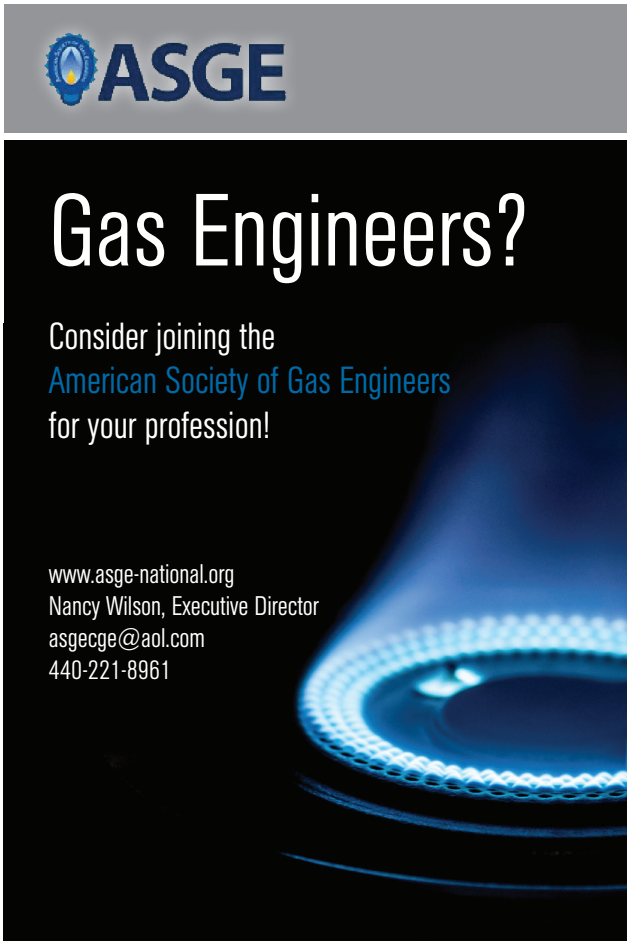


Paulius Juskevicius *is a Strategic Marketing Manager for the Electronics Business Unit at Littelfuse. Paulius Joined Littelfuse in 2016 as field applicaion engineer for the EMEA region. His current responsibilities include the management of marketing activities for new product launches and performing marketing studies and feasibility analysis for new product ideas. Paulius earned his master's in electrical engineering from Kaunas University of technology.*

References

Circuit Protection Product Selection Guide

Power Semi-conductor & ICs Selection Guide



Four Reasons to Replace a Reed Switch With an MR Sensor in Appliances

As sensor manufacturers continue to advance MR sensor technologies, designers will have one more sensor technology in their arsenal.

Design engineers have used reed switches in low-power, battery-operated applications for four key reasons. Themechanical reed switch offers "zero" power consumption, high sensitivity, and low cost. In addition, there hasn't been a suitable alternative technology. These advantages are not entirely true anymore thanks to new magnetoresistive (MR) sensing IC options that can provide position sensing with virtually no power consumption, high sensitivity, and high reliability and durability, while housed in a small package.



Before the development of solid-state sensors, magnetically-activated reed switches, which have been around for decades, provided a proven and inexpensive solution for position sensing. The reed switch consists of two ferromagnetic leads that are hermetically sealed in a glass capsule or tube. When a magnet comes in range of the switch, i.e., a magnetic field is applied to the leads, the contacts close creating a switching function.

Reed switches have remained a popular choice for many designers because of their simplicity as a mechanical switch and a lack of suitable alternatives, particularly in low-power applications. Reed switches have found homes in a wide range of products. Applications include consumer electronics, metering, security, WHITE GOODS/APPLIANCES, medical equipment, robotics, and automation equipment.

Though reed switches are common among these types of applications, many designers also recognize that reed switches have some key disadvantages. These include quality issues due to breakage, both in the manufacturing process and in shock and vibration applications, limited life as a mechanical switch, size issues and reliability issues due to bounce effect (when the reed switch contacts bounce apart causing the application to turn on, off and then on again).

As improvements were made to Hall-effect technology, Hall-effect sensors started to replace reed switches in some battery-powered applications such as cell phones, laptops, consumer electronics, and white goods. This was driven by designers who continue to demand higher reliability and higher performance switching.

Like a reed switch, the Hall-effect sensor actuates when a magnet comes in range of the device. One of the biggest advantages of Hall-effect sensors is that they are solid state and immune to wear, shock and vibration. Switch bounce is also not an issue as there are no moving parts in the solid state sensor. In addition, Hall-effect devices are more rugged and compact than reed switches, making them well-suited for use in many of the same applications. Pricing is also equivalent to the relatively inexpensive reed switches.

Despite these advantages and inroads into some low-power applications, Hall-effect sensors today cannot replace reed switches in many applications because they do not meet the high sensitivity and extremely low-power requirements needed for many battery-operated devices.

For design engineers who are looking for an alternative to reed switches to reduce size, increase quality and durability, and maximize battery life, there are new MR technologies that offer power requirements in the sub-500 nanoamp (nA) range, while offering high sensitivity at a price point that is

equivalent to reed switches.

Like Hall sensors, MR sensors are solid state magnetic sensors. The key difference is that they sense in the parallel plane of the sensing element vs. the perpendicular plane for Hall-effect, and they are typically much more sensitive.

This enables the MR sensors to be used in virtually any battery-operated application.

Here are four reasons—high sensitivity, low power, small size and inherent solid-state advantages—why designers of battery-operated products should consider making the transition from reed switches to MR sensors.

1. High Sensitivity is Required for Battery-Operated Equipment

High-sensitivity magnetic sensors allow manufacturers to use smaller or lower strength magnets, which reduces cost and enables smaller designs. This has become a bigger issue over the past several years as the pricing for rare earth magnets has increased significantly. Another benefit is that it allows for a larger air gap, which provides greater design flexibility by allowing the designer to place the sensor further away from the magnet and still maintain reliability.

Reed switches offer a high sensitivity range required for low-power, battery-operated applications. The magnetic sensitivity of reed switches is measured in ampere-turns (AT), while the sensitivity of MR sensors is measured in gauss. Using a 10 AT high-sensitivity reed switch as an example, this would be equivalent to a 10 to 20 gauss magnetic sensor. The high-sensitivity range for a Hall-effect sensor, for example, is about 30 gauss typical. This means a reed switch can sense a magnetic target at two times the distance or more of a high-sensitivity Hall-effect sensor, offering higher design flexibility for those applications that require a large air gap. But, reed switches also have a number of drawbacks, which will be discussed later.

Today, reed switches are not the only switch option with high sensitivity, as sensor manufacturers continue to advance MR technologies. With new products available today, the sensitivity of these sensors is equivalent to or higher than their high sensitivity reed switch counterparts.

2. Battery-Operated Equipment has Extremely Low-Power Requirements

One of the key benefits of a reed switch in battery-operated applications is that it does not require power to make it work, making the technology ideal for battery-operated equipment.

Up until the early 2000s, magnetic sensors all used power in the milliamp range so they could not be considered for any low-power applications. Around this time, electrical engineers started to work with CMOS technology, allowing magnetic sensor designers to add an internal clock into the devices in order to give it a sleep/awake mode to lower the power requirements of the sensor.

As the technology improved, the power consumption of magnetic sensors dropped to single-digit microamps. Today, for example, Hall-effect sensors have power requirements of 3-8 µA, depending on the manufacturer and parts. New



MR sensor technologies can consume only 360 nA, enabling the sensor to be used as a replacement for reed switches in most battery-operated equipment, requiring 10 times less power than competitive sensors.

These sensors can be used in a variety of battery-operated applications including portable power tools, water and gas meters, industrial smoke detectors, exercise equipment, security systems, handheld computers, and scanners. They can also be used in white goods such as dishwashers, microwaves, washing machines, refrigerators and coffee machines, and medical equipment such as hospital beds, medication dispensing cabinets, infusion pumps and consumer electronics such as notebook computers, tablets, and cordless speakers.

3. Reed Switches Have Several Inherent Drawbacks

Reed switches have several inherent disadvantages, including susceptibility to breakage issues during installation, and in shock or vibration applications, lower durability, a limited life due to the mechanical nature of the switch, as well as issues due to "contact bounce."

Reliability and durability are challenges for reed switch users. When leads on the reed switches are soldered into the circuit, they bend and can easily crack the glass enclosure of the switch, rendering the switch unusable. In fact, there is quite a bit of breakage on these types of units, and quite often, reed switch manufacturers will provide very specific installation instructions in order to limit this breakage. One solution is to enclose the reed switch in a plastic casing, but this adds to the cost and size of the switch.

Reed switches are also impacted by shock and vibration, which can separate the contacts of the switch, making the part unreliable. Mechanical reed switches will wear out over time. As a result, cell phone designers, for example, were the first to transition to Hall-effect sensors. Magnetic sensors are solid-state devices with no moving parts so they will not wear out over time. They are also housed in plastic molded packages versus a glass tube or enclosure for reed switches.

"Contact bounce," which can result in several make-break cycles (close/open/close), also causes issues for designers using reed switches. To fix the problem, engineers need to implement a "debounce" function in either hardware or software, adding additional risk to the system and time to a designer's development cycle.

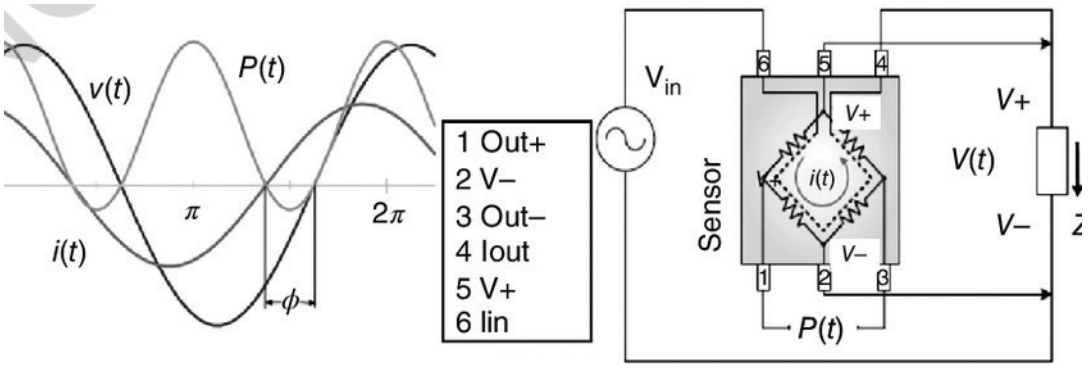
MR sensors eliminate each of these issues. As a solid state sensor in a molded plastic package, these units have no moving parts and are virtually immune to breakage and wear and tear.

4. Size is an Issue

The relatively large size of reed switches makes them a bottleneck in product miniaturization. When comparing reed switches and the new AMR sensors with about the same sensitivity range, reed switches are significantly larger than the SOT-23 package, measuring 2.9 mm x 2.8 mm x 1.45 mm. The relatively small size of the AMRsensor will allow for designs to continue the trend of miniaturization, lowering cost and adding to opportunities for new applications.

As sensor manufacturers continue to advance MR sensor technologies, designers will have one more sensor technology in their arsenal for battery-operated equipment. These AMR solid-state devices are inherently more reliable and durable thanks to no moving parts; they are smaller than reed switches and are available in the same sensitivity range. This allows designers to develop smaller, more reliable, and higher quality appliances and devices with virtually no power required by the sensor components.

Power Measurement With a MR Sensor





Global sales of smart kitchen appliances are expected to reach $43 billion in 2027, growing at a compound annual rate of 19 percent over the next four years, according to a new report from market research firm **Business Research Co.**

Sales grew from $17.79 billion in 2022 to $21.47 billion in 2023.

Smart kitchen appliances refer to appliances connected through internet of things technology, Bluetooth or Wi-Fi. These appliances are integrated with sensors, computing power, one or more actuators, communication capabilities, and even artificial intelligence.

North America was the largest market for such devices in 2022, but the Asia-Pacific region is expected to be the fastest-growing region in the forecast period.

Smart kitchen appliances include refrigerators, cookware, dishwashers and ovens. Smart refrigerators, for example, are equipped with features such as a touch screen interface, the option to connect to the internet through Wi-Fi, internal cameras, flexible user-controlled cooling options, and the ability to connect to a smartphone or tablet.

Increased demand for intelligent cooking appliances is contributing to the growth of the smart appliances market. The COVID-19 pandemic, along with increased access to smartphones and wireless services, has spurred growth in demand for smart kitchen appliances.

32 percent of U.S. households have access to smart home technology, and that percentage is expected to grow to 57 percent by 2025. Manufacturers of smart kitchen appliances are focusing on developing innovative products with advanced technology, such as machine learning. Bosch recently launched the Series 8 Accent Line oven, a smart oven equipped with AI software. Through machine learning, the oven makes intelligent predictions about the time required for a baking or cooking process.



Almost 98 percent of the total waste produced at **Electrolux**'s manufacturing sites was either recycled or recovered in 2022, and 55 percent of the appliance manufacturer's factories are now certified as "**Zero Waste to Landfill**" facilities.

A factory that is certified as a Zero Waste to Landfill facility sends less than 1 percent of its total waste to landfill and uses less than 3 percent of its waste for converting energy.

"We reduced the percentage of waste sent to landfill by 20 percent in 2022 compared with the previous year, which is an amazing result," says Claudia Mazzon, operations sustainability specialist for Electrolux and global coordinator of the company's Zero Waste to Landfill program. "I am so proud of the great job done by our colleagues around the world who are proactively working to reduce waste and find recycling opportunities."

During 2022, seven additional Electrolux Group factories were certified to the Zero Waste to Landfill program. They are Santiago, Chile; Zarow,Poland; Forlì, Italy; Cairo, Egypt; Juarez, Mexico; Swidnica, Poland; and Kinston, NC. Electrolux now has zero waste facilities in Argentina,Australia, Brazil, Chile, Egypt, Italy, Mexico, Poland and the United States.



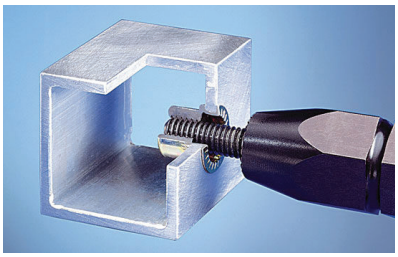
What's Happening

David Reitz recently returned from this year's forum for air conditioning, heating, and refrigeration professionals, known as the AHR Expo, where **Matelex** was singled out as one of three finalists for an **Innovation Award in the category of Refrigeration**. While in Atlanta, Reitz spoke about **PolarBox™** (patent pending) and PolarVisor™ - two products that work together - in a presentation titled "Benefits of Proactive Refrigeration Maintenance to Your Bottom Line and Workforce." He referred to the company's track record in the industry, its experience installing over 4,000 systems worldwide and recent accolades such as Matelex's 2020 AHR Expo Innovation Award in the category of Tools and Instruments.

PolarBox™ (patent pending) is a remote monitoring device for refrigeration installations. With measurements taken every 5 seconds and data analysis tools, the PolarBox is able to learn the normal operation of an installation in order to identify drifts and alert operators. This simplifies the management of refrigeration installations, improves their performance and drastically reduces their environmental impact. A visual dashboard capable of viewing multiple installations along with tips for improvements and reminders is available with the accompanying PolarVisor Web app.

Matelex's award-winning technology for detecting early leaks and optimizing energy usage complies with the coming American Innovation in Manufacturing (AIM) regulations, offering 24/7 remote visibility to owners and technicians. Says Reitz, "Too many 3am emergency service calls can take a toll on any maintenance and facilities management team; fortunately, there is a new solution. I look forward to more people finding out how Matelex can help bring peace of mind by scheduling maintenance proactively, for more 3pm calls instead."





Automakers are increasingly using hydroformed metal tubing in vehicular structures. Compared with stamped and welded metal parts, hydroformed parts weigh less, cost less, and have a higher stiffness-to-weight ratio.

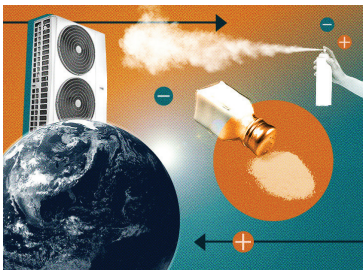
That's all well and good—until the need arises to attach other parts to the structure with threaded fasteners. Tapping threads in the tube may not be feasible because the material might not be thick enough or strong enough. Self-clinching nuts, nut plates or weld nuts are not an option, since installation requires access to the opposite side of the metal. Cage nuts are a possibility, but they require a square hole and are difficult to install.

That's where **rivet nuts** come in. Also known as blind threaded inserts, rivet nuts provide strong fastening threads in thin panels. The fasteners were originally developed decades ago by B.F. Goodrich to attach rubber de-icing boots to airplane wings. Today, rivet nuts are found in a variety of products.

A rivet nut is a one-piece internally threaded and counterbored tubular rivet that can be installed while working entirely from one side of a panel. As with a classic blind rivet, the body of the rivet nut is formed on the blind side. The back-side flange is large enough to resist being pulled out even under conditions of eccentric load. Because rivet nuts can be installed without accessing both sides of the panel, the fasteners are ideal for attaching parts to housings, tubes or extrusions. The fasteners can be installed into all metals, most plastics and even ceramics.

"Rivet nuts are great for plastics, where you don't have the ability to weld or clinch a fastener," says Victor Lanni, president of MDS Fastening Systems.

The fasteners can be made from aluminum, steel, stainless steel, Monel and brass. "The most popular material is zinc-plated steel, but you might specify stainless steel if you're particularly concerned about corrosion," says Richard J. Kull, product manager for rivet nuts at PennEngineering.



Adding salt to a road before a winter storm changes when ice will form. **Researchers at the Department of Energy's Lawrence Berkeley National Laboratory** (Berkeley Lab) have applied this basic concept to develop a new method of heating and cooling. The technique, which they have named "**ionocaloric cooling**," is described in a paper published Dec. 23, 2022 in the journal Science.

Ionocaloric cooling takes advantage of how energy, or heat, is stored or released when a material changes phase – such as changing from solid ice to liquid water. Melting a material absorbs heat from the surroundings, while solidifying it releases heat. The ionocaloric cycle causes this phase and temperature change through the flow of ions (electrically charged atoms or molecules) which come from a salt.

Researchers hope that the method could one day provide efficient heating and cooling, which accounts for more than half of the energy used in homes, and help phase out current "vapor compression" systems, which use gases with high global warming potential as refrigerants. Ionocaloric refrigeration would eliminate the risk of such gases escaping into the atmosphere by replacing them with solid and liquid components.

"The landscape of refrigerants is an unsolved problem: No one has successfully developed an alternative solution that makes stuff cold, works efficiently, is safe, and doesn't hurt the environment," said Drew Lilley, a graduate research assistant at Berkeley Lab and PhD candidate at UC Berkeley who led the study. "We think the ionocaloric cycle has the potential to meet all those goals if realized appropriately."



Mactac® Engineered Tapes & Laminates recently unveiled its newest 100% solids, solvent-free performance product line. Environmentally and economically friendly, **Macbond™ HSA440** acrylic tapes are also highly versatile, meeting a wide range of requirements in applications such as APPLIANCES, automotive, transportation, electronics and printed circuits, building and construction, sign and display, and general industrial uses.

"Mactac is proud to bring another 100% solids solvent-free performance product to the market," said Janet Page, business manager, Mactac Performance Adhesives. "Our customers asked for an adhesive with the perfect balance of adhesion and cohesive strength. To answer that request, Macbond HSA440 acrylic tapes feature an excellent balance of properties, resulting in a truly versatile group of tapes that can be used in countless applications."

According to the company, Macbond HSA440 acrylic tapes offer exceptional performance on medium- to high-surface energy materials. Additionally, the tapes:

- Maintain adhesion after exposure to heat and humidity;
- Are solvent- and UV-resistant;
- Are non-whitening and low-odor;
- Are easy to handle and die-cut; and
- Ensure minimal adhesive ooze.

Macbond HSA440 acrylic tapes are available as a double-coated tape or transfer adhesive, in various coat weights. The tapes feature either a moisture-stable PCK liner, known to resist welting and provide dimensional stability, or a PET liner, which delivers an ultra-smooth adhesive appearance for laminating or electronics applications.

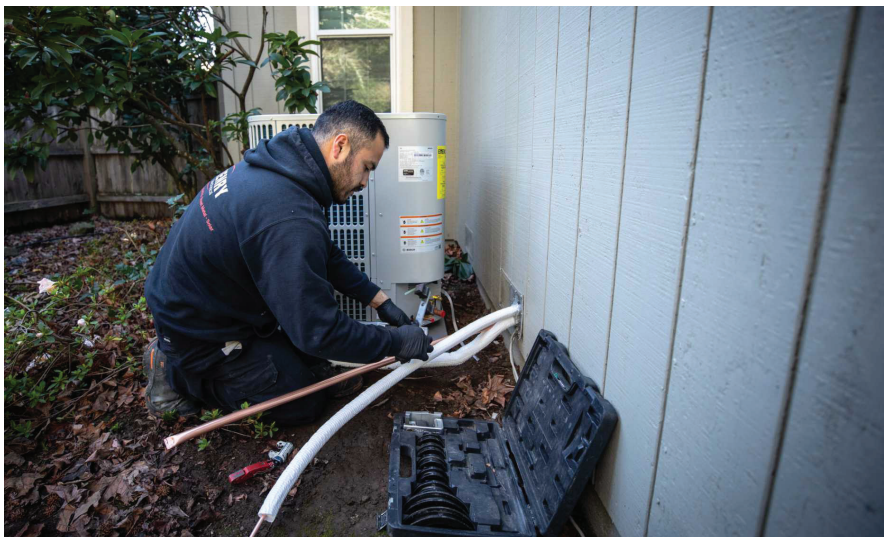
The tapes are offered in 60-inch rolls and have a two-year shelf life. They are UL recognized for indoor and outdoor application and have been third-party tested for flammability, passing FMVSS302.

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Air quality officials in the San Francisco Bay Area have become the first in the nation to adopt rules that will phase out new gas-fueled water heaters and furnaces in homes and businesses starting in 2027.

The **Bay Area Air Quality Management District** voted on March 15 to adopt a policy that, starting in 2027, will phase in requirements that only zero-emission water heaters and furnaces be sold and installed in homes and buildings. The rules don't apply to other appliances, such as gas stoves or clothes dryers, which release far less pollution than water heaters and furnaces.

The California Air Resources Board adopted plans last year to phase out sales of gas water heaters and furnaces statewide by 2030, but isn't going to consider setting rules to do so until 2025. The South Coast Air Quality Management District, which regulates emissions across much of Southern California, is also years behind.

Many cities in California, including Los Angeles, have banned new gas hookups, but these are the first rules that would effectively ban the sale of gas appliances.

In California, appliances such as dryers, stoves, furnaces and water heaters are overwhelmingly fueled by natural gas. Collectively, these appliances generate four times as much smog-forming pollution as the state's gas power plants, according to state environmental officials.

The Bay Area's gas water heater and furnace phase-out is expected to slash more than 3,000 tons of nitrogen oxide emissions each year.

Officials concede that transitioning to emission-free appliances will not be easy. The biggest obstacle is up-front cost. Electric appliances are typically more expensive than gas ones. Putting in a new heat pump costs an average of $2,900 more than a gas furnace, and a heat-pump water heater costs about $850 more than a gas one, according to the Bay Area air district. But the higher initial costs could be offset by savings, including lower utility bills, tax credits, rebates and other state and federal financial incentives.



A-Gas is pleased to announce the appointment of **Louise McCann** as Group Commercial Director.

Her objective is to lead the global commercial team in providing first class key account management, while enhancing the solutions A-Gas offers to its customers worldwide. Louise said: "I am proud to hold the position of Group Commercial Director as we continue our environmental journey. I am highly encouraged by the dedication of our global commercial teams as we seek to support our customers in fulfilling their sustainability goals through lifecycle refrigerant management."

She joined A-Gas in 2005 and has held a number of roles in the A-Gas business, supporting customers during periods of regulatory change in various regions in line with their corporate commitments.

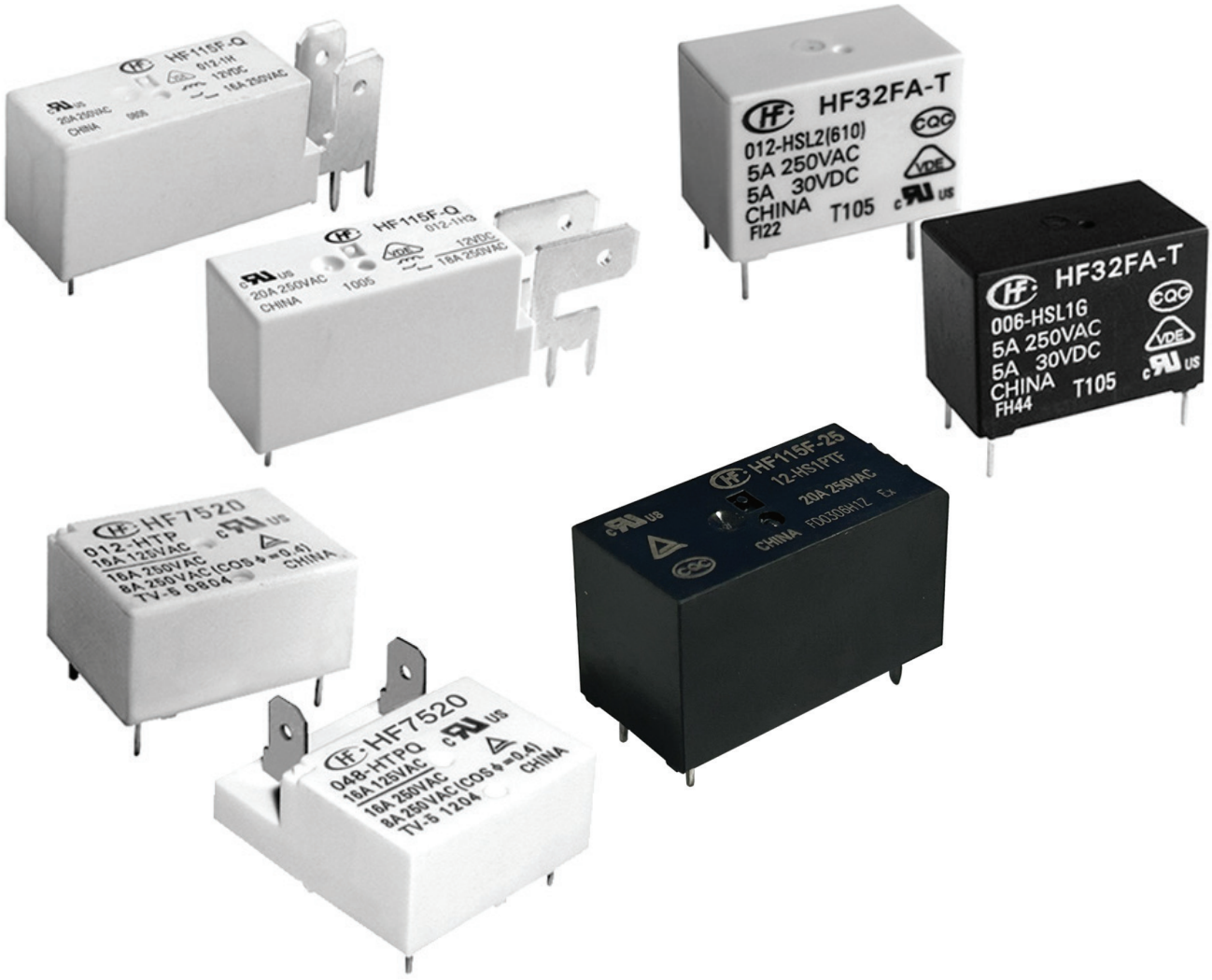
In 2015, Louise became Managing Director of A-Gas Australia, followed by re-locating to Canada in 2019 after accepting the role of Managing Director of A-Gas Canada where she helped establish the business on the ground. She relocated to Dallas, Texas, in 2021 when her role was extended to include all commercial responsibilities for North America. Louise returns to Australia as she begins her role as Group Commercial Director.

Appliance manufacturer **Miele** has announced that all of the aluminum needed to make its ovens will be produced exclusively using green electricity from hydropower. Miele anticipates that the move will reduce its CO_2 footprint by 645 tons per year.

Miele had already been sourcing low-CO2 steel for its appliances since 2021.

"We are the first in our branch of industry to prove that CO_2-reduced aluminum can be successfully used in ovens and help reduce the CO_2 footprint," says Hans Krug, senior vice president for procurement at Miele. "The objective is to use climate-friendly aluminum on a broad front and thereby contribute towards a future-proof economy."





Power Relays for 105°+ Cooking Appliances

Are you using the right power relays for hot appliances? You have options!

BY RICH HALL

Discover the hidden world behind your favorite kitchen appliances! From steamers to popcorn poppers and crepe makers, uncover the crucial safety and environmental concerns that are transforming the industry. Stay ahead of the game by learning about the critical components, such as relays, that certification agencies are examining more closely than ever before. Dive in and satisfy your curiosity about what's happening behind the scenes in the realm of commercial equipment and residential appliances!

The commercial and residential appliances affected by this scrutiny include a huge array of hardware, such as steamers, ovens, cooktops, warmers, griddles, char broilers, panini grills, fryers for funnel cakes, donut fryers, induction ranges, broilers, toasters, steam kettles, waffle makers, popcorn poppers, hot dog cookers/steamers, bun warmers, crepe makers, rice cookers and more!

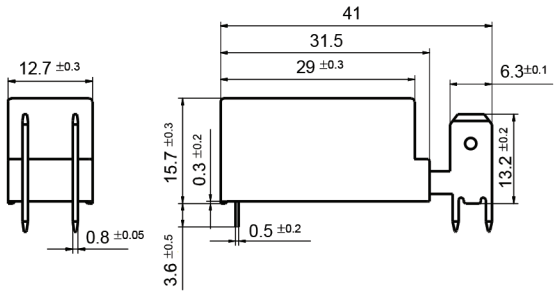
Some relay manufacturers are helping customers to solve these safety issues caused by heat,

OUTLINE DIMENSIONS, WIRING DIAGRAM AND PC BOARD LAYOUT

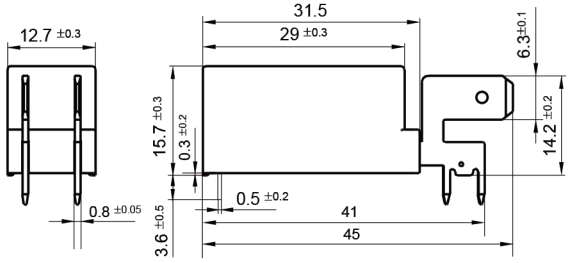
Unit: mm

Outline Dimensions

Quick connect terminals vertical



Quick connect terminals horizontal



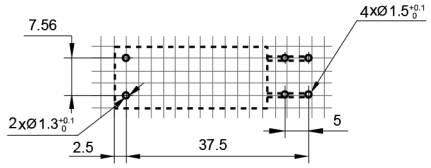
Wiring Diagram

(Bottom view)



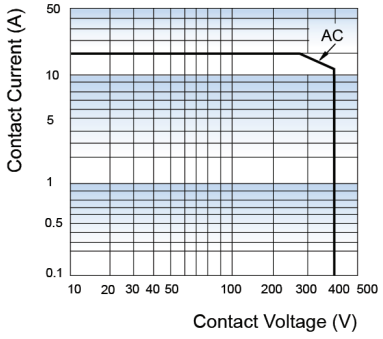
PCB Layout

(Bottom view)

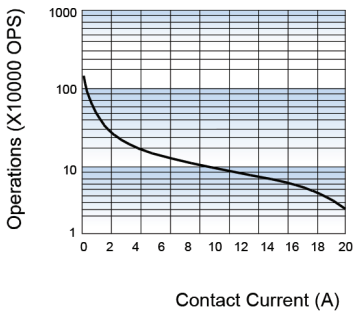


CHARACTERISTIC CURVES

MAXIMUM SWITCHING POWER



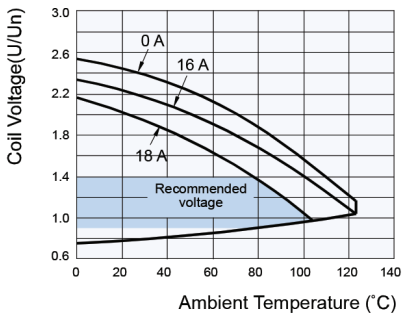
ENDURANCE CURVE



Notes:

1) Curve: 1H type
2) Test conditions:
   NO, 250VAC, Resistive load, Flux proofed,
   Room temp., 1s on 9s off.

COIL OPERATING RANGE (DC) *



Notes: * The use of a relay with an energising voltage other than the rated coil voltage may lead to reduced electrical life. An energising voltage over the abver range may damage the insulation of relay coil.

cleaning solutions, flammable gasses, refrigerants, and contaminants, not to mention the desire to operate at higher efficiency, to reduce the potential for climate change. This is being accomplished with special electro-mechanical components for 105°C environments. These safe components function at cooler operating temperatures and lower energy consumption, a benefit for the equipment that you manufacture. Read on to see how this can help!

It is imperative for manufacturers of cooking appliances, and other devices that get hot, to provide solutions that can meet the challenges of efficiency, safety, and environmental concerns as the industry evolves. In addition to continuing to invest in research and development, responsible equipment manufacturers are dedicated to deploying products and technologies that minimize environmental impact and safety risks, while meeting customer needs. If you are involved with the design and manufacture of these types of appliances, it's likely that you feel this pressure and obligation.

It is possible for your electromechanical components to be the safest and most efficient they can be, while at the same time providing reliable, long-lasting, and environmentally friendly qualities that consumers want to see from you. Paramount to your customers is protecting their investment, whose price is increasing every year.

Power relays built for these high temperature cooking appliance applications typically feature high temperature capabilities to 105°C, for starters. The demand for some high temperature relays has also enabled some manufacturers, such as Hongfa, to produce many versions of these relays to meet a wide range of applications, such as those which require miniature sizes and various mounting options, which can include PCB, Quick Connect, SMT and socket mount. Plastic sealed and flux proofed construction is also available. And Hongfa also addresses environmental concerns with Cadmium-free contact options and Lead-free solder options, to name a few. One example of a versatile miniature relay that can handle ambient temperatures up to 125°C is Hongfa's HF115F-Q. In addition, it uses UL94 V-0 compliant materials and UL Class F insulation in the coil wire. This part has a rating of 20A and 250 VAC. There are so many options available with component characteristics, it is recommended that engineers and procurement personnel consult their suppliers for the product features needed. It may be in a future product release, or a product option in their standard product line.

Certifications cannot be overlooked in our increasingly global production and marketing environment. UL (Underwriters Laboratories) has certified many of the insulation systems on these Power Relays as conforming to Class F, which is important in the North American market. Many manufacturers are also being expected to conform to VDE certifications such as the VDE 0700 and 0631 standards and some sell their products overseas and are asking to meet the IEC 60335-1 standard or others.

Conclusion

There are many relay and electromechanical component options for specialty appliances and applications that you have choices for, when designing your next cooking or heating appliance. As we have mentioned, your customers are trying to make smart decisions about their investments in equipment that will last and be as maintenance-free as possible. Your reputation with customers and their repeat purchases depends on your company manufacturing products to a standard that stands out among your competitors. Likewise, it is important that your component choices are of the best quality that you can afford, while meeting the standards and certifications that your customers expect, and having the specific features that guarantee your product's performance. My best advice is: "Don't settle!" Challenge your suppliers to deliver exactly what you need, with the best quality possible and the availability to meet your production demands! ●

Reference

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2 Amani, S (2022, December 20). New Regulations and Electronic Components Bring Safer Ways to save the Planet. The Electronic Specifier. https://www.electronicspecifier.com/industries/alternative-energy/new-regulations-and-electronic-components-bring-safer-ways-to-save-the-planet

3 (2023, April 20) Hongfa.com. Miniature High Power Relay – HF115F-Q https://www.hongfa.com/en/Product/Item/HF115F-Q. https://source.hongfa.com//pdf/web/viewer.html?file=/Uploads/Product/PDF/HF115F-Q_en.pdf&timestamp=1682103475

Rich Hall *is the Marketing Manager with Hongfa America, the distribution and sales subsidiary for award-winning Xiamen Hongfa Electroacoustic Co., Ltd. Parent-company Hongfa is the largest manufacturer of relays in the world, producing electromechanical components for most of the world's top manufacturers who use electronics. Rich earned his MBA from the University of Southern California; a Bachelor of Science Degree from California State University Long Beach and he has worked in the high-technology and electronics industry for over 30 years.*



#2 IN A SERIES

THE 6 HAZARDS OF PRODUCT SAFETY – RISK OF ENERGY

BV CERTIFIGROUP

Designing for Compliance is critical to getting your product certified on the first try. Designing for Compliance requires owning, knowing, and applying the standard(s) while designing your product. However, in order to successfully read and understand the standard, you have to know the intent of the requirements. Our ''Designing for Compliance'' series of whitepapers will educate you on ''The 6 Hazards of Product Safety''. The intent of the requirements in all UL/CSA/EN/IEC safety standards is to protect the user from the ''6 Hazards of Product Safety''. This whitepaper covers Hazard #2 – Risk of Energy.

Risk of Energy Definition

A ''Risk of Energy is considered to exist within a product if the user can access low voltage, hazardous energy circuits (>240VA available). Emphasis is placed on ''available'' energy – if the circuit is bridged by conductive jewelry or hand-held tools, the ensuing short-circuit will cause all available energy in the circuit to pass through the necklace, ring, bracelet, watch, or hand-held tool. With available energy over 240 VA, the jewelry/tool will overheat faster than the user can respond causing severe burns! A Risk of Energy is defined as: Risk of Energy > 240 VA available energy

Risk of Energy – Not All Standards

Risk of Energy is a hazard that is referenced in only a few product safety standards. However, in the United States, manufacturers have ''ultimate liability''. Ultimate liability means that product manufacturers can be held liable for injuries suffered by the user regardless if the product meets the safety standards and is certified. It therefore behooves all product manufacturers to consider all possible hazards, even if they are beyond the scope of the safety standards that apply to their product. With this in mind, all product designers should at least know the definition for a Risk of Energy and how to prevent the user from being exposed to such a hazard.

Risk of Energy – Accessibility

The first element of learning Risk of Energy protection is to understand the term ''accessibility''. In order for the user to be subjected to an energy hazard, the user's jewelry or tool must touch an electrical circuit. Ability to touch an electrical circuit is typically referred to as ''accessibility''. This is critical to understanding Risk of Energy and it provides us with the first

set of important compliance design questions:

1) Can the user access the circuit? And,

2) Do you need the user to access the circuit?

To answer these questions we need the product safety standards. Product safety is not intended to be a subjective process. Determining whether the user can access the circuit should not be dependent on what jewelry or tool is used. Rather, the product safety standards specify ''accessibility probes'' that are used to determine what circuits are considered to be user accessible. There are different accessibility probes in different standards.

Many compliance professionals are familiar with the ''International Finger'' which is based on an adult male hand size. There is also a ''UL Finger'' that is much smaller as it is based on the hand size of a women and, a set of ''Child Finger Probes'' representing two different age groups of children, with the probe including a child's arm. In addition, some standards include probes that represent a basic tool that is typically found in the product's user environment (paper clip, screw driver, etc.). There is also a test chain that simulates a user's jewelry drooping into a product vent to see if it can ''access'' a hazardous circuit. Be sure to check your product safety standards to identify what accessibility probes and conditions of use apply to your products (i.e. force limitations, limited use guidelines, etc.).

It should be noted that most safety standards require opening and removing all parts that can be removed or opened without tools before applying the accessibility probes. This can include using a Finger Nail probe to try and pry open snapped together parts. And for products with electrical connectors for communication or accessories (USB, headphones, etc.), these connectors are assumed to be accessible regardless of the type of connector. This is very important – all circuits connected to external connectors are usually considered user accessible (other than certified power receptacles).

Risk of Energy – Determination

To determine if a user accessible circuit is considered a Risk of Energy, measure the energy in the circuit under all conditions of loading (including short-circuit) to determine if the circuit is capable of supplying greater than 240 VA (for 1 minute). If the circuit is considered a Risk of Energy, you must limit the available energy in the circuit to below 240 VA. This is typically done by including an overcurrent protection device in the circuit – a device rated to limit the current such that the maximum VA ''available'' is less than 240 VA – use a fuse, PTC, or other current limiter. Any device that reliably limits the circuit below 240 VA is acceptable. However, unlike Risk of Shock, only one level of protection is required. This means that you do not have to meet the Risk of Energy requirement with any fault conditions. Whereas with Risk of Shock, you must meet the limits during a single fault condition.

Risk of Energy – A Real Hazard?

There are some that question whether 240 VA can create a hazard. Recent research by a technical committee suggests that 240 VA may not lead to heating sufficient to cause burns. Informal testing done by a CertifiGroup engineer found that the specific jewelry is a major factor – some chain link designs prevented conductivity and heating, other chains had too much resistance to conduct sufficient current for heating.

Regardless of the results of formal or informal research, there are a few facts that may outweigh this awareness, at least for now:

a) Risk of Energy remains a hazard in some standards = if it's in your standard and you exceed 240VA, you will not be in compliance with the standard.

b) Clearly there is some energy level (VA) through the wrong material that could cause high temperatures. It would seem to be a safe assumption that the user could have jewelry of such a design and material that energy through the material could cause a burn. The 240VA limit appears to be a safe level considering the unlimited possibilities in materials, shape, and contact surface.

c) Why leave 240VA accessible if you don't need it? As a manufacturer, you can be sued for anything – cases with merit and cases without. Jury trials, pictures of burns, and an accessible high energy level presents some risk of liability.

Risk of Energy – Summary

In summary, low voltage accessible circuits with available energy exceeding 240VA is considered an unacceptable hazard in some standards. As with Risk of Shock, the 1st step in applying the Risk of Energy requirements is determining circuit ''accessibility'' using the accessibility probes from the product safety standards that apply to your product. To protect the user, the product should be designed to prevent access to circuits that have greater than 240 VA available, while also limiting the energy in user accessible circuits below this limit.

Protecting Your People, Customers and Business From Illegal Refrigerants

BY BRANDON MARSHALL

We're all familiar with the concept of history repeating itself. Sometimes the experience is positive. Other times it's not so beneficial. Regardless, if you can anticipate a repeat of history and take proactive steps to leverage its lessons, that's ideal. The HVACR industry currently finds itself in this position when it comes to the subject of illegal and counterfeit refrigerants. As the U.S. phasedown of high global warming potential (GWP) hydrofluorocarbon (HFC) refrigerants continues, the industry can draw on past events to predict, plan, and protect itself.

This past January, the industry experienced a significant phasedown in HFCs under the American Innovation and Manufacturing (AIM) Act. The next phasedown is coming quickly and will require an additional 30% reduction in HFC production and consumption, starting Jan. 1, 2024. As phasedowns progress and reduce the supply of HFCs that are available to service equipment, the risk of illegal materials coming into the country increases. To an extent, we saw this happen when hydrochlorofluorocarbons (HCFCs) were phased out in the U.S. The stronger indications, however, come from more recent developments in the European Union (EU), where HFC phaseouts began in 2015. According to the European Chemistry Industry Council, authorities in the EU seized hundreds of metric tons of illicit HFCs in 2019 and 2020. Certainly, we hope that we won't see illegal activities to this extent driven by AIM Act phasedowns. However, we expect that, due to reduced supply of HFCs, attempts of illegal activities will increase in the U.S. and Canada. So, the industry must be prepared.

It's unfortunate that, while a significant number of players in the industry—from contractors and OEMs to refrigerant innovators and manufacturers like Chemours—are investing in and supporting an orderly transition away from HFCs to lower-GWP hydrofluoroolefin (HFO) refrigerants, there are entities and individuals seeking to capitalize on the situation by offering illegally imported refrigerants. Awareness and efforts to avoid these illegal activities, coupled with enforcement protocols, can prevent a potentially devastating impact.



Counterfeit wrapping on Chemours Opteon™ products offers an example of assurance that you are getting an authentic, quality product.

Why should you care?

There are several ways the use of illegally imported HFC refrigerants can cause significant damage to the industry and your business. First and foremost, illegal imports can be extremely dangerous. Illegal products may have unknown flammable contents such as hydrocarbons, impurities, and other contaminants. In addition, in an attempt to "stretch" profits, individuals may mix the HFC with alternative refrigerants that are less expensive to buy. The resulting "product" creates significant safety risks to the people who work with them as well as the end user of the HVACR equipment. A quick Internet search on "unapproved refrigerant explodes" will drive home this point.

Secondly, consider the quality of what you're getting. Chemours has engaged in testing of illegal imports which supports the reality that the quality is poor at best. I personally observed a test where the moisture level of an illegal refrigerant was so high, it was likely that if it was used in equipment, it would have burned out in under three months. System performance, energy efficiency, and overall system life can be negatively affected by poor quality. The AIM Act requires that all virgin or reclaimed refrigerant products sold in the U.S meet AHRI 700 Standards.

Third, we cannot forget the reason behind phasedowns in the first place—protecting the environment. Illegal products sabotage regional, national, and global efforts to ensure a sustainable, healthy planet. The more unregulated volumes of product entering the market, the greater the delay in meeting climate objectives in the U.S. and Canada.

Plus, remember, illegal imports are, in fact, illegal and the EPA, in coordination with Customs and Border Protection and other agencies, has initiated enforcement protocols to stay ahead of illegal import activities. Moreover, under the AIM Act and Ozone-depleting Substances and Halocarbon Alternatives Regulations (ODSHAR), import, distribution, and/or sales of illegally imported HFCs are subject to penalties including confiscation, imprisonment, and fines.

It all comes down to this—the use of illegally imported refrigerants can be damaging to your people, your business, your reputation, the environment, and your bottom line.



By using the information on the Izon® label, you can scan a QR code or enter a seven-digit code to get immediate confirmation of a refrigerant's authenticity.

How to avoid illegal refrigerants

Step one is to be wary of any too-good-to-be-true situations, like an unbelievably low price or "unlimited supply" suddenly being available in a market undergoing reduced production. Be wary of any offer you get that doesn't align with current industry pricing and avoid Internet "deals."

Next, I encourage my customers to follow the SAFEguard system.

- Select—Make sure to select a reputable refrigerants distributor for all purchases.
- Ask—Don't leave it up to chance; ask for a genuine refrigerant.
- Find—Closely examine refrigerant packaging to find key security features and authentication labels. All Chemours cylinders should include an Anti-Counterfeiting Security Shrink Sleeve, while disposable cylinders should also include an Izon® security label.
- Ensure—Take a moment to ensure the authenticity of a refrigerant's package by scanning the QR code on the Izon® security label or by entering its 7-digit code at GenuineRefrigerants.com

The golden rule is to only source refrigerants from someone you know and trust. The danger with illegal refrigerants is that you just don't know what is in that cylinder. This is why it's imperative to rely on a wholesaler with whom you have a proven and established relationship and only use brands you trust.

Lastly, if you see something, say something. Use the EPA website (echo.epa.gov) to report environmental violations; and always, if you are wary about a refrigerant product you've come in possession of, talk to a different, trusted source. There are a number of refrigerant manufacturers, including Chemours, invested in preventing the damage illegal imports can do to our industry, customers, and environment. Never hesitate to make a phone call—doing so can go a long way in protecting your people, customers, and business.



***Brandon Marshall**, MBA, Americas Marketing Manager, Stationary and Specialty Applications, The Chemours Company. For over a decade, Brandon has built experience and knowledge, from the contracting market through manufacturing, and he possesses the skills to support the challenges of today to create a greener tomorrow. Brandon is passionate about helping the HVACR industry navigate the complex technological and regulatory landscape to further institute the use of new and intelligent systems to reduce the impact on the environment.*

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Beckett Corp.
www.beckettus.com

c3controls
www.c3controls.com

Continental Fan
www.continentalfan.com

Copper Development Association
www.copper.org

ETCO
www.etco.com

Hongfa America
www.hongfaamerica.com

ICM Controls
www.icmcontrols.com

Intec Display
www.intecdisplay.my

International Copper
www.microgroove.net

Littelfuse
www.littelfuse.com

Soler & Palau
www.solerpalau-usa.com

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www.surfaceigniter.com

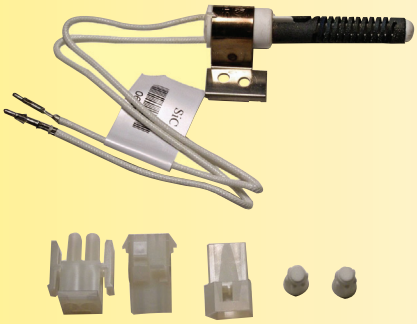
ULVAC Technologies
www.ulvac.com

Varflex
www.varflex.com

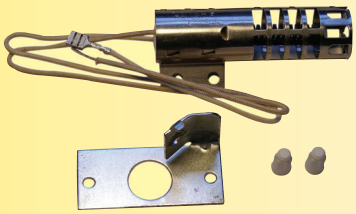
Vitrek
www.vitrek.com

Surfaceigniter LLC

THE PIONEER IN HOT SURFACE IGNITERS



Surface Igniter has been pioneering the development of silicon carbide igniters since 1969. We are the premier manufacturer of hot surface ignition products for BBQ grills, clothes dryers, gas ranges, HVAC systems, boilers, and more.



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- 2.5 ~ 3.0 Range Igniter
- 3.2 ~ 3.6 Range Igniter
- Boiler Igniter
- Dryer Igniter
- Flame Rods
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