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Troubleshooting Three-Phase AC Motors with U1210 Series Handheld Clamp Meters

Application Note

Agilent Technologies

INTRODUCTION

In today's world, the three-phase AC induction motors are widely used in commercial and industrial applications ranging from grain dryers to saw mills, conveyer belt systems, refrigeration, and air conditioning due to its simplicity, rugged construction, and relatively low manufacturing costs. The use of electric motors has increased productivity significantly and lowered operational costs. However, unexpected electric motor failure could results in lost capacity as well as excessive repair and unnecessary maintenance costs.

As the motor-control systems become more complex, troubleshooting has become more difficult without the use of proper test tools. In this application note, you will discover the common causes of a three-phase AC motor failure and how to diagnose them with Agilent U1210 Series Handheld Clamp Meters, thereby preventing costly replacement.

Common Causes of Motor Failure

Motor failure can be caused by various electrical or mechanical conditions. Based on motor manufacturers' analysis, about 44% of motor failure problems are related to heat resulting from overloads and single phasing. The overheating problem reduces motor winding insulation life by half for every 10 ˚C increase in winding temperature. In other words, operating a motor at 10 ˚C above its maximum temperature rating will reduce its expected life expectancy by 50%.

Motor Overload Caused by Voltage Unbalance

Motor failure is a common result of voltage unbalance. Voltage unbalance occurs when the line voltages on a three-phase supply are unequal. With 1% of voltage unbalance, it can actually cause 6 to 10% current unbalance. Therefore, the motor will draw more current than it is rated for. If this condition is allowed to continue, the motor will be damaged because additional slippage causes additional heating that the motor overload protector cannot predict.

However, a current unbalance does not necessarily mean that a voltage unbalance exists. For example, there may be a loose terminal connection on one leg of the motor or there may be a buildup of carbon or dirt on one set of contacts of the contactor. The current will flow to the path of least resistance and cause the current to increase in the other leg of the motor.

Common Causes of Voltage Unbalance

- Unbalanced incoming utility power supply
- Open phase on the primary three-phase transformer on the distribution system
- A blown fuse on a three-phase bank of power-factor improvement capacitors
- Open delta-connected transformer banks
- Unequal impedances of the three-phase transmission and distribution lines
- Unbalanced distribution of single-phase loads such as lighting

Symptoms of Motor Voltage Unbalance

Symptoms of motor problems related to either voltage unbalance or to voltages not matching the nameplate rating are not always easy to diagnose. System load variation and variations in other system characteristics can significantly affect both utility and facility distribution voltages. Here are a few symptoms that may trigger voltage-unbalance investigation:

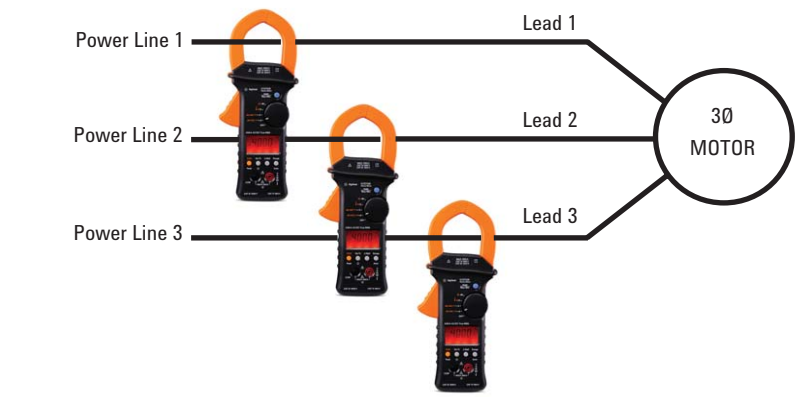
- Nuisance tripping of a motor-protective device.
- High numbers of motor failures
- Difficult getting a specific motor started

How to Identify Unbalance Power Source to Three Phase AC Motor

When testing for voltage unbalance, the phase-to-phase voltages should be measured rather than the phase-to-neutral voltages. If an unbalance is found, then the following test can help determine whether the source of the problem is the motor itself or the power supply to the motor.

STEPS FOR PERFORMING TEST

1. Record the current flowing through each motor lead as shown in Figure 1.
2. Rotate all three input power lines by one position as shown in the diagram below.
3. Measure and record the current in each lead in the new setup.
4. Rotate all three input power lines by one more position.
5. Measure and record the current in each lead in the new setup.
6. Determine the average current and the maximum deviation from the average current in each rotation configuration.
7. Compare the three combinations with maximum current deviation.
8. If the combination always contains the same motor lead, this indicates a problem with the motor. If the combination always contains the same power line, then the power supply may be at fault.
9. Figure 1 indicates that the incoming power is the source of unbalance because the maximum current deviation follows the input power line.

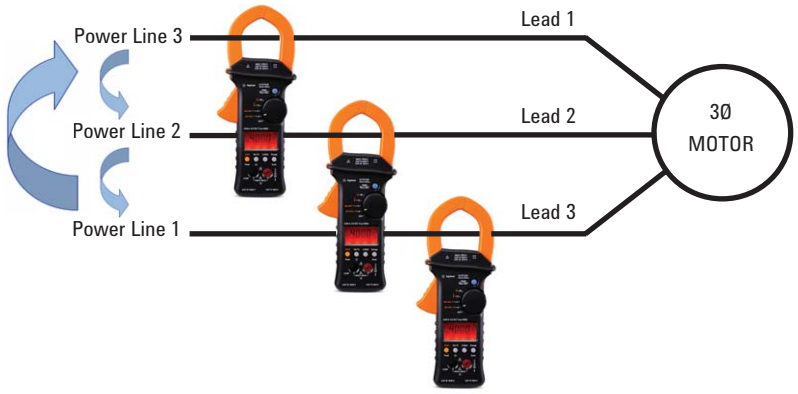


Original Setup

Power Line 1 - Lead 1 = 34 A
Power Line 2 - Lead 2 = 32 A
Power Line 3 - Lead 3 = 24 A

Average = 30 A

Maximum Deviatation : Power Line 3 - Lead 3 = 6 A



Setup 1

Power Line 3 - Lead 1 = 25 A
Power Line 1 - Lead 2 = 36 A
Power Line 2 - Lead 3 = 32 A

Average = 31 A

Maximum Deviatation : Power Line 3 - Lead 1 = 6 A

Setup 2

Power Line 2 - Lead 1 = 34 A
Power Line 3 - Lead 2 = 26 A
Power Line 1 - Lead 3 = 33 A

Average = 30 A

Maximum Deviatation : Power Line 3 - Lead 2 = 4 A

Figure 1. *Steps to identify the source of unbalance*

How to Identify Motor Single Phasing

Single phasing is a condition in which one leg of a three-phase motor is open. When motor is interrupted by the loss of a phase, the other two phases of the motor will attempt to pick up the load that the lost phase was carrying. If the motor is loaded, it will push the current draw of the motor beyond the “must-trip” current of the overload protection. The test below can help you to identify the single-phasing condition in the three-phase AC motor.

STEPS FOR PERFORMING TEST

1. Measure and record the current in each motor lead as shown in Figure 2.
2. During normal operation, all the current drawn in each phase are the same. Single-phasing is present only when one of the motor lead current measurements is 0 A.
3. This situation could be due to a damaged motor starter contact, burned-open overload relay, or a switch or circuit breaker on the main, feeder or motor branch circuit. A thorough check is needed.

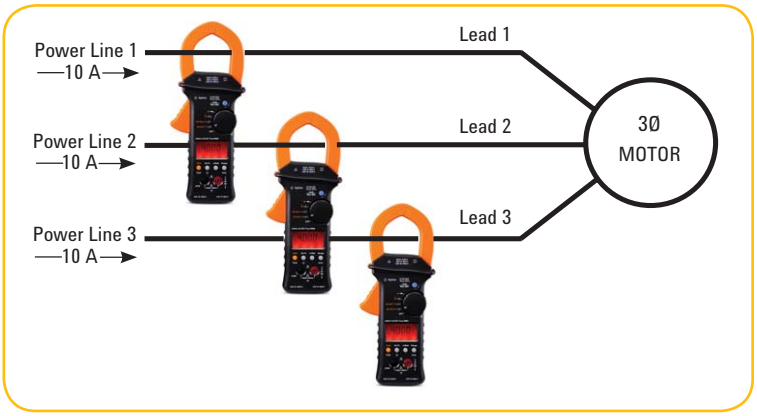


Figure 2. *Motor under normal condition*

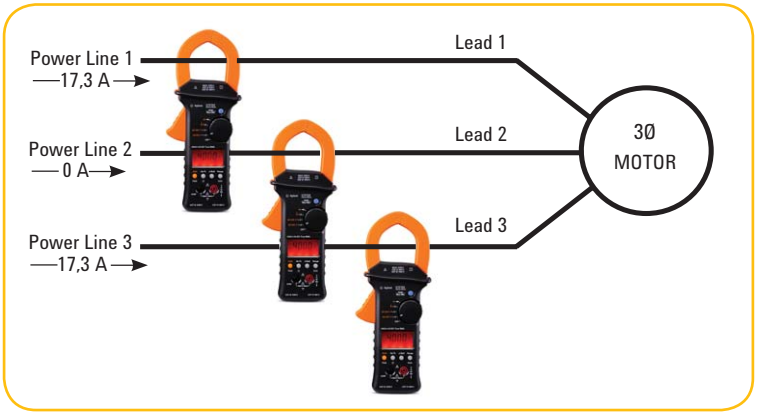


Figure 3. *Motor under single-phasing*

SUMMARY

Industrial applications use three-phase motors extensively in high-power applications. Any voltage unbalance or current unbalance can create excessive heat that damages the motors. Unanticipated failure of motors in critical service may damage equipment and affect plant availability. Proper predictive and preventive maintenance should be in place to reduce these motor failures. Electricians and technicians must equip themselves with the right tools, such as Agilent U1210 Series Handheld Clamp Meters, in order to perform such preventive maintenance program effectively. Furthermore, the large jaw openings of Agilent U1210 Series Handheld Clamp Meters are provide the best fit for other applications such as current measurement in transformers.

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