

37 Park Road, Hemel Hempstead Herts, HP1 1JS.
 Mob: 07855 435384 Fax: 0870 1245336

3 Filey Close, Sutton, Surrey, SM2 5JZ
 Mob: 07855 435385 Fax: 020 86421765

Date:
 To:
 Att:
 From: Steve Orlando.
 Email: steve.orlando@fridgetek.com

Chiller No1. Mod: YKFBFAH65CSD Ser: PLGMH50288
 Chiller No2. Mod: YKFBFAH65CSD Ser: PLGMH50294
 Chiller No3. Mod: YKFBFAH65CSD Ser: PLGMH50287
 Chiller No4. Mod: YKFBFAH65CSD Ser: PLGMH50290

Following on from my site visit last week, please find a breakdown of the problems encountered. The above site suffered from Power Faults on a running Chiller during the start sequence of another. Initial investigations of the Chillers CM2 Motor Protection Module's three-phase rectified input signal, showed irregularities. We would expect a 300Hz ripple (3.3mSecond period) on the input signal, denoting the rectification of the 3 Current Transformer signals from each of the phases to the motor. With the aid of an oscilloscope we can see that we have only a 150Hz ripple (6.6mSecond period) with a higher amplitude than we would expect. Refer to Figure 01.

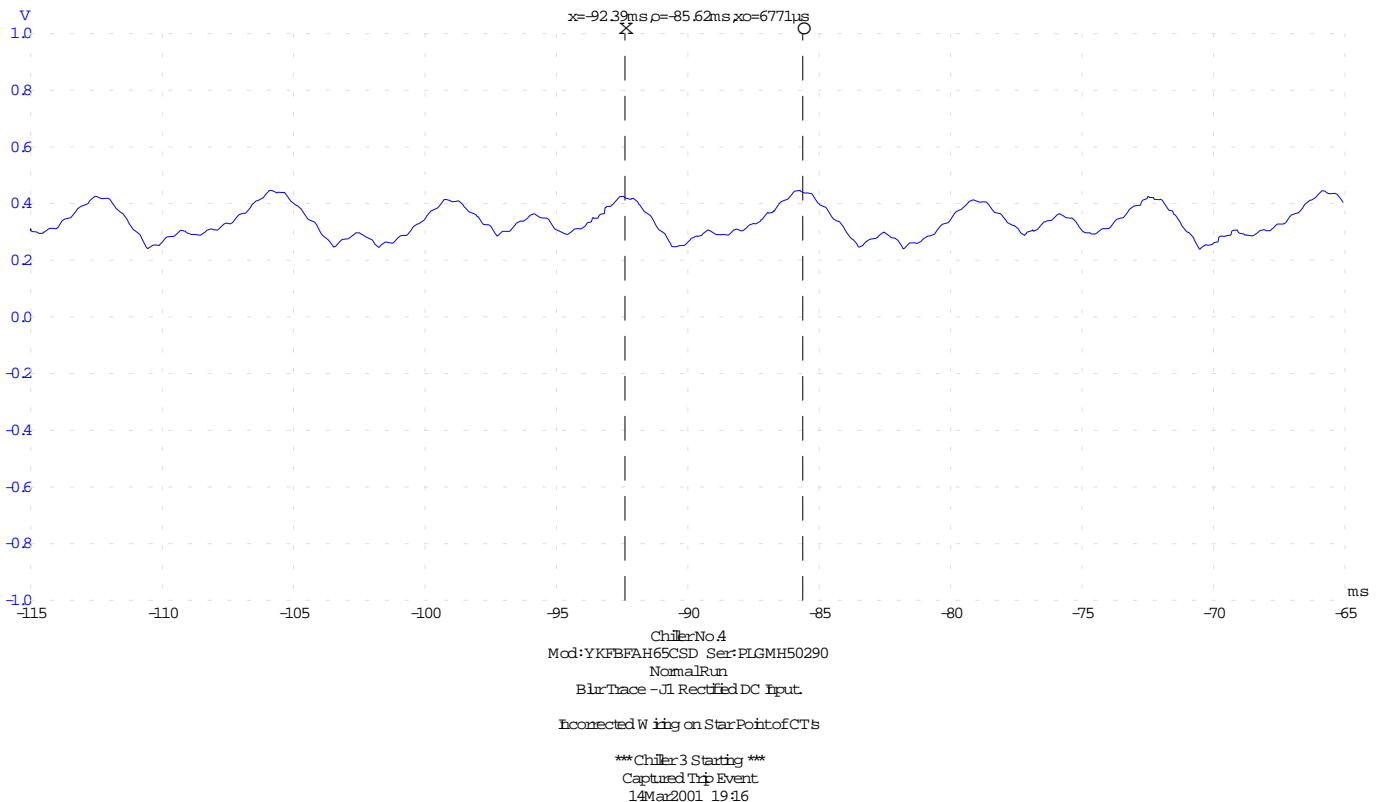


Figure 01.

Further investigation showed that the star point on the CM2 Module's Current Transformers had been earthed. This mis-wiring caused the loss of half the CT's Signal to the three-phase rectifier with a resultant reduction on it's output RMS signal. The manufacturer overlooked this mis-

wiring at the commissioning stage and the CM2 Module was inadvertently mis-calibrated. This had no detrimental effect on chillers or motor's safety protection circuits, as this mis-calibration actually made the CM2 Modules Safety levels twice as sensitive to tripping, as seen on site.

We actually captured a trip event on a running Chiller with the mis-wiring still in place, as reflected in Figure 02. The whole event took around 100 m seconds from initial start of the other Chiller to the running compressor's contactor dropping out.

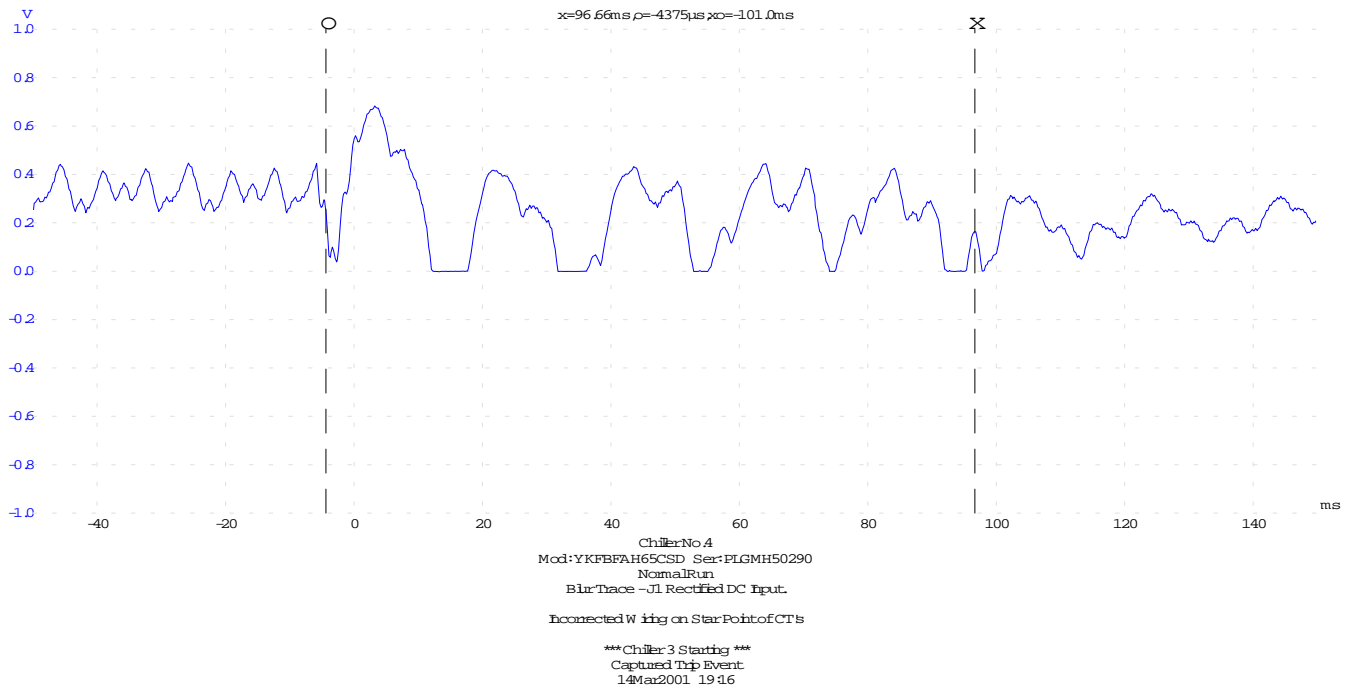


Figure 02.

After removing the Earth lead from all the chillers CM2 Modules CT's Star points, the correct waveform was captured as per Figure 03.

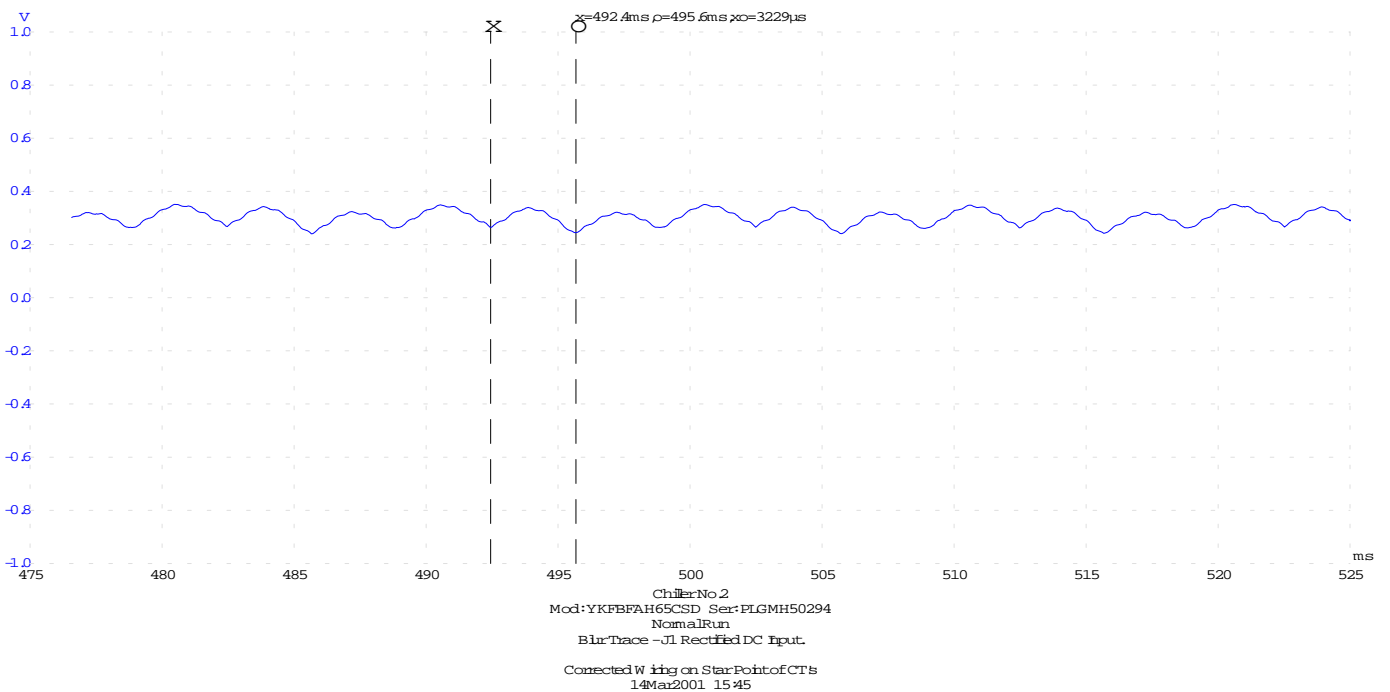


Figure 03.

All 4 Chiller CM2 Modules and burden resistors were recalibrate to the Alan Bradley current readings. The chillers were tested over several starting and running conditions, which proved successful until there were 3 compressors running lightly loaded and the 4th being started. Again a Power Fault Shutdown occurred on one of the running compressors. Although a trip did occur, the regularity of these trips has reduced since the correction of the earth mis-wire, to a level of no trips with 2 chillers running and one starting.

Although the Power Faults have reduced, the problem behind the trips is still present during every start of a compressor. This event is a reduction in the 3.3kV power supply to the running compressor when another Chiller starts. Although I did not directly measure the 3.3 kV network during one of these events, I did capture a large volt drop on a 3.3kV to 110Vac transformer output in the running chillers starter cabinet. This volt drop was measured as a 14% reduction on line voltage as reflected in Figure 04.

This captured event also shows the running chillers current waveform phase shifting at the instant the other Chiller is started. This can be explained as reduced Line Voltage at the instant the other starting compressor is flashed up, causing the running driveline to decelerate and the motor to be driven by the compressor and it's own rotor's inertia. The back EMF produced by the motor exceeds the line voltage and current from its windings is dumped back into the 3.3 kV Network, assisting the starting compressor to break away. This phase shift, an almost anti-phase distinguishes between the motor being a load to a generator in relation to the 3.3kV Network. This current dumping event lasts between 1 to 4 cycles. The oscillating current distortion after this event is a function of slip and acceleration whilst the running motor achieves synchronous speed.

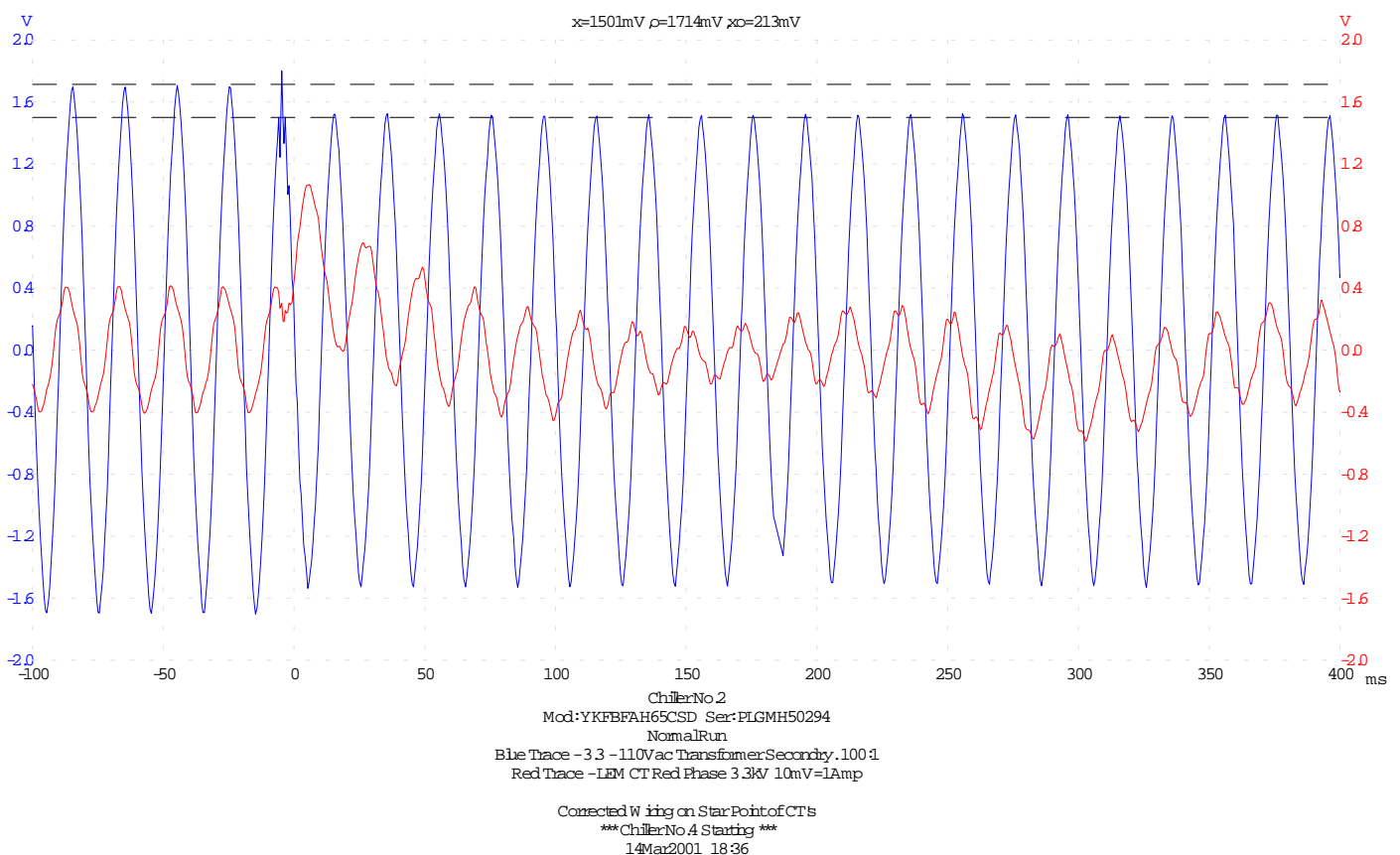


Figure 04.

The above event can be seen even better when using two current probes on the motor leads. It can be seen from all our data collected (Figure 05) that around 50 to 60 Amps RMS is being dumped back into the 3.3 kV Network, this calculates to around 160 kW of power.

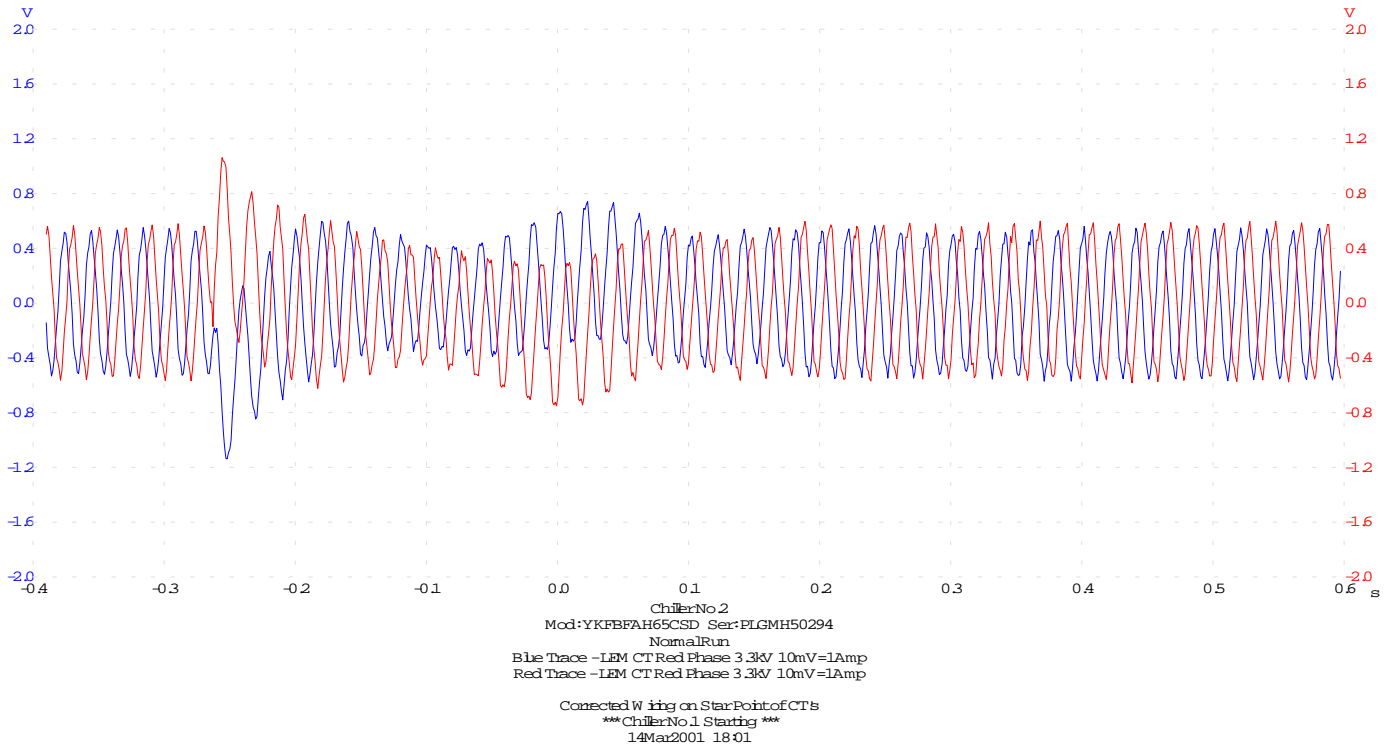


Figure 05.

To show you the theoretical resultant rectified waveform to the CM2 module of the above waveform we apply a unitary algorithm to calculate the third phase current draw. (Only 2 inputs on my oscilloscope) Using the absolute value from all three phases we can show the resultant rectified signal to the CM2 Module. (Figure 06) As you can see there are several major dips in the signal (Black Trace) that once exceed the 15% minimum current threshold will result in a Power Fault Shutdown. This theoretical calculated rectified signal takes the exact form as a captured scope trace as reflected in Figure 07. This suggests that even with the corrected earth wiring the real rectified waveform to the CM2 Module is very close to a trip condition as the 3.3kV Network now stands.

Three Phase Rectified Current

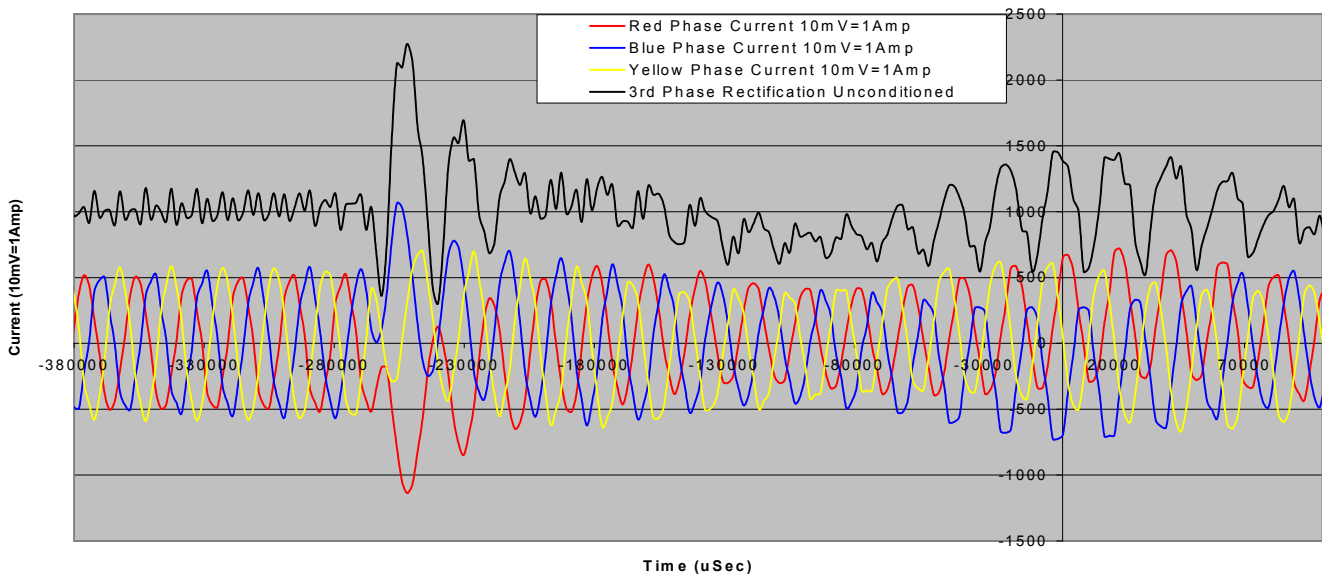


Figure 06.

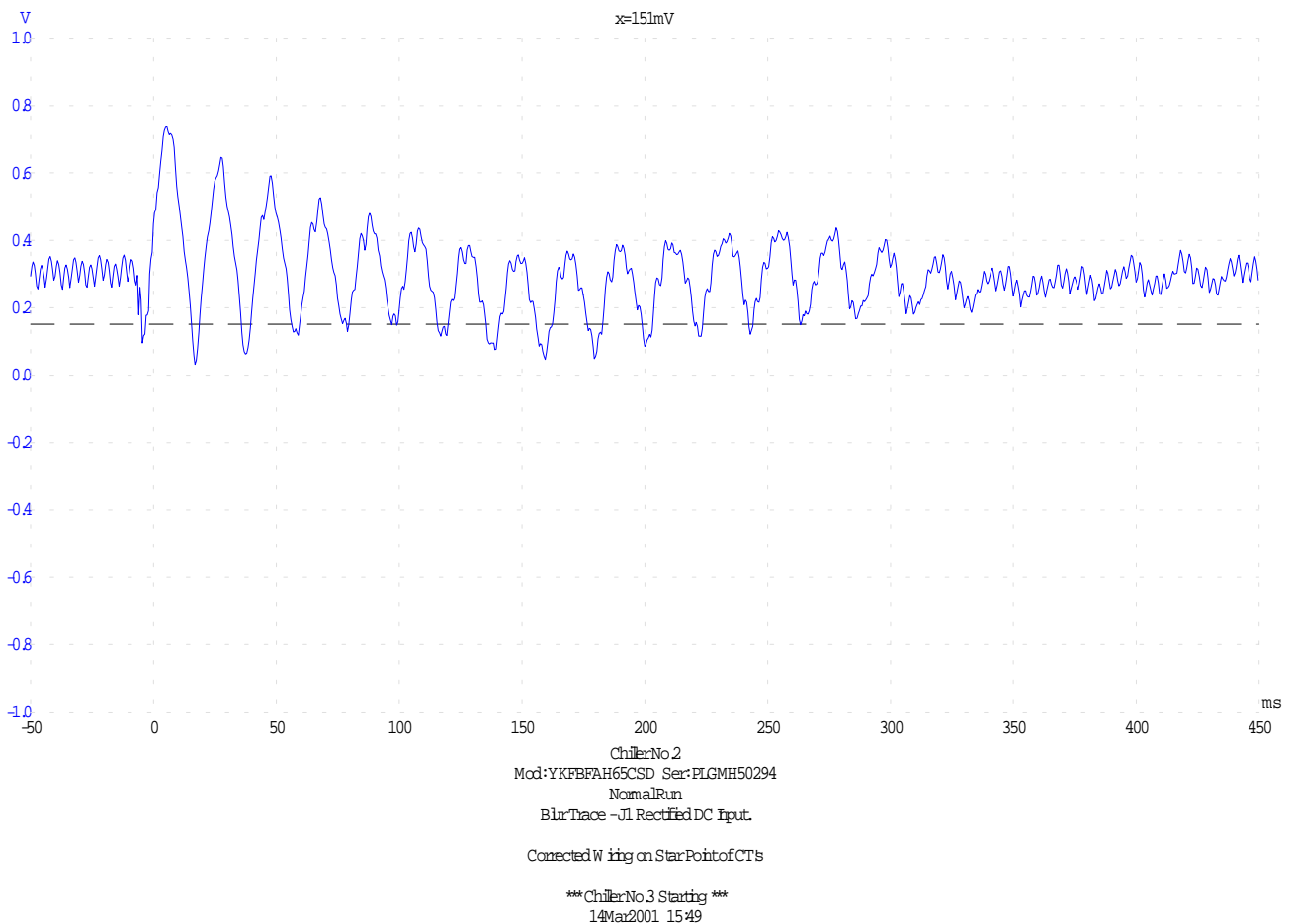


Figure 07.

As discussed on site, an oversight on the installation of two of the four 3.3kV Chiller Starter Panels, saw two different sized starters fitted to the wrong machines. This has been sited as the potential failing of the 3.3kV Network, due to the incorrect power factor correction packs being applied to the wrong motor. When works are completed and the correct 3.3kV Starters are on the correct chillers, we expect to see no difference to the compressor starting characteristics of the 3.3kV Network.

Fundamentally the compressor motor is being used as a generator during the starting of another Chiller due to excessive volt drop on the 3.3kV Network. The negative torque energies present during this roll reversal of the motor have not been incorporated into the design of Chiller drivelines. Therefore if left to operate in this manner the driveline could suffer a catastrophic failure. I recommend the 3.3kV Network be scrutinised for any shortfall in performance, as the voltage drop and current waveforms captured suggests a problem with it. This could also encompass the 11kV performance on the 3.3kV Transformer.

Whilst on site several service issues were noticed, which requires urgent attention, these include:

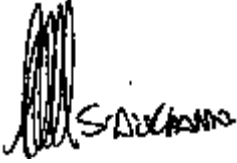
- There is severe vibration of the Chiller Control Panels currently mounted on the evaporator vessels. This has caused the deterioration of the CM2 Burden Resistors on all 4 chillers. All 4 resistors require urgent replacing as there output changes with the degree of vibration present due to the loose fitting wiper arm assembly. I recommend as a course of action to mount the Panels via Unistrut from the plant room floor, this will isolate any vibration and it's premature failing effects on the panel's components.
- There was no load on site during the recalibration process on all 4 chillers. The 105% Overload Potentiometer needs to be positively tested, currently it is set to a theoretical

value.

- Chiller No2 Chilled Water Return Sensor is out of calibration, a replacement sensor is required.
- Chiller No1 shaft seal seems to have an excessive oil leak. Further investigation required.

Assuring you of our closest attention at all times.

Regards

A handwritten signature in black ink, appearing to read "S. Orlando". The signature is stylized and somewhat illegible due to the cursive nature of the writing.

Steve Orlando
Partner