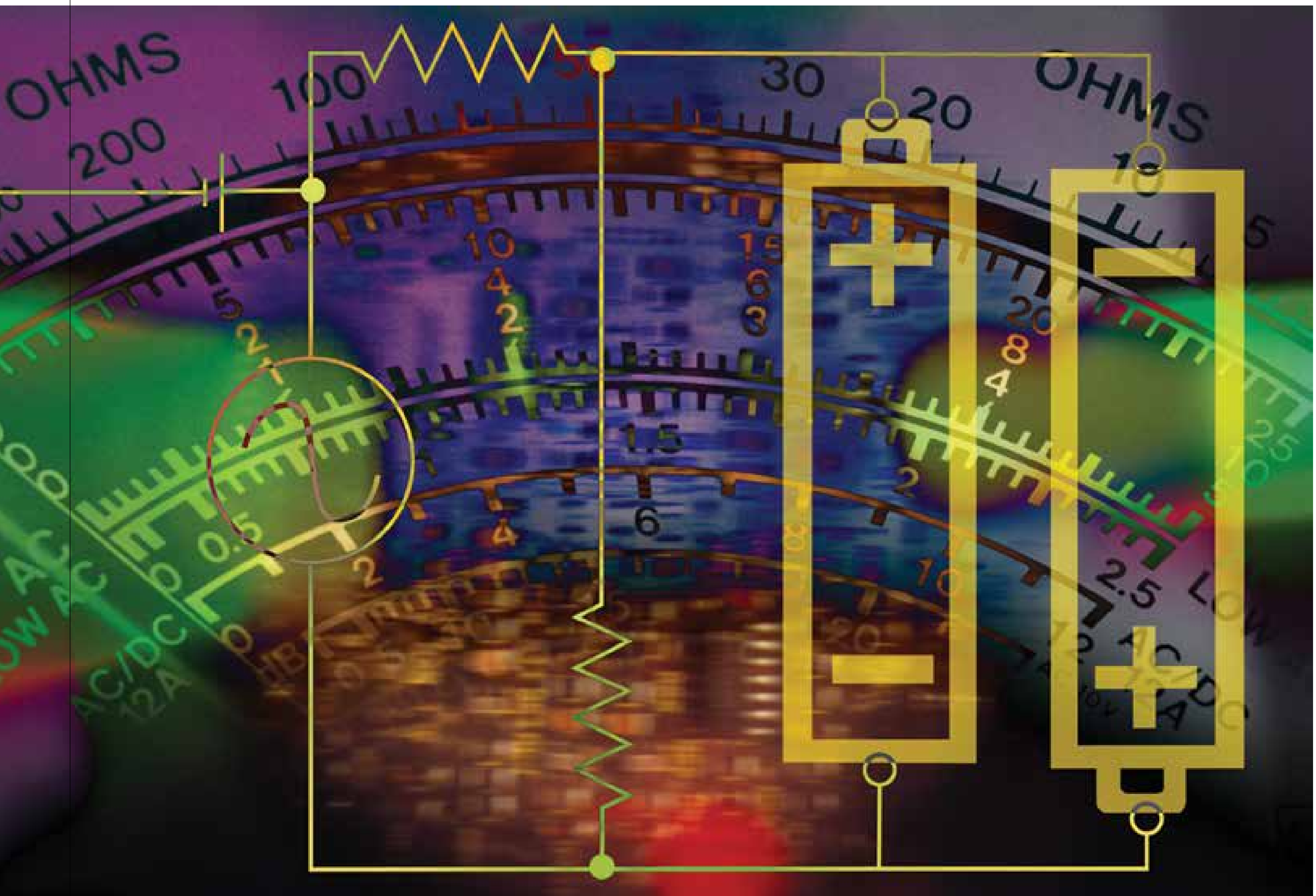


Electrical issues for compressors and fans

THE POWER SYSTEMS SPECIALIST AT POWER PARAMETERS, COLIN KINSEY, EXPLAINS HOW INTELLIGENT MULTI-PARAMETER ELECTRICAL METERING OF COMPRESSORS AND FANS CAN SIGNIFICANTLY REDUCE MAINTENANCE COSTS.

COMPRESSORS AND CONDENSER fans are at the heart of HVAC, refrigeration and cool room climate control. Chances are that they only come to notice if they fail, or exhibit problems that are solved simply by replacing them.

Either way, needless expenditure can be avoided by monitoring the electrical input so that timely alarms alert maintenance staff to take action.

The sort of electrical issues that affect compressors and fans are under-voltage, voltage unbalance, harmonics and, perhaps less frequently, excessive voltage at variable speed drive motor terminals, bearing corrosion through earth current leakage.

That will do for possible scenarios, and yes, most of these electrical power quality problems slip under the radar.

What is strongly advised is that for installations with large energy bills for HVAC, for cool stores, for supermarkets, shopping malls and so on is to implement electrical monitoring and associated preventive maintenance.

To get a handle on what this might save in operating costs, maintenance costs need to be split by type - mechanical and electrical maintenance. Once that visibility is gained, the potential benefits become evident.

This knowledge will help with planning corrective action and ensure wise capital expenditure.

POWER QUALITY ISSUES

Voltage unbalance is a killer of three-phase motors, causing excessive replacement frequency. It is not easily picked up unless appropriate metering is in place. Of course, if voltage unbalance occurs, what do you do about it? In some cases the cure can be relatively easy, for example, rerouting of single-phase loads sharing the motor circuits.

Or it might mean relocating motor circuits at switchboard level. In some cases the problem is imported from the network service provider. Note that low voltage (LV) distribution is far more prone to voltage imbalance than medium voltage (MV) supply. However, no point lying awake at night wondering about this—measure first, and measurement is a low cost option.

Unbalance even when sounding low, for example, say three per cent, voltage imbalance can cause motors to draw more than 20 per cent excess current and that is no good for motors running at their full nominal rating.

A simple measure of voltage unbalance is to take the highest phase voltage as a ratio of the average of the three phase voltages but that hides the severity of the problem. Modern, intelligent metering (see inset) resolves voltage unbalance in symmetrical components. The concept of symmetrical components resolves the three phase voltage in a positive sequence (the only one we really want), a negative sequence (causing problems) and a zero sequence (which gets away via the neutral) is shown diagrammatically.

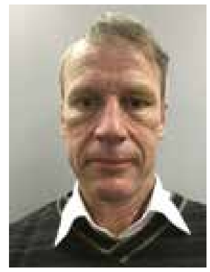
> "VOLTAGE UNBALANCE IS A KILLER OF THREE-PHASE MOTORS, CAUSING EXCESSIVE REPLACEMENT FREQUENCY."
> – COLIN KINSEY

Let's assume a negative sequence to positive sequence ratio of four per cent and an induction motor drawing six times full load current when starting from the 'locked rotor' position. The motor will draw an additional current of six times four per cent, i.e. 24 per cent additional current to the full load current. A brief explanation follows.

The impedance of an induction motor is low at high slip (starting phase), and high at low slip (running phase). We use Z2 to designate the negative sequence impedance of the motor, and Z1 for the higher impedance at full load. The negative sequence voltage is V2 and the positive sequence voltage is V1. Negative sequence ('starting') current as a ratio of running (full load) current is equal to Z1/Z2. The negative sequence current I2 is equal to V2/Z2 and likewise the positive sequence current is equal to V1/Z1.

Voltage unbalance in variable speed drives is also bad. The common six-pulse, three-phase converter supplying the DC link of a drive, in theory has the characteristic 'golden arches' line current with harmonics starting at the fifth.

Note: the harmonic numbers (in theory) are given by 6n 1 where n is an integer. The practice is often very different. As unbalanced voltages creep in, one of the twin peaks collapses, and third and ninth harmonics present themselves. Worse, the DC link voltage decreases so that motor torque also decreases.



Power Parameters power systems specialist, Colin Kinsey.

Harmonics cause overheating and rough running and monitoring of motor circuits both for voltage and current. Don't confuse harmonic currents drawn by motors connected to variable speed drives, with those caused by voltage harmonics in the supply circuits. Negative sequence harmonics, the fifth, and the eleventh can cause bad torque oscillation, and in general all harmonic voltages cause additional heating, shortening motor life. The heating is both in the stator but more pronounced in the rotors of induction motors because of the 'deep bar' effect which causes the higher frequency components of rotor current to flow at the surface of rotor bars (skin effect).

Monitoring is the key to lower costs for compressor and fan motor operation. Without the facts as revealed by intelligent metering, lots of potential analysis of things like shortened life are just put in the 'we'll look at in the future' basket.

The only realistic monitoring procedure is via exception reports—hence the need for intelligent metering. For example, based on the explanation of voltage unbalance, a discrimination function will report only the instances where unbalance exceeds a preset ratio of negative sequence to positive sequence.

Furthermore a combination of parameters including the above with an excess of voltage harmonics above a preset level can be combined logically to provide exception reports. It is hard to overestimate the potential of this data in extending plant life.

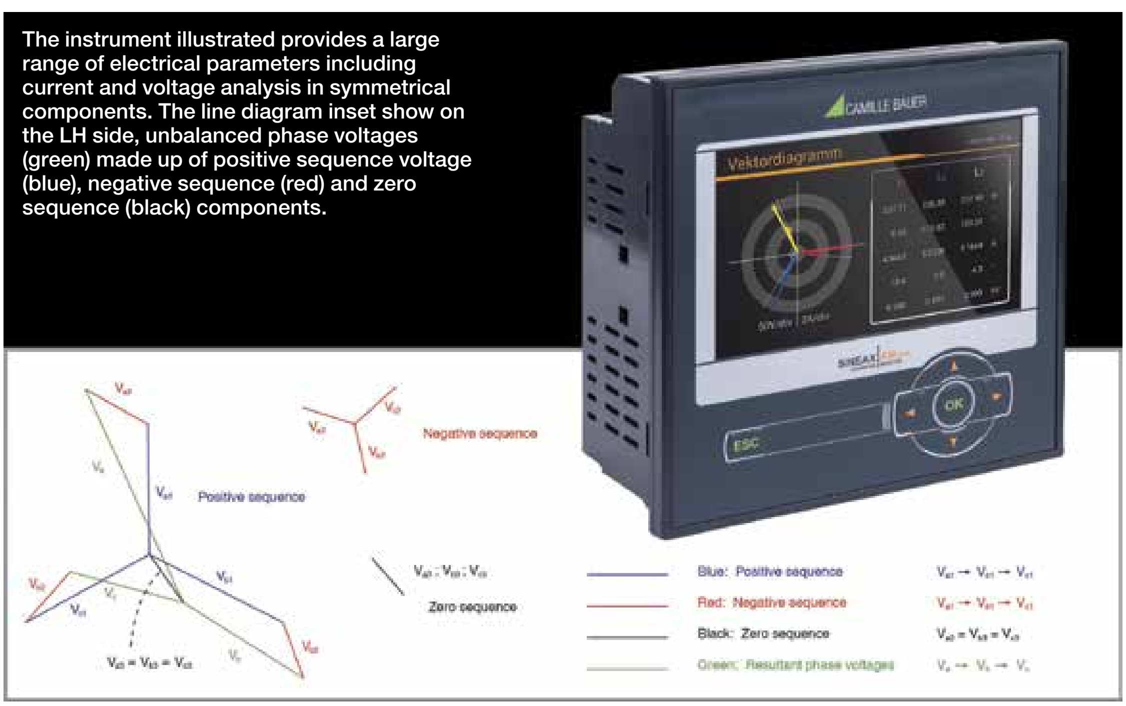
Potential for lower plant maintenance costs is one thing; doing something about is the key. Solutions have to be based on realities meaning that there will always be a degree of voltage imbalance on the incomers as well as a level of harmonics.

Plant layout is important and in the self-help department (i.e. not making matters worse), motor control centres should be connected as close to the incomers as possible.

Phase transposition so as to equalise current in cables or busbars may be necessary. Obviously, connection downstream brings up problems of phase balance—something which in practice is impossible to achieve.

Some active filters used for harmonics mitigation also offer phase balancing and this can be an excellent solution. However, power quality analysis is necessary before specifying an active filter solution.

Motor protection should also be considered. The use of intelligent panel meters combined with traditional motor protection should also be considered. An obvious one for protection purposes is an external trip signal to protection breakers, but equally to PLCs controlling task allocations. ✷



The instrument illustrated provides a large range of electrical parameters including current and voltage analysis in symmetrical components. The line diagram inset show on the LH side, unbalanced phase voltages (green) made up of positive sequence voltage (blue), negative sequence (red) and zero sequence (black) components.