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Managing VF drives: A little maintenance effort can save a lot in time and money

SPECIAL REPORT Variable Speed Drives

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Your asset management system may tell you that your variable frequency drives (VFDs) need some attention, but do you know how to maintain them properly? It's easier than you might think, and will pay off in the long run. By integrating some simple, logical steps into your preventative maintenance (PM) program, you can ensure that your drives will provide many years of trouble-free service.

In the following, we'll examine each of these steps in some detail. But let's first quickly review what a VFD is and how it works.

A quick overview

A VFD controls the speed, torque, and direction of an ac induction motor. It takes fixed voltage and frequency ac input and converts it to a variable voltage and frequency ac output. Figure 1 shows what the three main sections of a VFD are and what they do. In very small VFDs, a single power pack unit may contain the converter and inverter.

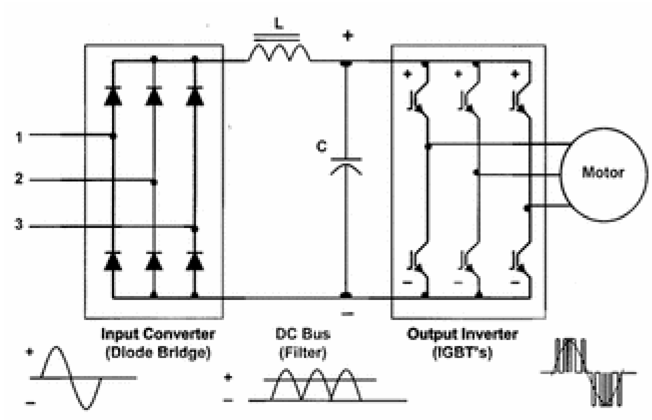

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FIG. 1: Schematic of simple VFD.

Fairly involved control circuitry coordinates the switching of power devices, typically through a control board that dictates the firing of power components in the proper sequence. A microprocessor or digital signal processor (DSP) meets all the internal logic and decision requirements.

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From this description, you can see that a VFD is basically a computer and power supply, and the same safety and equipment precautions apply. As a result, the three primary VFD maintenance requirements are: (1) keep it clean, (2) keep it dry, and (3) keep the connections tight. Let's look at each of these.

Keep it clean

Most VFDs fall into the NEMA 1 category (side vents for cooling airflow) or NEMA 12 category (sealed, dust-tight enclosure). Drives that fall in the NEMA 1 category are susceptible to dust contamination.

Fig. 2: Fan injecting dust particles into VFD.

Dust on VFD hardware can cause a lack of airflow, resulting in diminished performance from heat sinks and circulating fans (Fig. 2). In addition, dust absorbs moisture, which can contribute to the malfunction or failure of a VFD's electronics.

Periodically spraying air through the heat sink fan is a good PM measure against dust related problems. Discharging compressed air into a VFD is a viable option in some environments, but most plant air contains oil and water. To use compressed air for cooling, you must use air that is oil-free and dry, or you are likely to do more harm than good. This requires a specialized, dedicated, and expensive air supply. And you still run the risk of generating electrostatic charges (ESD). A nonstatic generating spray or a reverse-operated ESD vacuum will reduce static build-up. Common plastics are prime generators of static electricity. The material in ESD vacuum cases and fans is a special, nonstatic generating plastic. These vacuums, and cans of non-static generating compressed air, are available through companies that specialize in static control equipment.

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Keep it dry

In Fig. 3 you can see what happened to a control board that was periodically subjected to a moist environment. Initially, this VFD was wall-mounted in a clean, dry area of a mechanical room and moisture was not a problem. However, as is often the case, a well-meaning modification led to problems.

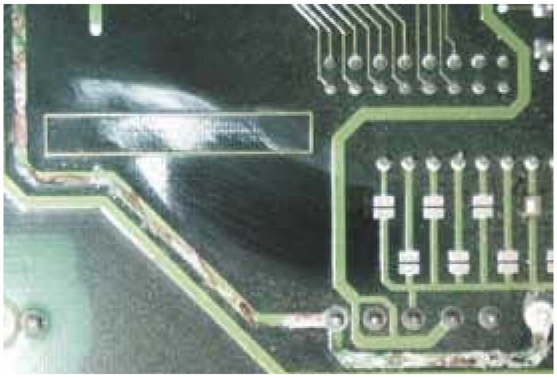

Fig. 3: Moisture caused corrosion

An area of the building required a dehumidifier close to the mechanical room. Because wall space was available above the VFD, this is where the dehumidifier was mounted. Un fortunately, the VFD was a NEMA 1 enclosure style (side vents and no seal around the cover), so water dripping from the dehumidifier made its way into the drive. In six months, the VFD accumulated enough water to produce circuit board corrosion.

What about condensation? Some VFD manufacturers included "condensation protection" on earlier product versions. When the mercury dipped below 32 °F, the software logic would not allow the drive to start. Today, VFDs seldom offer this protection. However, if you operate the VFD all day every day, normal radiant heat from the heatsink should prevent condensation. If you locate a VFD where condensation is likely, and you don't expect continuous operation, use a NEMA 12 enclosure and thermostatically controlled space heater.

Keep connections tight

While this sounds basic, checking connections is a step many people miss or do incorrectly-and the requirement applies even in clean rooms. Heat cycles and mechanical vibration can lead to substandard connections, as can standard PM practices. Retorquing screws is not a good idea, and further tightening an already tight connection can ruin the connection (see sidebar, "Retorquing-A screwy practice).

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Fig. 4: Loose input power connections

Bad connections eventually lead to arcing. Arcing at the VFD input could result in nuisance overvoltage faults, clearing of input fuses, or damage to protective components. Arcing at the VFD output could result in over-current faults, or even damage to the power components. Figures 4 and 5 show what can happen.

Fig. 5: Loose output power connections

Loose control wiring connections can cause erratic operation. For example, a loose START/STOP signal wire can cause uncontrollable VFD stops. A loose speed reference wire can cause the drive speed to fluctuate, resulting in scrap, machine damage, or injuries to plant personnel.

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Additional steps to keeping VFDs up

Fig. 6: Foreign object in fan

1. As part of a mechanical inspection procedure, don't overlook internal VFD components. Check circulating fans for signs of bearing failure or foreign objects-usually indicated by unusual noise or shafts that appear wobbly.
2. Inspect dc bus capacitors for bulging and leakage. Either could be a sign of component stress or electrical misuse. Figures 6 and 7 show fan and capacitor stress problems.
3. Take voltage measurements while the VFD is in operation. Fluctuations in dc bus voltage measurements can indicate degradation of dc bus capacitors. One function of the capacitor bank is to act as a filter section (smoothing out any ac ripple voltage on the bus). Abnormal ac voltage on the dc bus indicates the capacitors are headed for trouble. Most VFD manufacturers have a special terminal block for this type of measurement, and also for connection of the dynamic braking resistors. Measurements of more than 4 V ac may indicate a capacitor filtering problem or a possible problem with the diode bridge converter section (ahead of the bus). If you have such voltage levels, be sure to consult the variable frequency drive manufacturer before taking further action. With the VFD in START and at zero speed, you should read output voltage of 40 V ac phase-to-phase or less. If you read more than this, you may have transistor leakage. At zero speed, the power components should not be operating. If your readings are 60 V ac or more, you can expect power component failure.
4. What about spare VFDs? Store them in a clean, dry environment, with no condensation allowed. Place these units in your PM system so you know to power them up every six months to keep the dc bus capacitors at their peak performance capability. Otherwise, their charging ability will significantly diminish. A capacitor is much like a battery-it needs to go into service soon after purchase or suffer a loss of usable life.
5. Regularly monitor heat sink temperatures. Most VFD manufacturers make this task easy by including a direct temperature readout on the keypad or display. Verify where this readout is, and make checking it part of a weekly or monthly review of VFD operation.

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Fig. 7: Capacitor stress problem

You wouldn't place your laptop computer outside, on the roof of a building, or in direct sunlight, where temperatures could reach 115 °F or as low as -10 °F. A VFD, which, as we indicated earlier, is basically a computer with a power supply, needs the same consideration. Some VFD manufacturers advertise 200,000 hours-almost 23 years-of mean time between failures (MTBF). Such impressive performance is easy to obtain if you follow the simple procedures outlined above.

About the author

Dave Polka is Training Center manager for ABB Inc., Automation Technology Products Division, Drives and Power Electronics, New Berlin, WI. He has been involved with ac and dc drive technology for more than 18 years, with particular focus on training and education efforts.

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Retorquing - A screwy practice

Although "retorquing" as a way of checking tightness is common in many PM procedures, it violates basic mechanical principles and does more harm than good. A screw has maximum clamping power at a torque value specific to its size, shape, and composition. Exceeding that torque value permanently reduces the clamping power of that screw by reducing its elasticity and deforming it. Loosening and then re-torquing still reduces elasticity, which means a loss of clamping power. Doing this to a lock washer results in a permanent 50% loss.

What should you do? Use an infrared thermometer to note hot connections. Check their torque. If they have merely worked loose, you can try retightening them. Note which screws were loose, and be sure to give them an IR check at the next PM cycle. If they

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are loose again, replace them. Finally, don't forget the "tug test." This checks crimps, as well as screw connections. Don't do this with the drive online with the process, though, or you may cause some very expensive process disturbances.

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