Distortion in acoustic emission and acceleration signals caused by frequency converters

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Abstract

Acquiring signals without disturbance is a crucial part of condition monitoring. This paper discusses some observations concerning disturbance in signals caused by two different frequency converters when measuring acoustic emission and acceleration. Signals are acquired by means of two acoustic emission and acceleration sensors. The test rig includes an electric motor and a worm gear. Measurements are performed when the motor is driven by a frequency converter at 594 and 1494 rpm. The results are compared to the motor connected directly to the power line. In acoustic emission signals one frequency converter caused a repeating peak in the spectrum at intervals of 40 kHz. The other frequency converter produced a general rise in amplitudes from about 200 to 400 kHz. When measuring acceleration in the frequency range 0...30 kHz the signals show no significant distortion.

Keywords: Condition monitoring, diagnostics, acoustic emission, acceleration, frequency converter, signal distortion

1. Introduction

Detecting faults in machines is often based on measurements. It can sometimes be difficult to find reliable indication of certain defects even when signals are faultless, while performing diagnostics with distorted signals can cause extreme problems. The unhealthy part of a signal can in some cases be eliminated e.g. through band stop filtering.

When a signal seems to be unhealthy, a common assumption would be to think that it is caused by a faulty or unsuitable measuring device. These are potential
sources of signal distortion, but distortion may also stem from the environment. This paper shows that it can be problematic to measure electric motors controlled by means of frequency converters. In addition, measurements indicate that it is extremely important to ensure the correctness of signals before using them as a basis of condition monitoring.

Tests were performed in order to examine the condition monitoring of worm gears. The primary target was to detect wear in a worm and a wheel. Another aim was to compare acceleration signals with acoustic emission signals. Reaching these goals was found difficult because the signals did not seem to be healthy. When trying to reduce disturbance in the signals, many solutions were tested. The results of these tests were taken into discussion, as error-free signals are an important part of condition monitoring in general, and avoiding signal distortion is not always a straightforward task.

2. Test rig and measurement equipment

The test rig is shown in Figure 1. It is equipped with a 1.4 kW electric motor. The worm gear\(^{(1,2)}\) has a transmission ratio of 19:1, and it is coupled to a hydraulic pump via torque sensor.

For acoustic emission (AE) measurements two different sensors were used. These were of type 8152B111 and 8152B211 manufactured by Kistler. Two piezotron couplers, both type 5125B were used for power supply to sensors and signal preprocessing. Filters had pass band from 50 to 1000 kHz and gain factor was 10, i.e. 20 dB.

The accelerometers used in the tests were SKF CMSS 726 and Brüel & Kjær 4384. The latter one does not include an amplifier, so its signal was preamplified using the
Brüel & Kjær Nexus 2692 charge amplifier. A battery powered unit was used as the power source of the SKF CMSS 726 accelerometer. A PC with LabVIEW software and NI PCI-5922 measurement card was used to store the signals.

All the sensors were stud mounted on the housing of the gearbox (Figure 1). In order to ensure proper contact to the surface, the gear housing was machined in order to make it as flat as possible. Acoustic emission sensors were mounted using silicone grease between the surfaces of the sensors and the gear housing.

3. Tests

Tests were carried out with a test rig at the Mechatronics and Machine Diagnostics Laboratory at University of Oulu. The setup of the test rig itself was not changed during the tests, but different measurement devices and ways to drive the motor were utilised. These were:

1. ABB ACS 600 frequency converter
2. ABB ACS 550 frequency converter
3. ABB ACS 550 frequency converter with a du/dt filter of type NOCH0016-65
4. No frequency converter.

Two rotational speeds, \( n = 1494 \) rpm and \( n = 594 \) rpm, were used. In addition, measurements were performed when the measuring devices were powered by uninterruptible power supply (UPS). In this case the ACS 600 frequency converter was plugged, but the motor was not running. In addition, certain measurements with setups 1 and 3 were performed using an isolation transformer, which was tested to avoid power line originated disturbance in the measurement devices.

4. Analysis of the measurements

The measurements were analysed in both time and frequency domain. In the frequency spectra all the components are presented as peak values. Some features from different circumstances were also calculated in order to show relative changes between the signals. The weighted \( l_p \) norm was used to calculate features from the signal \( x^{(\alpha)}(t) \). It is defined as

\[
\|x^{(\alpha)}\|_{p,w} = \left( \sum_{i=1}^{N} w_i |x_i^{(\alpha)}|^p \right)^{\frac{1}{p}},
\]  

(1)
where real number $\alpha$ is the order of derivative, $N$ is the number of signal values, and real number $p \neq 0$. If $w_1 = w_2 = \ldots = w_N = 1$ the question is of a classical $l_p$ norm $\|x^{(\alpha)}\|_p$. Furthermore, if $w_1 = w_2 = \ldots = w_N = 1/N$, we obtain the formula (2). It has the same form as the generalised mean, also known as the power mean or the Hölder mean. Lahdelma has introduced in (3) the concept of space $l_p$. The $l_p$ norm is

$$\|x^{(\alpha)}\|_p \equiv \left( \frac{1}{N} \sum_{i=1}^{N} |x_i^{(\alpha)}|^p \right)^{\frac{1}{p}} = \left( \frac{1}{N} \right)^{\frac{1}{p}} \|x_i^{(\alpha)}\|_p.$$  (2)

This norm was introduced by Lahdelma and Juuso in (4), with the name “generalised norm”. In condition monitoring the absolute mean, root mean square (rms) and peak value are often used. These are special cases of (2), when $p = 1$, $p = 2$ and $p = \infty$, respectively. Further reading on norms can be found in (5,6,7).

4.1 Acceleration measurements

In acceleration measurements, distortion was detected in some cases, but it was interesting to note that it may be caused by other measurement devices used simultaneously. When the measurement was performed by means of the SKF CMSS 726 accelerometer alone, the signal seems to have a different level than in the case where the acoustic emission sensor and accelerometer were used at the same time. The Brüel & Kjaer 4384 accelerometer was not battery powered, so measurements performed with the sensor enable the effect of power line on acceleration signals to be estimated.

4.1.1 Motor not running

To find out whether the power line has an impact on the measurement devices, an uninterruptible power supply was used. Measurements were performed when the motor was not running at all so as to make sure that changes occurring in the signals in this case are solely caused by electrical disturbance.

The signal in Figure 2(a) is obtained using the Brüel & Kjaer 4384 accelerometer when the UPS is connected to the power line. In Figure 2(b) when the measurement devices were powered with the battery of the UPS. The difference between these cases is very clear. When the cable was plugged, $\|x^{(2)}\|_2$ had the value 1.464 m/s², and when the cable was unplugged, the value dropped to 0.020 m/s². In other words, when the UPS was disconnected from the power line, $\|x^{(2)}\|_2$ dropped to 1.37 % from the initial value.
Figure 2. Signals from the B&K 4384 accelerometer in the frequency range 1 Hz...100 kHz when measurement devices were powered by the UPS. The signal (a) is obtained when the UPS was plugged to the power line and the signal (b) when the UPS was unplugged.

Figure 3. Spectrum (a) is from the signal in Figure 2(a) and spectrum (b) is the same from the signal in Figure 2(b).
In the spectrum presented in Figure 3(a) there are peaks at line frequency $f_l = 50\text{Hz}$ and its odd harmonics. When cable is plugged, peaks at $(f_l, 3f_l, 5f_l, \ldots)$ are visible, but on battery powered situation (Figure 3(b)) all amplitudes in the frequency range 1 Hz...10 kHz are practically zero.

### 4.1.2 Motor run without frequency converter

Figure 4 (a) shows the signal from the SKF CMSS 726 accelerometer, when the motor is plugged directly into the power line. The spectrum in Figure 4 (b) is from 0 to 900 kHz and in Figure 4 (c) from 0 to 30 kHz. The signal in Figure 4 (a) is the basic signal, which is compared with the accelerometer signals acquired when the frequency converters were used.

![Time domain signal](image)

![Frequency spectrum](image)

Figure 4. Signal from the SKF CMSS 726 accelerometer when the motor was run without the frequency converter at 1494 rpm
4.1.3 Motor run with ACS 600 frequency converter

Figure 5 (a) shows the time domain signal acquired by means of SKF CMSS 726 accelerometer. Its spectra from 0...900 kHz (Fig. 5 (b)) and 0...30 kHz (Fig. 5 (c)) are also shown. Significant disturbance cannot be seen in either the time or frequency domain. Some peaks appear at the frequency range 0...5 kHz, but they do not seem to be caused by electrical source, because they are not vibration at the harmonics of line frequency, and the spectrum is almost identical when the motor is run with and without the ACS 600 frequency converter (Figures 5 and 4).

Figure 5. Signal from the SKF CMSS 726 accelerometer when the motor was run at 1494 rpm with the ACS 600 frequency converter

Figure 6 shows the SKF CMSS 726 accelerometer signal when the motor was run at 594 rpm. The signal level is lower than in Figure 5. This should not be the case if the signal was caused by an electrical source. The signal does not seem to be very seriously disturbed when the ACS 600 frequency converter is used. The same
thing is seen from the features shown in Table 1. The values do not point to any major change when the motor is driven with or without the frequency converter if the rotational speed remains the same. The result is quite expected, as the signals in Figures 4 and 5 seem to be somewhat similar.

![Time domain signal](image1)

![Frequency spectrum](image2)

Figure 6. Signal from the SKF CMSS 726 accelerometer when the motor was run at 594 rpm with ACS 600 frequency converter

<table>
<thead>
<tr>
<th>Feature</th>
<th>Without frequency converter at 1494 rpm</th>
<th>With ACS 600 at 1494 rpm</th>
<th>With ACS 600 at 594 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>$|T^{(2)}|_2$</td>
<td>4.288 m/s²</td>
<td>4.420 m/s²</td>
<td>1.489 m/s²</td>
</tr>
<tr>
<td>$|T^{(2)}|_4$</td>
<td>5.910 m/s²</td>
<td>6.036 m/s²</td>
<td>1.994 m/s²</td>
</tr>
<tr>
<td>$|T^{(2)}|_\infty$</td>
<td>23.947 m/s²</td>
<td>23.240 m/s²</td>
<td>7.167 m/s²</td>
</tr>
</tbody>
</table>

Table 1. Features from the signal of the SKF CMSS 726 accelerometer in the frequency range 0...100 kHz

Figure 7 shows one more example of the signal from the SKF CMSS 726 accelerometer. In this case the motor is plugged directly to the power line, and the Kistler 8152B211 sensor is used simultaneously for the measurements. The signal is otherwise obtained with the same test setup as in Figure 4, the only difference being the additional acoustic emission sensor. In this case the acceleration signal shows a significant difference as compared with Figures 4 and 5. In Table 2, the difference is presented using time domain features.
Table 2. Features from the signal of the SKF CMSS 726 accelerometer in the frequency range 0...100 kHz

<table>
<thead>
<tr>
<th>Feature</th>
<th>Without frequency converter at 1494 rpm</th>
<th>Without frequency converter at 1494 rpm and with AE sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$|x(2)|_2$</td>
<td>4.288 m/s²</td>
<td>6.562 m/s²</td>
</tr>
<tr>
<td>$|x(2)|_1$</td>
<td>5.910 m/s²</td>
<td>8.859 m/s²</td>
</tr>
<tr>
<td>$|x(2)|_\infty$</td>
<td>23.947 m/s²</td>
<td>34.224 m/s²</td>
</tr>
</tbody>
</table>

Figure 7. Signal from the SKF CMSS 726 accelerometer when the AE sensor was used simultaneously and the motor was run without the frequency converter at 1494 rpm

4.1.4 Motor run with ACS 550 frequency converter

When using the ACS 550 frequency converter, the SKF CMSS 726 accelerometer signal seems to be quite similar as compared with a situation where the motor was driven with the ACS 600 frequency converter. When using the du/dt filter, the signal is at a slightly lower level than without the filter, but the difference is not very large. The value of $\|x(2)\|_2$ from the signal in Figure 8 is 6.670 m/s² and in the case of Figure 9, it is 5.915 m/s². In both the cases the signals are quite similar to Figure 7. It should be noted, that in these measurements the acoustic emission sensor was used together with the accelerometer.
Figure 8. Signal from the SKF CMSS 726 accelerometer when the motor was run with the ACS 550 frequency converter at 1494 rpm

Figure 9. Signal from the SKF CMSS 726 accelerometer when the motor was run with the ACS 550 at 1494 rpm and the du/dt filter was used

4.2 Acoustic emission measurements

Acoustic emission signals were clearly more distorted by frequency converters than those acquired using accelerometers. Feeding the motor by means of a frequency converter instead of plugging it directly into the power line could also change the
mechanical behaviour of the motor. In this case, this does not explain the change in the signals, because using an isolation transformer with the measurement devices produces different signals (Section 4.2.2). Part of the problem is that acoustic emission must be measured at higher frequencies and over a wider frequency band than acceleration. Consequently, electrical disturbance at high frequencies is more likely to affect measurements.

4.2.1 Motor run without frequency converter

Signals from acoustic emission sensors when the motor was run without frequency converter are shown in Figures 10 and 11. Despite the fact that the frequency response of these sensors is different than that of accelerometers, the AE time domain signals are very similar to the acceleration signals when the motor was plugged directly into the power line (Figure 4). It is possible that the signals originate from the same mechanical vibrations and are not electrically distorted.

![Time domain signal](image1)

![Frequency spectrum](image2)

**Figure 10.** Signal from the Kistler 8152B211 AE sensor when the motor was run without a frequency converter at 1494 rpm
4.2.2 Motor run with ACS 600 frequency converter

The signal in Figure 12 is from the Kistler 8152B211 AE sensor. Distortion is clearly seen especially in the frequency spectrum as peaks repeating at 40 kHz intervals. The difference with the signal presented in Figure 10 is very clear. There is also considerable increase in the calculated features, as seen in Table 3. Distortion is so severe that this signal can be considered quite useless for condition monitoring.

Figure 12. Signal from the Kistler 8152B211 AE sensor when the motor was run with the ACS 600 frequency converter at 1494 rpm
Table 3. Features from the signal of the Kistler 8152B211 AE sensor in the frequency range 50...900 kHz

<table>
<thead>
<tr>
<th>Feature</th>
<th>Without frequency converter at 1494 rpm</th>
<th>With ACS 600 at 1494 rpm</th>
<th>With ACS 600 at 594 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>$</td>
<td></td>
<td>\mathbf{v}</td>
<td></td>
</tr>
<tr>
<td>$</td>
<td></td>
<td>\mathbf{v}</td>
<td></td>
</tr>
<tr>
<td>$</td>
<td></td>
<td>\mathbf{v}</td>
<td></td>
</tr>
</tbody>
</table>

When reducing the rotational speed of the motor to 594 rpm, an indication of electrical disturbance is also seen. Figure 13 shows the signal from the Kistler 8152B211 AE sensor in this situation. The time domain signal seems to be only slightly different, and the frequency spectrum shows quite clearly that the signal is distorted at the same frequencies as in Figure 12.

![Time domain signal](image1)

![Frequency spectrum](image2)

Figure 13. Signal from the Kistler 8152B211 AE sensor when the motor was run with the ACS 600 frequency converter at 594 rpm

Table 3 shows that when the ACS 600 frequency converter was used to drive the motor at 594 rpm, the signal features are much higher than when the motor was run without the frequency converter at 1494 rpm. When the motor was run at much slower rotational speed, it was actually expected that the values of features would decrease. Opposite results can be considered a sign of electrical distortion in the signal.

Even if the signal is distorted when using the ACS 600 frequency converter, the signal shows a change when rotational speed is changed. Calculated features are lower when the motor was run at 594 rpm than in the case where rotational speed
was 1494 rpm. On the other hand, in the frequency domain the most significant change occurs in peaks that repeat at 40 kHz interval in both the cases. The peaks are quite obviously caused by an electrical source, so after all the change might partly result from a change in electrical distortion.

Figure 14 shows a signal from the Kistler 8152B211 when the motor was run with the ACS 600 frequency converter at 1494 rpm, and the measurement devices were plugged into the power line via an isolation transformer. The level of signal in the time domain is clearly lower than in Figures 12 and 13, and the frequency spectrum is also quite different.

![Signal from the Kistler 8152B211 AE sensor when the motor was run with the ACS 600 frequency converter at 1494 rpm and the isolation transformer used](image)

**Figure 14.** Signal from the Kistler 8152B211 AE sensor when the motor was run with the ACS 600 frequency converter at 1494 rpm and the isolation transformer used

As seen in Figure 15, distortion was also observed when using the Kistler 8152B111 AE sensor. The difference when compared to Figure 11 is seen in both time and frequency domain. The distortion is quite similar as seen in the signal obtained from the Kistler 8152B211 AE sensor, even though relative change in the signal is much smaller. However, the absolute change seems to be even higher. For example, the growth of $\|V\|_2$ is 7.115 mV in Table 3 but 11.710 mV in Table 4.
Figure 15. Signal from the Kistler 8152B111 AE sensor when the motor was run with the ACS 600 frequency converter at 1494 rpm

Figure 16. Signal from the Kistler 8152B111 AE sensor when the motor was run with the ACS 600 frequency converter at 594 rpm
Table 4. Features from the signal of the Kistler 8152B111 AE sensor in the frequency range 50...400 kHz

<table>
<thead>
<tr>
<th>Feature</th>
<th>Without frequency converter at 1494 rpm</th>
<th>With ACS 600 at 1494 rpm</th>
<th>With ACS 600 at 594 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>$|\mathbf{V}|_2$</td>
<td>32.016 mV</td>
<td>43.726 mV</td>
<td>26.265 mV</td>
</tr>
<tr>
<td>$|\mathbf{V}|_4$</td>
<td>44.343 mV</td>
<td>59.471 mV</td>
<td>35.100 mV</td>
</tr>
<tr>
<td>$|\mathbf{V}|_\infty$</td>
<td>319.664 mV</td>
<td>393.301 mV</td>
<td>168.924 mV</td>
</tr>
</tbody>
</table>

4.2.3 Motor run with ACS 550 frequency converter

When driving the motor with the ACS 550 frequency converter, the level of distortion in the time domain signal is comparable to the distortion caused by the ACS 600 frequency converter. However, frequency spectra differ clearly between these cases. The signals in Figures 17 and 18 show that the time domain signals look quite similar to those presented in Section 4.2.2, whereas the frequency spectra indicate that in this case distortion is much more evenly distributed. It can be seen from Figure 19 that in this case the difference was caused by the simultaneous use of the accelerometer. In this measurement, the NI PCI-5922 card was in a single-ended mode. An interesting point here is that using the card in a pseudodifferential mode did not affect the signals to any appreciable extent.

Figure 17. Signal from the Kistler 8152B211 AE sensor when the motor was run with the ACS 550 frequency converter at 1494 rpm
The use of the du/dt filter does not seem to have any appreciable impact on the AE signal (Figure 20). The signal from the Kistler 8152B211 AE sensor cannot really be considered more healthy, compared to a situation where the ACS 550 frequency converter was used without the filter and the accelerometer was used simultaneously. In the features presented in Table 5, a change can only be seen in
the peak value. When studying the spectra more carefully, some peaks that seem to repeat at intervals of 150 Hz can be found. Nonetheless, these amplitudes are very low, mostly less than 0.2 mV, and frequencies higher than 200 kHz seem to be comparable to the signal acquired when the motor was plugged directly into the power line (see Figure 10).

![Time domain signal](image1)

![Frequency spectrum](image2)

Figure 20. Signal from the Kistler 8152B211 AE sensor when the motor was run with the ACS 550 frequency converter at 1494 rpm and the du/dt filter was used

Table 5. Features from the signal of the Kistler 8152B211 AE sensor in the frequency range 50...400 kHz

<table>
<thead>
<tr>
<th>Feature</th>
<th>Without frequency converter at 1494 rpm</th>
<th>With ACS 550 at 1494 rpm</th>
<th>With ACS 550 and filter at 1494 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>$|V|_2$</td>
<td>2.709 mV</td>
<td>4.013 mV</td>
<td>4.027 mV</td>
</tr>
<tr>
<td>$|V|_4$</td>
<td>3.671 mV</td>
<td>5.739 mV</td>
<td>5.731 mV</td>
</tr>
<tr>
<td>$|V|_\infty$</td>
<td>21.016 mV</td>
<td>40.698 mV</td>
<td>35.108 mV</td>
</tr>
</tbody>
</table>

Table 6 shows relative changes in feature values. It is included in order to facilitate the comparison of different measurements and also to provide a way of estimating the level of disturbance signals in each case.
Table 6. Relative change in features, * = simultaneous measurement with the CMSS 726 accelerometer and the 8152B211 acoustic emission sensor

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Feature</th>
<th>Without frequency converter 1494 rpm</th>
<th>With ACS 600 594 rpm</th>
<th>With ACS 600 1494 rpm</th>
<th>With ACS 550 1494 rpm</th>
<th>With ACS 550 and filter 1494 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMSS 726</td>
<td>$|\pi(2)|_2$</td>
<td>1.000</td>
<td>0.347</td>
<td>1.031</td>
<td>1.003</td>
<td>1.400*</td>
</tr>
<tr>
<td></td>
<td>$|\pi(2)|_4$</td>
<td>1.000</td>
<td>0.337</td>
<td>1.021</td>
<td>0.996</td>
<td>1.354*</td>
</tr>
<tr>
<td></td>
<td>$|\pi(2)|_{\infty}$</td>
<td>1.000</td>
<td>0.299</td>
<td>0.970</td>
<td>1.013</td>
<td>1.210*</td>
</tr>
<tr>
<td>8152B111</td>
<td>$|V|_2$</td>
<td>1.000</td>
<td>0.820</td>
<td>1.365</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$|V|_4$</td>
<td>1.000</td>
<td>0.792</td>
<td>1.341</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$|V|_{\infty}$</td>
<td>1.000</td>
<td>0.528</td>
<td>1.230</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8152B211</td>
<td>$|V|_2$</td>
<td>1.000</td>
<td>2.949</td>
<td>3.626</td>
<td>3.898</td>
<td>1.487*</td>
</tr>
<tr>
<td></td>
<td>$|V|_4$</td>
<td>1.000</td>
<td>4.690</td>
<td>5.378</td>
<td>5.816</td>
<td>1.561*</td>
</tr>
<tr>
<td></td>
<td>$|V|_{\infty}$</td>
<td>1.000</td>
<td>6.035</td>
<td>6.146</td>
<td>6.910</td>
<td>1.937*</td>
</tr>
</tbody>
</table>

5. Conclusions

The results indicate that frequency converters can cause significant problems to measurements. Electrical devices of this kind are very commonly used in industrial applications. Unhealthy signals can lead to false conclusions about the condition of machines. Difficulties can also arise from the simultaneous use of multiple sensors. It is also shown that using an isolation transformer can reduce signal distortion.

Both acceleration and acoustic emission signals showed some degree of distortion in the tests. In acoustic emission measurements, disturbance seems to be originated in the frequency converter. In the case of the CMSS 726 accelerometer, distortion seems to be caused by other measurement devices, but not by the frequency converters (Table 6). On the other hand, the simultaneous use of the CMSS 726 accelerometer reduced distortion in the acoustic emission signal. Using the measurement card in the pseudodifferential or differential mode can be considered one way of eliminating interdependence between the signals, but in this case it did not solve the problem.

The signal was severely distorted when measured with the Brøel & Kjær 4384 accelerometer, which was powered by the UPS plugged into the power line while the
frequency converter was plugged but the motor was stopped. This distortion disappeared, when the UPS was unplugged and the measurement devices were only powered by the battery of the UPS. This may be due to a ground loop. Using a filter with a frequency converter seems to make acceleration signals a bit healthier, although the difference is not very significant. Distortion in the acoustic emission signal was clearly reduced if an isolation transformer was used.

The highest level of distortion as a relative change was measured with the Kistler 8152B211 AE sensor. As the absolute level of distortion was highest in the signal of the 8152B111 AE sensor. Frequency converters clearly caused different types of changes in the frequency spectra. The ACS 600 created high peaks in the spectrum repeating at intervals of 40 kHz, and the ACS 550 also caused a rise in the signal level though it was more evenly distributed in the frequency domain. When using the ACS 600 or ACS 550 frequency converter, the AE time domain signal disturbance level was about the same in both the cases.

The best results when trying to avoid distortion in the signals were achieved with a battery powered accelerometer, and with acoustic emission sensors when the motor was driven without the frequency converter. It should be noted, however, that the measured distortion at 40 kHz and its harmonics cannot be considered a major problem when measuring acceleration, because in normal acceleration measurements the upper cut off frequency is below 40 kHz.

For further research, a good approach could be to test different types of motors or gearboxes with similar frequency converters. Line voltage distortion should also be investigated. It would also be interesting to repeat the measurements in the same environment using other measurement devices completely independent of our current equipment.

References


