International Journal of Latest Research in Engineering and Technology (IJLRET)
ISSN: 2454-5031
www.ijlret.com || Volume 03 - Issue 11 || November 2017 || PP. 26-29

Variable Frequency Drives in Residences

Sherif Attallah[1], Christopher Davison[2], Firuz Oev[3]
[1](*Construction Management and Interior Design/ Ball State University, USA)*
[2](*Information Systems and Operations Management / Ball State University, USA)*
[3](*Construction Management and Interior Design / Ball State University, USA)*

Abstract: Heating, Ventilation and Air Conditioning (HVAC) systems are commonly found in modern homes to regulate the temperature and humidity for the individuals who dwell in these homes. As HVAC system typically consume more energy than any other element in buildings, there is an increasing demand on reducing the energy consumed by these systems. The goal of this paper is to explore the Variable Frequency Drives (VFD) and their use in the today's contemporary commercials buildings and to investigate the possibility of more implementation in the residential projects. Therefore, this paper is going to discuss the benefits and gains from installing a VFD into the HVAC systems in homes located in the parts of the globe with excessive cold and hot climate, and as a result another natural aim of the paper is to identify the challenges of integrating VFD's with HVAC systems and possible difficulties with compatibility of one system with another, which might arise from pursuing this goal.

I. INTRODUCTION

In today's construction industry there is an emphasis on not only designing products that building owners can use at ease but also designing them to be environmentally friendly. One of the ways contractors and owners are achieving these goals are through the use of various home automation systems. These systems provide two-way communication between power utilities and home owners (Zhou et al., 2016 [1]). By providing this communication it opens up many opportunities for owners such as energy savings, comfortability, and highly efficient systems.

One of these main systems is Heat Ventilation and Air Conditioning (HVAC) system, which account for 40 to 60 percent of energy consumption in residential buildings (Ozturk et al. 2013 [2]) This shows that there is a large demand for energy efficiency within the HVAC systems. Home automation systems and the components that go with those systems are one way to improve the energy savings in HVAC of houses. Of a particular interest, the use of Variable Frequency Drives (VFD s) connected to the blower within the forced-air cooling/heating system is a way to help save energy. A VFD is an electric powered device that drives induction motors over a range of speeds by converting standard frequency and voltage of alternating current (ac) power to variable frequency and voltage power to energize the motor. The use of VFDs in the commercial sector is very common with proven savings of 44% (Cho et al., 2009 [3]). Although there is a widespread use of VFDs in the commercial sector, it is reluctant to break out in the residential sector of construction. It is the intent of this paper to explore the use of Variable Frequency Drives (VFD) in residential Heating, Ventilation and Air Conditioning (HVAC) systems.

The following sections unravel the fact that, these devices come in different models, have various efficiency characteristics topped with alternating probable difficulties that can arise from their use. This is followed by a discussion of the immense benefits of VFD's and their implementation in HVAC systems in commercial systems and the potential of their introduction in homes. VFD improve energy consumption levels in homes especially in severe hot or cold regions of the globe.

II. VARIABLE FREQUENCY DRIVES

Variable Frequency Drives are in essence electrically charged devices that help control the work of a motor by converting standard frequency and voltage ac power to variable frequency and voltage power to energize the motor in HVAC systems. While simple in concept, most VFD projects require an expert application engineer to apply the technology to variable load motors. Typical VFD applications in commercial buildings include: (Lubinski, 2010 [4])

- Air handling units
- Cooling tower fans
- Cooling tower pumps
- Circulation pumps for HVAC
- Chillers
- City-water booster pumps

- Compressed air systems.

By introducing variable frequency drives, you are able to take advantage of an HVAC system, which works as hard as it is required to maintain the preferred conditions. As the motor does not need to run on full capacity and is regulated by a VFD, there is far less noise as a result.

Another major advantage of using VFDs is reducing the wear and tear of motor components. Additional example of commercial is the Burns Harbor Facility of Bethlehem Steel Corporation, where the facility was able to better match the fan speed to the basic oxygen furnaces' (BOF) varying requirements by installing a variable frequency drive and making equipment modifications to the induced draft fans that remove gases from this BOF. As a result, the energy use of the BOF was cut by about 50%. In addition, operation costs and system maintenance expenses were reduced. The project's simple payback time was just under two years (Caddet, 1999b [5]). Apart from energy savings, which is a major component, there are also benefits of reducing unexpected breakages and maintenance expenses, not to mention the losses as a result of those breakages.
Figure 1 shows that the entire process inside VFDs is controlled by a microprocessor which monitors the following:

- incoming voltage supply,
- speed set-point,
- DC link voltage,
- output voltage and current to ensure operation of the motor within established parameters.

Figure 1

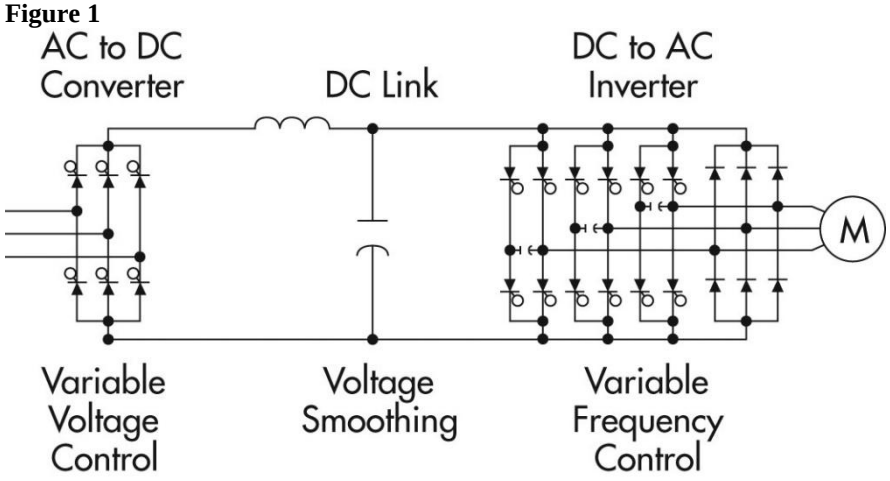
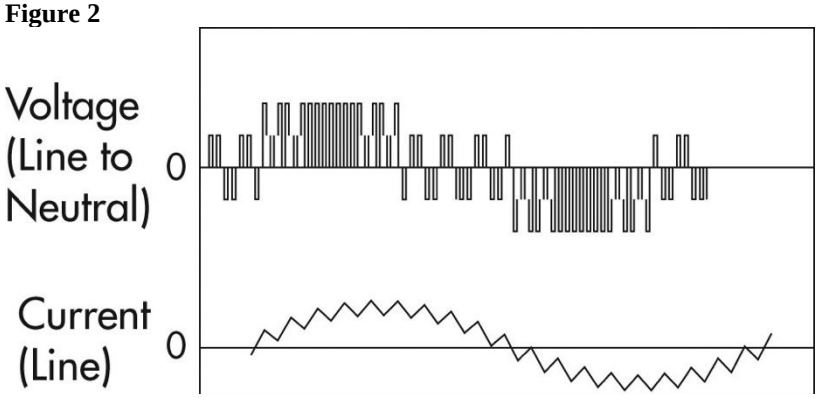


Figure 2 shows the effect of the VFD on the voltage regulation and output to the motor.

Figure 2



(Natural Resources Canada, 2015 [6])

A potential improvement to the devices could be an addition of monitoring systems, although drives do nothave the wide-rangingmonitoring capabilities of devices intendedexplicitly for predictive maintenance or monitoring, they have the function of monitoring the current and speed (Weber, 2006 [7]). Design and application of a simple monitoring solution to VFD's could greatly increase their functionality. This type of

application could enhance VFD's capability to monitor its own voltage output, spend and current, but it could also measure the varying output for the load it has been designated to optimize. Another important statement to bear in mind was made more recently, "Electric motor driven systems account for more than one third of America's electrical demand and between 43 to 46 % globally" (Yoon, 2015 [8]). Taking into account the massive consumption derived from only one source, it is obvious, that VFD's have immense importance and are to play a great role in the battle for energy consumption optimization.

An earlier model of VFD, an Adjustable Speed Drive (ASD), was used in a demonstration for residential application as an attachment to permanent magnetic motors in loads like compressors, air conditioners and heat pumps. Although this may seem like specific and targeted application of the device, the authors reporting on the demonstration conclude, that ultimately allowing the widespread use of residential heat pumps might be considered reasonable.Once the initial cost barrier has been overcome, the user will profit from the reduced operation costs and improved comfort gained through introducing an adjustable speed drive (Jurgreis, Kelley 1995 [9]).

III. RESIDENTIAL HVAC SYSTEMS

Most modern residential and commercial buildings employ Heating, Ventilation and Cooling (HVAC) systems to control the temperature inside these buildings to maintain a certain temperature for the people, machinery or certain goods that require to be stored at a certain temperature range. As reported by Cetin (2014, [10]), HVAC systems, often the single largest residential energy consumer, account for approximately 26-40% of all residential energy consumption. Undoubtedly, this is a large area of concern for homeowners; a third to a half of a home's energy consumption is from this single system. One could foresee that a problem with this system, even a minor one, could cause serious upcharges in one's energy bill. On the other hand, "going green" or efficient with HVAC system, could save a homeowner considerable amount of money in a relatively short span of time. While solar panels lead the movement with the best and quickest return value, variable frequency drives can address problems with the HVAC system and energy consumption in a cost efficient way as well. The complexity of energy consumption reduction problem forces residential building owners to invent and implement a variety of ways to preserve the energy, thus making the use of VFD's an important component as a part of the solution. A number of other symptomatic problems could relate to things like dirty coils and filters. With a VFD, the rate of fouling of these items could be greatly reduced. Additionally, the lifespan of the main HVAC components (fans, blowers, etc.) could be increased considerably. However, many "cookie-cutter" neighborhoods have rather simplistic designs that get in the way of efficiency. With the added simplistic components of these low-budget homes, it is a possibility that a VFD would not help and potentially hinder your HVAC system.

An article by Richard J. Bravo details a simulation of residential motor loads, which account for a considerable amount of energy consumption. These objects are refrigerators, window-air conditioners, and air conditioners with and without variable frequency drives. For this simulation, the author observes characteristics like current and voltage when a voltage disturbance (a grid power outage or other emergencies) is present.(Bravo, 2016, [11])

However, a very practical residential home use for VFD's would be large homes in very hot or cold areas. Regions close to the equator could be used as an example, temperatures in those regions rarely drop below 60 degrees Fahrenheit. Thus, making the use of air conditioners a year round norm similarly home owners in the cold regions furthest from the equator would feel the need to use their heaters almost all year long. Any region in between still has a need for varying uses of air conditioning during hot or humid summers and heating in the winter. It is still a considerable amount of time, but due to the nature of necessity for a year round use of HVAC systems in those permanently hot or cold areas, the use of VFD's would greatly improve the lifespan of an air conditioner or in the cases of larger homes the use of a number of air conditioners. Additionally, if a home is kept at a constant temperature, fluctuating the temperature inside does not require 100% of an air conditioners power. Introduction of a VFD would therefore result in increased efficiency.

IV. ANALYSIS AND CONCLUSION

Variable Frequency Drives, owing to their efficiency in mechanical and electrical systems are making their way into wide range of application in commercial buildings as well as some homes. Even though advancements seem to have stalled in the recent years, VFD's are making enormous strides in large commercial applications by reducing energy costs and saving on maintenance costs. On the other hand, when it comes to residential use, several factors need to be taken into account and improvements need to be made, before the technology can be fully implemented. A large number of residential HVAC systems have components incompatible with VFD's, such as compressors and motors. Considering appealing energy saving efficiency for

consumers, through improving their home automation systems by control their home appliances through highly efficient communication devices makes it a worthy investment. (Saini, Singh, Sharma, Wattanawisuth, Leeprechanon, 2016 [12]). Overall, with the necessary advancements on both VFD and on HVAC system components, the use of these devices is expected to witness an increased demand in the near future.

REFERENCES

[1] Zhou, B., Li, W., Chan, K., Cao, Y., Kuang, Y., Liu, X., & Wang, X. (2016). Smart home energy management systems: Concept, configurations, and scheduling strategies. Renewable & Sustainable Energy Reviews, 61, 30-40. doi:10.1016/j.rser.2016.03.047

[2] Ozturk, Y., et.al. (2013). An Intelligent Home Energy Management System to Improve Demand Response. IEEE Transactions on Smart Grid, 4(2), (694-701).

[3] Cho, Y., Liu, M., Wang, G., Wang, J., & Rauscher, T. (2009). VFD application for constant volume air-handling units. ASHRAE Transactions, 115(2), 824.

[4] Richard B. Lubinski (2010) ROI from VFDs: Cutting Costs with Variable Frequency Drives, http://www.buildings.com/article-details/articleid/9345/title/roi-from-vfds-cutting-costs-with-variable-frequency-drives

[5] CADDET (1999b). Variable Frequency Drives at Steel mill. Centre for the Analysis and Dissemination of Demonstrated Energy Technologies. Project US-1999-539, Sittard, The Netherlands. Available at: www.caddet.org

[6] Natural Resources Canada (2010) http://www.nrcan.gc.ca/energy/products/reference/15433

[7] Weber, D. (2006). Behind the Scenes with VFDs. EC&M Electrical Construction & Maintenance, 105(9), 18-21.

[8] YOON, J. (2015). VFD, motor strategies for energy efficiency. Consulting-Specifying Engineer, 52(1), 34-42.

[9] Jungreis, Kelley (1995) Adjustable Speed Drive for Residential Applications. IEEE Transactions on Industry Applications, VOL. 31, NO.6.

[10] Cetin, K., &Novoselac, A. (2014). Residential HVAC commissioning through energy consumptiondata analysis. ASHRAE Transactions, 120(2), 1-8.

[11] Richard J. Bravo (2016) Dynamic Performance of Residential Motor Loads. 2016 IEEE/PES Transmission and Distribution Conference and Exposition.

[12] Saini, R. P., Singh, B. P., Sharma, M. K., Wattanawisuth, N., &Leeprechanon, N. (2016). Designing of smart home automation system based on raspberry pi. AIP Conference Proceedings, 1715(1) doi:10.1063/1.4942698 our doorsteps. Hui, L.