EMI measurements for DC/DC converters

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Abstract: Electromagnetic interference (EMI) generally exists in all electrical equipment and can cause serious problems. The common way to measure EMI is to use a EMC analyzer. The purpose of this report is to present this way to measure EMI and an experimental verification. Additionally, some factors that affect the EMI will be pointed out.

1 Introduction

In the last decade, it has become more common to use variable speed wind turbines instead of the traditional fixed speed turbines. From this, an increased demand for power electronics follow in order to control the turbines. In all electrical and electronic equipment, especially DC/DC converters, electromagnetical interference (EMI) exists. EMI is a serious problem in power electronics because of their fast switching characteristics [1], which can cause disturbances in nearby electronic equipment as well as in wireless communication.

To measure the conducted and radiated EMI emission, an EMC analyzer is usually used [1]. In this report, a detection system for EMI is experimentally implemented on a test circuit. The EMI is measured with a EMC analyzer and the results are compared for different configurations of the test circuit in order to detect the EMI disturbances with the EMC analyzer for the different configurations.

2 Experimental setup

The experimental setup consists mainly of two parts, the test circuit and the EMC-analyzer.

2.1 Test circuit

The test circuit is a step-down DC/DC converter controlled by a PWM-circuit, which can be seen in figure 1.
The components used in the circuit are listed in table 1. As a control circuit for the transistor is a UCC3800N PWM-generator is used, giving a switching frequency of 30 kHz. A potentiometer controls the duty cycle, but it is kept constant during the measurements.

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>U\textsubscript{dc}</td>
<td>5V</td>
<td></td>
</tr>
<tr>
<td>C\textsubscript{in}</td>
<td>2200\mu F</td>
<td></td>
</tr>
<tr>
<td>R\textsubscript{load}</td>
<td>10\Omega</td>
<td></td>
</tr>
<tr>
<td>L\textsubscript{load}</td>
<td>100\mu H</td>
<td>50SQ, series</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>IRFIZ48N HEXFET</td>
</tr>
<tr>
<td>T</td>
<td></td>
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</tbody>
</table>

There are two different ways to change the test circuit for different measurements, to change the gate resistance for the transistor and to use two different configurations for the DC-link. Two values for gate resistance was used, 47 \Omega and 5.6 \Omega. For the DC-link in figure 1, the first version is a stripline consisting of the metal plates with the width 4.3 cm, the length 12 cm and the distance between them is 2 mm. The second version of the DC-link consists of two wires, with the length 15 cm and the largest separation 6 cm. It gives in total four different configurations of the test circuit. The test circuit with both wires and stripline can be seen in figure 2.

2.2 EMC-measurement

The EMC-measurements are made with a HP 8591 EM EMC-analyzer which covers the frequency range from 9 kHz to 1.8 GHz. For the voltage measurement, a LeCroy AP032
differential probe was used. To measure the load current, a Fluke 80i-110s AC/DC current probe was used. The measurements from the EMC-analyzer were extracted via a HP-IP port using the convenient software instrument program LabView.

3 Measurements

The measurements are done for four different configurations of the test circuit. For the transistor, the gate resistance was either 5.6 Ω or 47 Ω. As a DC-link, either be the stripline, which has a low inductance, can be used, or the wires, which have a considerable higher inductance.

The measured parameters are the load current $I_{\text{load}}$ and the diode voltage $U_D$, which are indicated in the circuit in figure 1. First, the current and voltage waveforms are studied in order to visually detect the oscillations. These oscillations have a high frequency, so the inductive load will make them disappear in the load current. As a result, the only way to detect these oscillations is to use the DC-link voltage, in this experiment chosen as the diode voltage.

All four different configurations for the test circuit described earlier are used in the experiments. There is a line inserted in all figures, which can be used as a reference line for the different figures. In figure 3(a) the diode voltage is shown when the gate resistance is 47 Ω and the stripline is used as the DC-link, and in figure 3(b) the DC-link consists of the wires. Similar waveforms are observed when the gate resistance is 5.6 Ω. It can be seen that there are more oscillations when the wires are used as a DC-link than when the stripline is used. This is easy to detect visually from the voltage waveforms, but the
challenge is to detect it from the frequency spectrum of the signal. It is quite difficult in this case since the frequency spectrum from the square-wave consists of many different components itself. The frequency spectrum for the signals are shown, for the stripline

Figure 3: Diode voltage using the gate resistance 47 Ω

Figure 4: Spectrum for the diode voltage using the stripline - LF

Figure 5: Spectrum for the diode voltage using the wires - LF
in figure 4 and for the wires in figure 5. These figures show that there is no significant difference between the spectra for the different cases, even though a clear difference could be detected in the voltage waveforms. To investigate this further, the spectra for the diode voltage was shown for higher frequencies in figures 6 and 7. In these figures, it is clear that there is a peak for the case with the wires at 16 MHz, which corresponds to the oscillations. The frequency content for the waveforms generated when the gate resistance is 5.6 Ω does generally have a slightly higher spectra for high frequencies.
4 Conclusions

From the measurements shown above, it is shown that EMI disturbances can be detected using the EMC analyzer. It is also shown that the disturbances on the DC-link varies for the different configurations of the test circuit. A faster switching, resulting from a lower gate resistance for the transistor, gives larger higher-order frequency components. The choice of DC-link has a large impact on the EMI, the stripline with the lower inductance results in much lower EMI then the wires with higher inductance.

References