

# VFD FAULT DETECTION USING MCEMAX

As motor drives become more important in industry, the need to analyze faults associated with them increases. PdMA's MCEMAX is a great tool for analyzing faults in Variable Frequency Drives (VFDs).

Although modern technology has seen great improvement in the reliability of drives, naturally occurring events will cause faults in a drive, especially if they were originally installed in an inappropriate application. The primary focus of this article is on Pulse Width Modulated (PWM) drives without fault mode operating capabilities. Although these drives do not employ fault mode operation capability, in some cases, they will keep running even with a fault. This article will show that through the use of the MCEMAX technology, faults in these drives are detectable with a very high level of confidence.

## FAULT DETECTION

As with other predictive maintenance technologies, trending is the best method of fault detection. Trending methodology also applies to fault detection in VFDs. By trending data over a period of time, a technician is better able to detect developing problems in motors or power systems. Occasionally, faults occur that did not exhibit any trends before the occurrence, these types of failures are considered random in nature. This article covers faults that have occurred, yet, the drive continues to operate in a mode that appears normal externally.

## Upstream (Line Side) Diagnosis

Upstream (Line Side) diagnosis of the VFD (not diagnosis of the motor) refers to testing on the incoming power to the VFD as shown in Figure 1. By testing upstream of the VFD, open diodes and open phases can be detected using the MCEMAX. Upstream diagnosis is only useful for diagnosing the VFD, do not perform overall motor diagnostics upstream of the VFD.

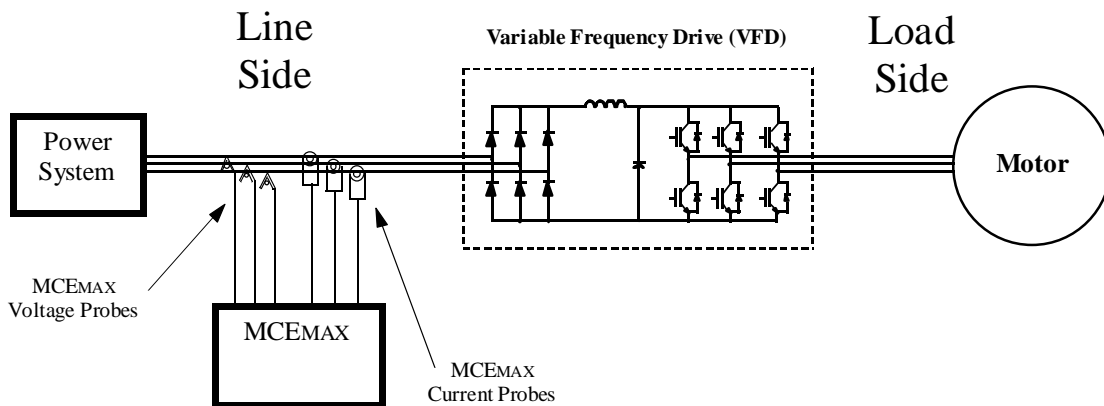


Figure 1

## Open diode

Using the MCEMAX technology, a technician is able to reliably detect an open diode fault (Figure 2) using the results from a MCEMAX Power Test.

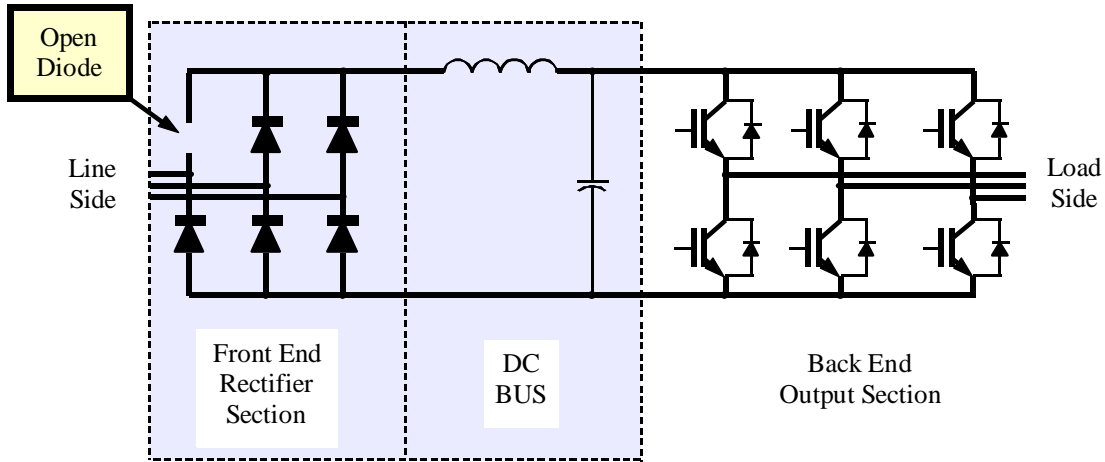


Figure 2

Table 1

	Non-Faulted	Faulted
Current 1 (RMS)	0.54	0.74
Current 2 (RMS)	0.54	0.29
Current 3 (RMS)	0.50	0.70

The phase current (Current RMS) of the phase with the open diode will decrease approximately 50% on the affected phase, and increase slightly on the other two phases (Table 1).

Table 2

	Non-Faulted	Faulted
% Current Imbalance	4.79 %	49.32 %

Percent (%) Current Imbalance will increase to approximately 50% on the affected phase (Table 2).

Table 3

	Non-Faulted	Faulted
Current 1 (THD)	151.56	169.94
Current 2 (THD)	148.84	79.19
Current 3 (THD)	154.02	168.61

Current THD will decrease by approximately 50% on the affected phase, and increase slightly on the other two phases (Table 3).

Table 4

	Non-Faulted	Faulted
Phase 1 kW	0.06	0.09
Phase 2 kW	0.06	0.03
Phase 3 kW	0.06	0.08

kW will decrease by approximately 50% on the affected phase, and increase on the remaining phases (Table 4).

**Table 5**

	Non-Faulted	Faulted
Phase 1 kVAR	0.11	0.16
Phase 2 kVAR	0.11	0.09
Phase 3 kVAR	0.11	0.15

kVAR will decrease by approximately 20% on the affected phase, and increase by approximately 40% on the remaining phases (Table 5).

**Table 6**

	Non-Faulted	Faulted
Phase 1 kVA	0.13	0.19
Phase 2 kVA	0.13	0.10
Phase 3 kVA	0.12	0.17

kVA will decrease by approximately 20% on the affected phase, and increase by approx 40% on the remaining phases (Table 6).

Of these methods, the best method of detection is the RMS current decrease of approximately 50% and the % Current Imbalance increase to 50%, which is detectable for all frequencies from 15 Hz to 60 Hz and loads from 0% Load (no-load) to 100% Load. The next best detection method is the current Total Harmonic Distortion (THD) decrease of approximately 50%.

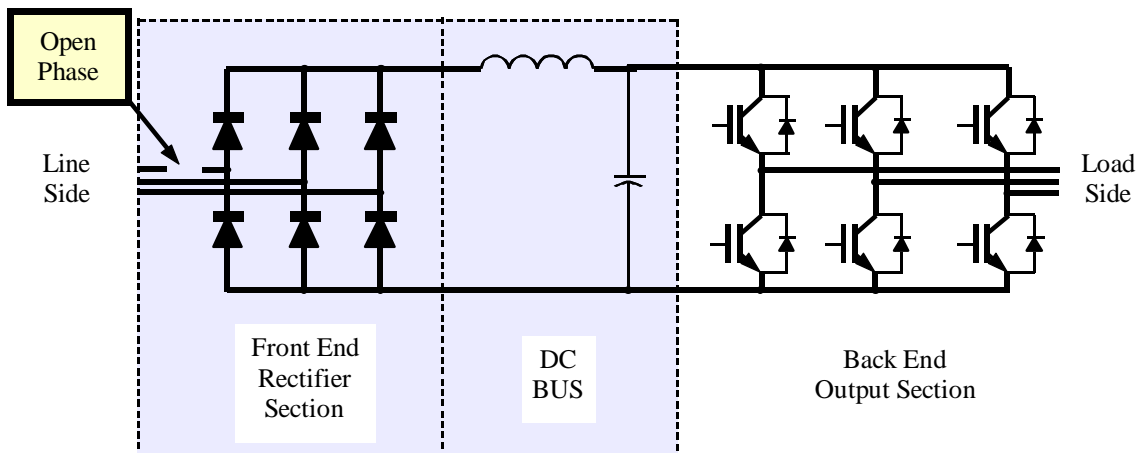
After detecting a possible fault in the drive, you should try to verify the fault is in the drive, and not a measurement error. To do this, switch the test leads of the MCEMAX between two of the phases, and perform the power test again. If you receive the same results, except on a different phase, the fault is most likely in the drive.

### Shorted diode

A shorted diode trips the drive on occurrence, therefore, there are no detection procedures for this type of fault.

### Open phase

An open phase occurs when a connection has come loose either at the component level or externally to the drive (Figure 3).



**Figure 3**

A technician can detect an open phase by the following:

**Table 7**

	Non-Faulted	Faulted
<b>Current 1 (RMS)</b>	0.53	0.00
<b>Current 2 (RMS)</b>	0.52	0.99
<b>Current 3 (RMS)</b>	0.50	0.98

RMS current on the faulted phase will decrease to 0.00 Amps and increase on the other two phases by approximately 90% (Table 7).

**Table 8**

	Non-Faulted	Faulted
<b>% Current Imbalance</b>	3.57 %	99.62 %

% Current Imbalance increases to approximately 100% (Table 8).

**Table 9**

	Non-Faulted	Faulted
<b>Current 1 CF</b>	3.51	15.41
<b>Current 2 CF</b>	3.37	4.31
<b>Current 3 CF</b>	3.66	4.31

Current Crest Factor (CF) on the faulted phase increases to approximately 15% and there is a slight increase on the other phases (Table 9).

**Table 10**

	Non-Faulted	Faulted
<b>Phase 1 kW</b>	0.06	0.00
<b>Phase 2 kW</b>	0.06	0.09
<b>Phase 3 kW</b>	0.06	0.11
<b>Total kW</b>	0.19	0.20

kW decreases to 0.00 on the faulted phase and increases by approximately 50% on the other phases, but the total kW remains constant (Table 10).

**Table 11**

	Non-Faulted	Faulted
<b>Phase 1 kVAR</b>	0.11	0.00
<b>Phase 2 kVAR</b>	0.11	0.26
<b>Phase 3 kVAR</b>	0.11	0.25
<b>Total kVAR</b>	0.32	0.51

kVAR decreases to 0.00 on the faulted phase and increases by approximately 100% on the other phases (Table 11).

**Table 12**

	Non-Faulted	Faulted
<b>Phase 1 kVA</b>	0.12	0.00
<b>Phase 2 kVA</b>	0.12	0.27
<b>Phase 3 kVA</b>	0.12	0.27
<b>Total kVA</b>	0.37	0.55

kVA decreases to 0.00 on the faulted phase and increases by approximately 100% on the other phases (Table 12).

## Downstream (Load Side) Diagnosis

Downstream fault diagnosis of the VFD refers to testing on the output side of the VFD, which is between the VFD and the motor as shown in Figure 4. By testing downstream of the VFD, open diodes, and open phases can be detected using the MCEMAX. Testing downstream of the VFD is not the preferred location when performing VFD diagnostics (Line Side is the preferred location), but is the recommended test location when performing overall motor diagnostics.

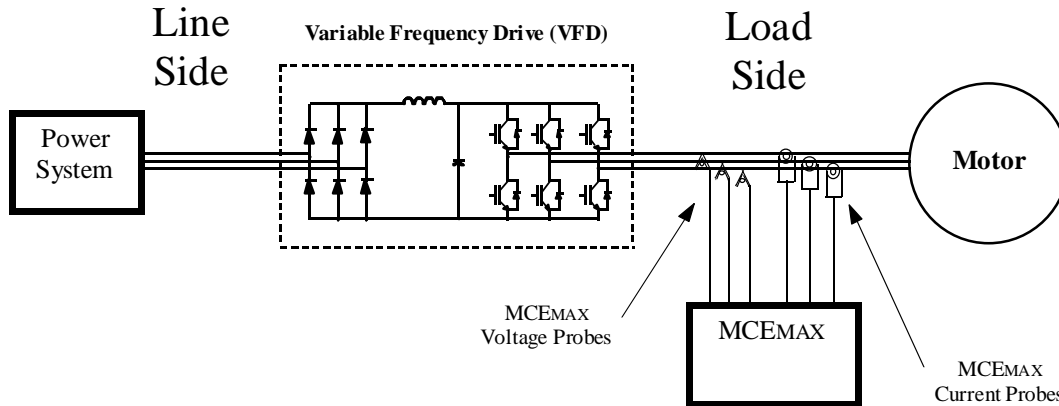


Figure 4

### Open diode

A technician is able to detect a faulted diode in the rectifier portion of the drive by using the MCEMAX technology downstream of the drive. At 60 Hz, with the motor loaded to at least 50%, an open diode is detectable by an increase in the Phase-Neutral Voltage Imbalance to approximately 15% (Table 13).

Table 13

	Non-Faulted	Faulted
Voltage Imbalance Ph-N	0.42 %	15.14 %

### Phase out

One phase that was completely out (open connection) was reliably detectable downstream of the drive when the drive was operating at 60 Hz (at any load) by an increase in the Voltage Imbalance to approximately 50%. At lower speeds, a phase out fault was not reliably detectable.

Table 14

	Non-Faulted	Faulted
Voltage Imbalance Ph-N	1.11 %	54.73 %

## AFTER A FAULT IS DETECTED

Once any of these faults are detected, although the drive may still be running, it is recommended that you repair or replace the drive, or contact the manufacturer of the drive for their recommendations. Failure to remedy the situation may result in excessive heat in either the drive or the motor and cause far greater losses.

## CONCLUSIONS

From our research, we found certain faults in drives can be reliably detected using the MCEMAX technology (Table 13). These faults include an open diode and an open phase. Open diodes were detectable both up and downstream of the drive. An open phase was detectable upstream of the drive at all frequencies and loads. Furthermore, an open phase was detectable downstream if the drive was running at full speed (typically 60 Hz), but it was not reliably detectable downstream if the drive frequency was below 60Hz. Future research will include a line and load side analysis of the back-end of a drive with back-end and power circuit related anomalies, and other possible detection methods using the MCEMAX technology.

**Table 15**

### **Fault Detection Capabilities of the MCEMAX Technology**

<b>Component</b>	<b>Type of Fault</b>	<b>Detectable Upstream</b>	<b>Detectable Downstream</b>
<b>Diode</b>	Open	Yes	Yes *
	Short	No (Drive Failure)	No (Drive Failure)
<b>Phase</b>	Open	Yes	Yes *
	Short	No (Drive Failure)	No (Drive Failure)

\* when the motor is run at full speed (typically 60 Hz).

### Related Sources

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