EU-Study of Elesol

MS 201: Lab-Test Emissions (LT-Em) Report – Version 01

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Contents

Summary: in this part of the study, we have measured the effect of Elesol on conducted and radiated emissions. Depending on the source of conducted emission (noise generator or VFD) and also the measurement method (directly or current probe), the measured attenuation value is different from 0.07% (VFD+current probe) up to 5% (noise generator + direct measurement).

We also investigated the effect of the Elesol on the radiated emission and the result is absolutely conclusive. Elesol could reduce the amount of radiated emissions up to 25%. Although, this emission is not very relevant for power grids.

1. Test Objectives

The objectives of the lab-test for testing conducted and radiated emissions (LT-Em) are as follow:

- **LT-Em-N**: investigating the effect of Elesol plate on emissions produced by a noise generator in two frequency ranges:
  - 0<frequency<30MHz
  - 0<frequency<3GHz
- **LT-Em-M**: investigating the effect of Elesol plate on conducted emission (frequency<30MHz) produced by a small industrial variable speed frequency (VFD) motor (1500 Watt)

2. Noise Generator (LT-Em-N)

2.1 Test Setup

In this test, the following test setup has been used:

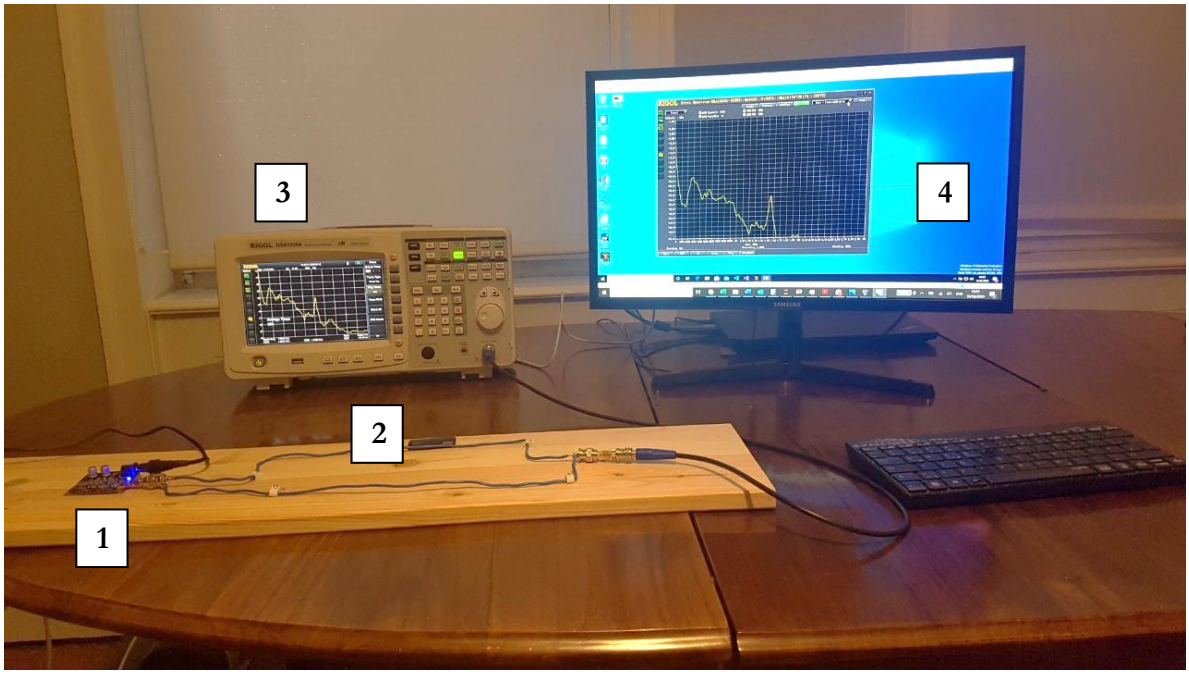

Figure 1: LT-Em-N Setup (a)

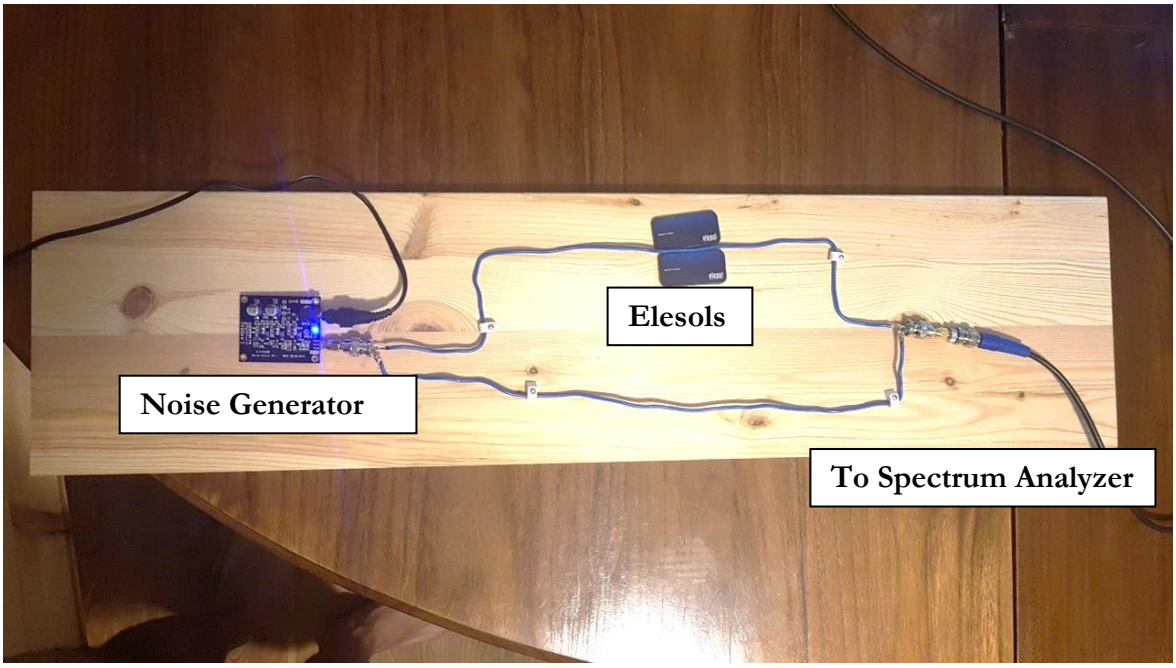

Figure 2: LT-Em-N Setup (b)

Where:

1. Noise Generator
2. Elesol plate
3. Spectrum Analyzer, RIGOL DSA1030A
4. UltraSpectrum Software

Figure 3: RIGOL DSA1030A

Figure 4: Noise Generator

2.2 Test Execution

The test has been performed as follows:

1) First, we measure the noise without installing any Elesol plates (background)
2) Then we install one, two, four, eight, and ten Elesol plates on the cable connected to the Spectrum analyzer and measured the differences compared to the background by measuring average over 300 samples.
3) In the case of one Elesol, we did two separate measurements, once where the Elesol has been installed on the cable (as it is proposed by Elesol company, Elesol-On in Figure 6), and once when the plate is installed next (Elesol-Side in Figure 6) to the cable
4) We did this experiment twice: once from 0-3GHz (mostly radiated emission domain) and once from 0-30MHz (conducted emission)
5) To be sure about the changes in the background, before each measurement with the Elesols, one background measurement has been performed and the measurement with Elesols was compared to the very adjacent background.

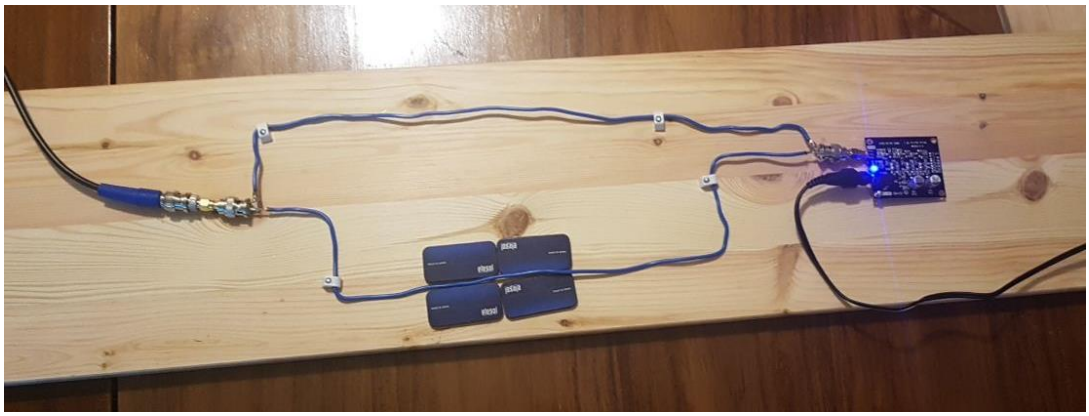

Figure 5: LT-Em-N test setup

2.3 Test Results

2.3.1 0Hz-3GHz

The test results for 0-3GHz range could be summarized as (Figure 6, Figure 7, and Figure 8):

- The blue line indicates the background in Figure 6.
- Elesol attenuates radiated emissions as seen in Figure 6.
- By adding more plates, we have more noise attenuation.
- The most noise attenuation happens between 0.5GHz and 2.5GHz (Figure 6).
- At some regions, 8 plates have more effect that 10 plates (Figure 6, Figure 7).
- Installing alongside the cable (red line in Figure 8) has more effect than installing on the cable (green line in Figure 8), because more magnetic fields are covered and therefore attenuated by Elesol when we install it next to the cable.

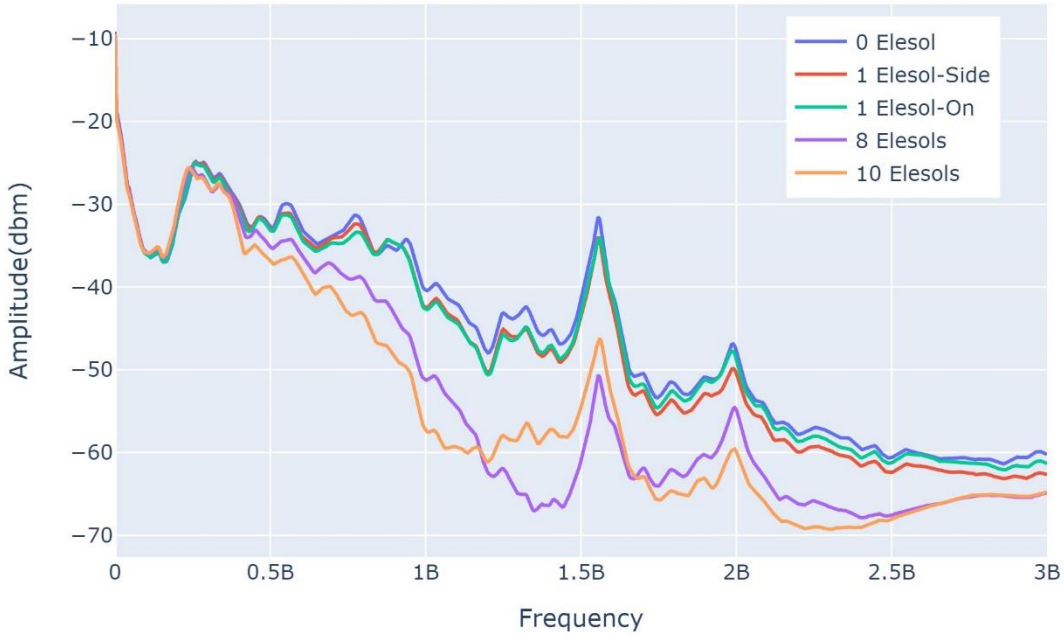

Figure 6: LT-Em-N, 0Hz-3GHz range.

Figure 7: LT-Em-N, 0Hz-3GHz range, percentage changes in amplitudes.

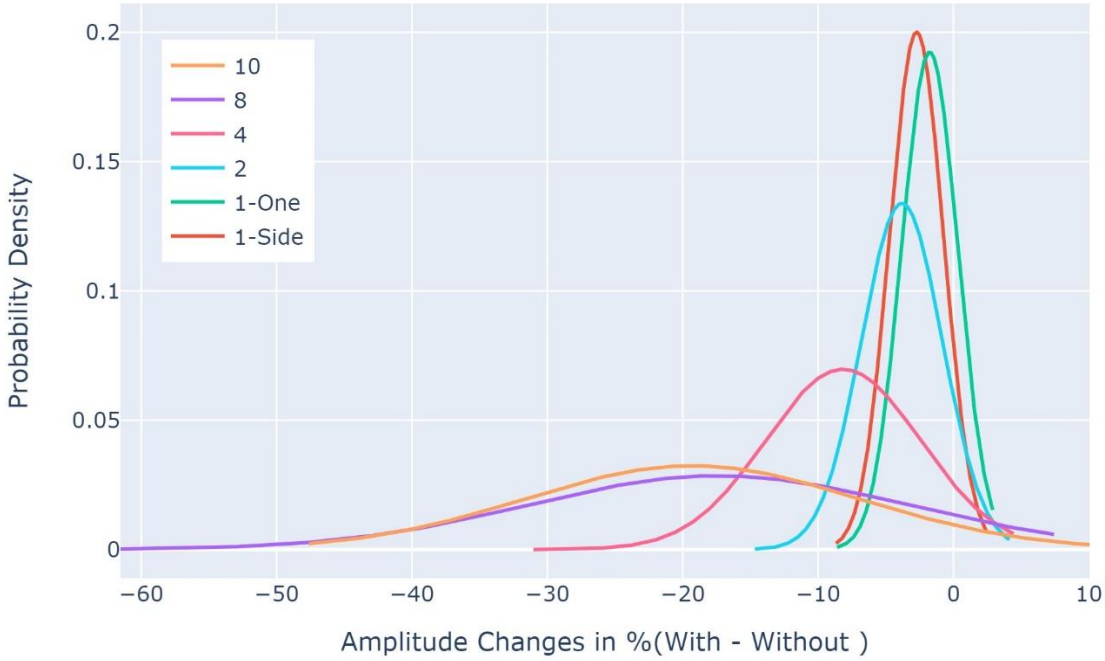

Figure 8: Normal Distribution of the amplitude changes due to installing Elesol on emission at 0Hz-3GHz range.

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2.3.2 0Hz-30MHz

The test results for **0-30MHz** range could be summarized as follows (Figure 9, Figure 10, and Figure 11):

- The blue line in Figure 9 indicates the background emission (the case where there is no Elesol.)
- Although the emission amplitude of 0-30MHz range (-30 to -24 dbm, Figure 9) is higher than the amplitude in the range of 0.5-2.5GHz (-70 to -30 dbm, Figure 6), the attenuation effect is lower. This indicates that the Elesol effect does not depend only on the strength (amplitude) of the emission (i.e. "higher effect on higher amplitudes" assumption is not correct).
- By adding more plates, we have more noise attenuation.
- The attenuation is almost the same for all frequencies between 0Hz and 30MHz (Figure 9).
- Installing alongside the cable (red line in Figure 11) has more effect than installing on the cable (green line in Figure 11). From Figure 11 you can see the effect of one Elesol alongside the cable is almost as the effect of two Elesols installed on the cable.

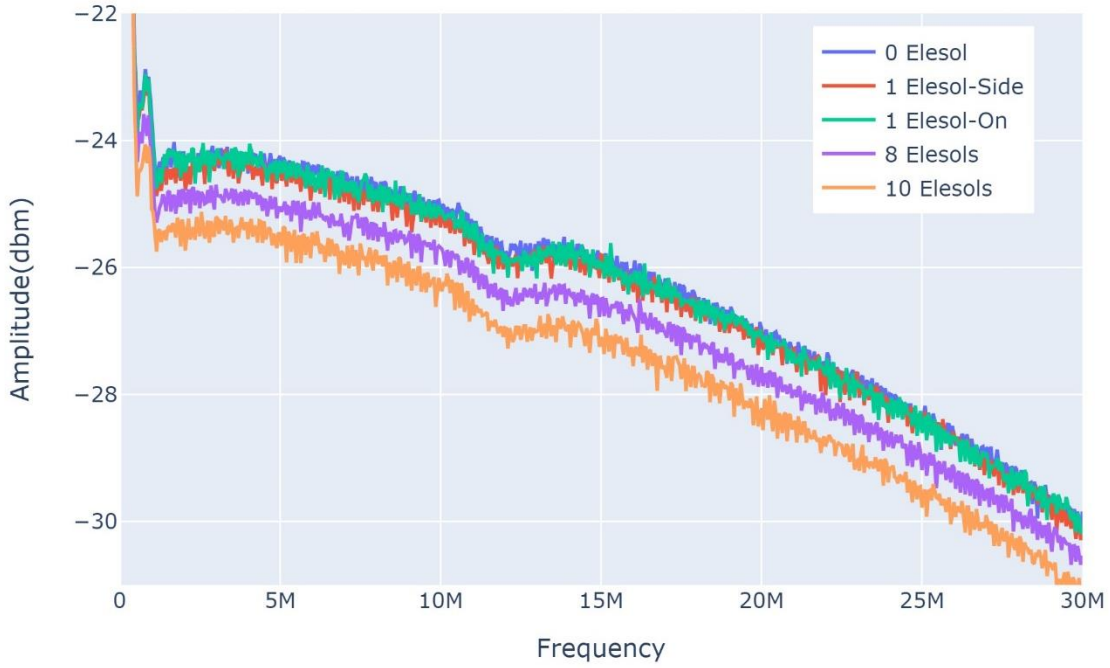

Figure 9: LT-Em-N, 0Hz-**30GHz** range.

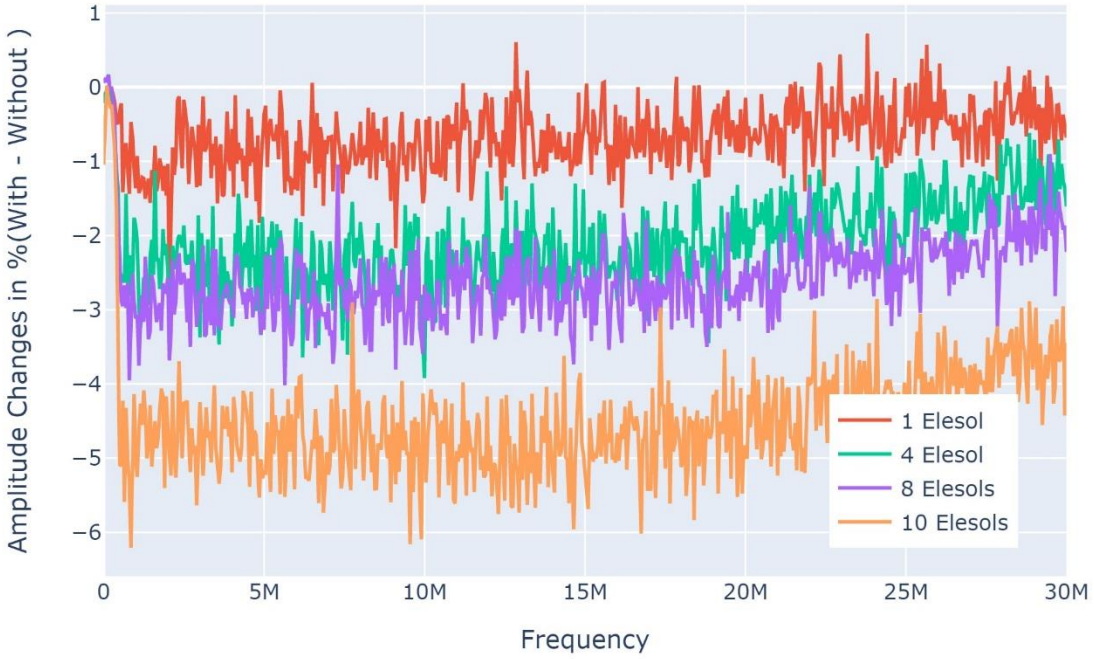

Figure 10: LT-Em-N, 0Hz-**30MHz** range, percentage changes in amplitudes.

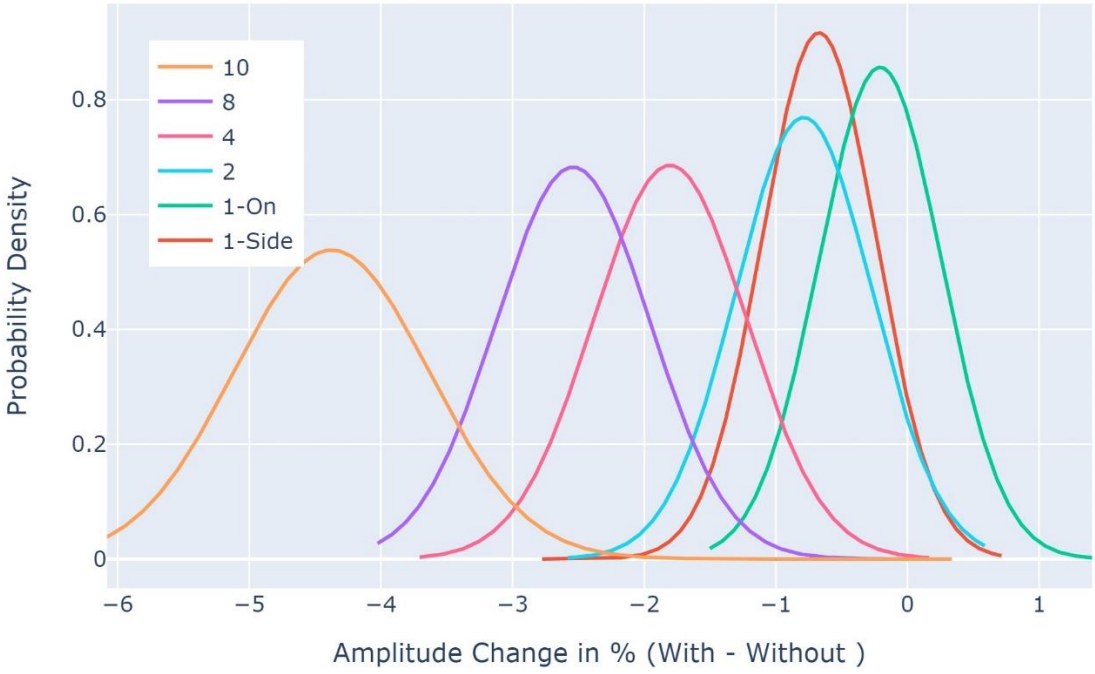

Figure 11: Normal Distribution of the amplitude changes due to installing Elesol on emission at 0Hz-**30MHz** range.

3. VFD Test (LT-Em-M).

In this test, we measured the conducted emission produced by a variable frequency inverter connected to a 1500W motor.

3.1 Test setup

The test setup with a variable frequency driver motor is shown in Figure 12

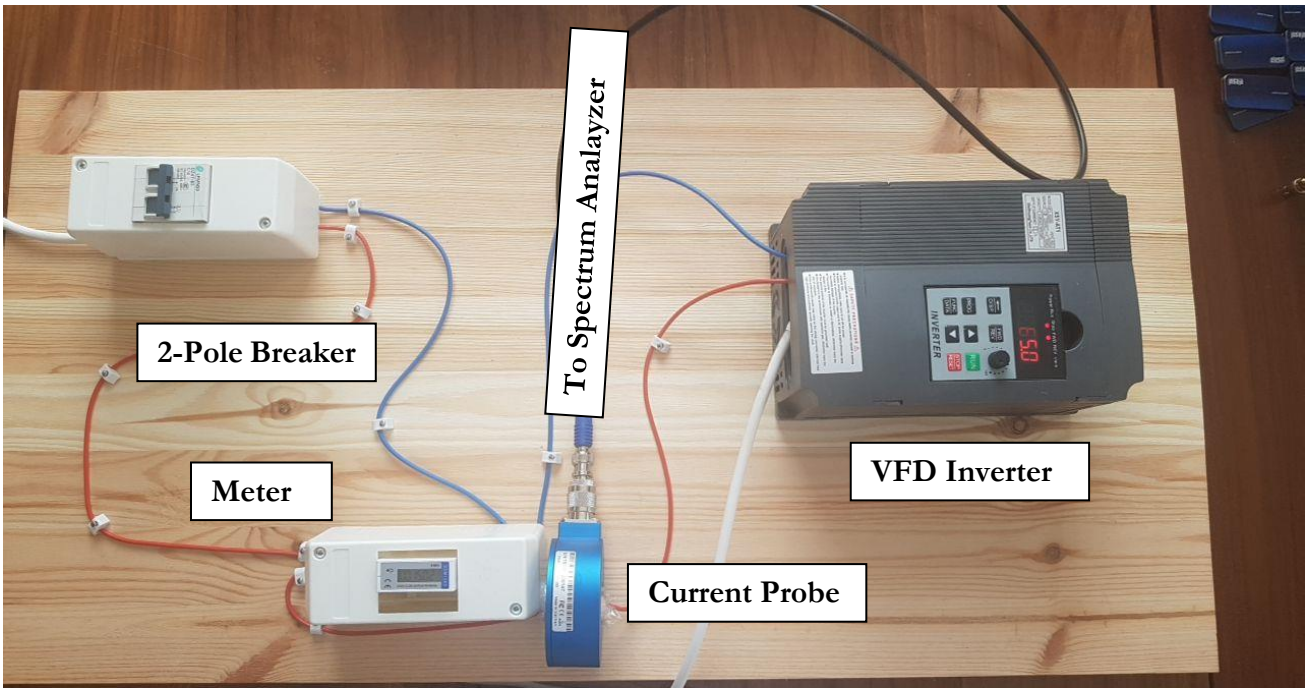

Figure 12: Test setup for measuring VFD Conducted Emission

The variable-frequency Driver has been shown in Figure 13 and the 1.5kW motor in Figure 14.

Figure 13: Hilitand AT1-1500S 1.5kW AC 220V Universal Frequency Variable Frequency Inverter VFD for Three-Current Motor.

Figure 14: Ribitech 02517 Motor Reversible 2 CV 1440 RPM 1500 W.

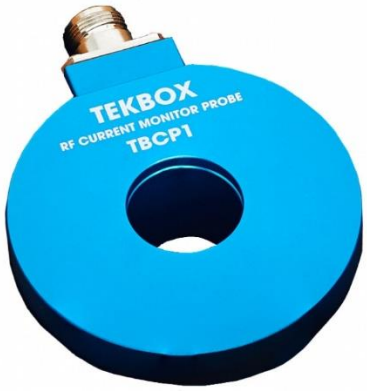

Figure 15: Tekbox TBCP1-200 / RF Current Monitoring probe.

3.2 Test Execution

The test has been performed in the following steps:

1. The motor started with the frequency 65Hz without Elesol for 33 minutes.
2. Then we measure the background emission (0-Elesol) by averaging over 1000 samples.
3. We add one Elesol on the cable between the VFD and the current prob and did the same measurements.
4. We repeated the experiments with 8 Elesol installed on the side of the cable.

3.3 Test results

The results could be summarized as follows:

1. From Figure 16 we see that the VFD inverter produced conducted emissions.
2. In Figure 17 we see the Kernel Density Estimation (KDE) distribution of the changes in the amplitude from averaging over 1000 samples. The attenuation mean value with 1 Elesol is 0.07% (orange line) or 0.11% (blue line). These two experiments (orange and blue lines) have been carried out under the same conditions at two different times. The mean value of the KDE distribution is always positive, which means that Elesol always attenuates the emissions.
3. With 8 Elesols (green line in Figure 17), the attenuation is a little bit higher (0.26%).

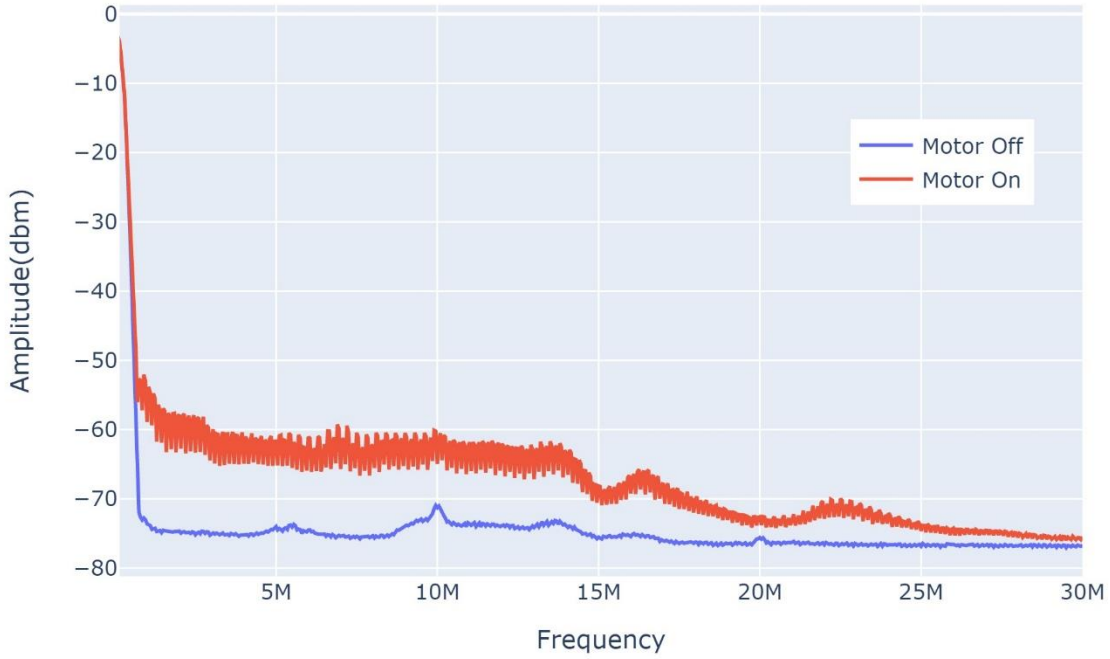

Figure 16: Increase of measured conducted emissions due to the VFD.

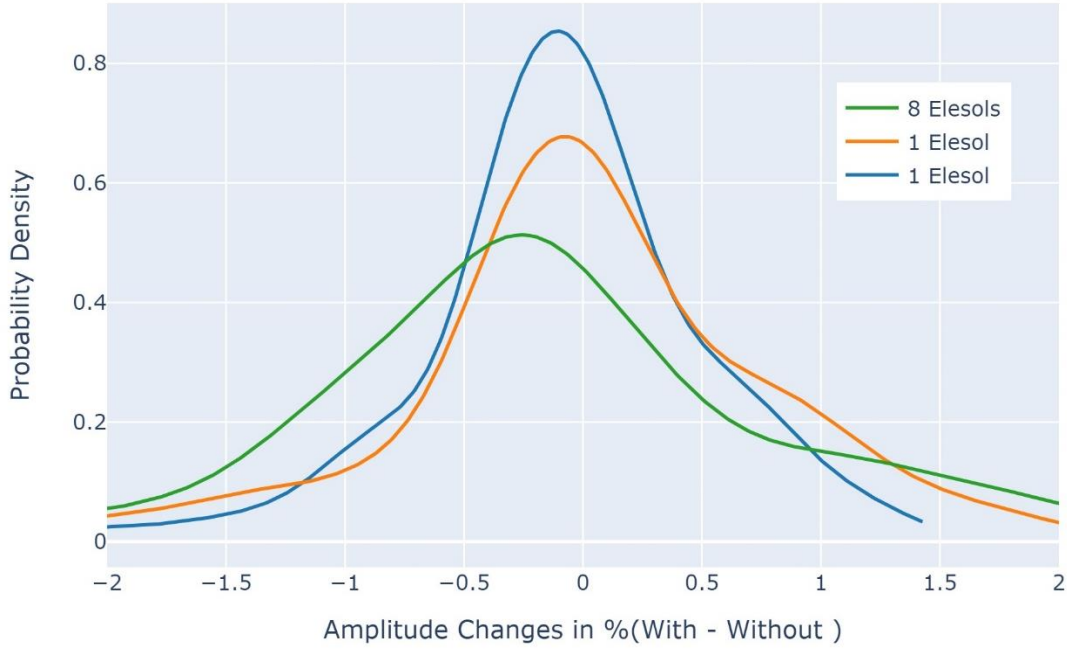

Figure 17: KDE Distribution of the conducted emission amplitude changes due to installing Elesol.

4. Final Remark

Elesol attenuates both radiated emissions and to some extent conducted emissions as well. We have measured the effect of Elesol on the conducted emissions using two methods: direct feeding the noises into the spectrum analyzer (LT-Em-N, 0-30MHz) and using the current prob (LT-Em-M).

The measurements of LT-Em-N are more reliable as the noises are fed directly to the spectrum analyzer, unlike LT-En-M, when we use the current probe. LT-Em-N shows a conclusive and firm attenuation effect of the Elesol on the conducted emissions (0-30MHz) generated by noise generator and detected directly by the spectrum analyzer.

The measurements of LT-Em-M are also conclusive but it shows less effect on the conducted emissions generated by VFD inverter and detected first by the current probe and then by the spectrum analyzer. The reason for measuring less effect in this case could be:

1. TEKBOX current probe precision
2. Week conducted emissions generated by VFD (-70 to -60 dbm, see Figure 16) compare to the conducted emissions generated by noise generator (-30 to -24 dbm, see Figure 9).

The best option to test the above hypothesis and conclude the effect of the Elesol on conducted emissions is to repeat the LT-Em-M test with a high power load (> 30kW).