

## Ageing Effects observed in Conducted Emission Spectra of Biotechnological Devices after Repeated Switching

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### Abstract

Power supply units are well-known sources of conducted emissions. We investigate the changes of conducted emission spectra of switched mode power supplies after repeated switching and compare the results to those before the ageing process.

### 1. Introduction

Biomedical electronic devices are usually supplied by switched mode power supplies (SMPS), which are known to be a main source for both conducted and radiated emissions [1]. Yet, by proper design, the emissions of SMPS can be reduced such that the devices pass the mandatory electromagnetic compatibility (EMC) tests and are approved for commercial use [2]. Medical electronic equipment faces two additional problems if emissions are concerned: First, the applicable standards are more rigid, i.e., emission thresholds are lower [3], and second, voltage supply levels are often much higher if compared to other applications. Taking into account these factors, one can assume that even minor changes in the characteristics of the components used within the SMPS can lead to increased emission levels and, in turn, to exceedance of regulation thresholds. While various reasons for varying emission characteristics can be considered, we focus in this investigation on component degradation by repeated switching.

### 2. Ageing Platform

For the purpose of this study, an ageing platform was designed to alternately switch on and off a set of SMPS [4]. The main objective was to automatically apply a high level of electrical stress over a short period of time to a device, assuming that there will be a change in the conducted emissions. The platform utilizes an Arduino microcontroller that drives multiple mechanical relays, such that each relay can independently switch on and off a device. Additionally, the platform logs the environmental parameters temperature and humidity. Any changes in the supply voltage or the current feeding one power plug are recorded as well and written to a log file for later analysis.

The duty cycle, i.e. the On-Off times, are chosen to be independent for each relay and adjustable to facilitate changes in future tests. After the artificial ageing of the devices due to multiple and automatic switching, conducted emissions were measured to observe changes in the EMC performance of the SMPS.

The tests were performed on the basis of eight SMPS units for desktops computers. The parameters of the tests are listed in TABLE 1. The On-Off duty cycles are given in units of seconds.

Test Sequence	No of SMPS	Iterations	Duty Cycle
A	1-4	5000	4-2
	5-8	5000	3-3
B	1-4	10000	4-2
	5-8	10000	3-3
C	1-4	15000	4-2
	5-8	15000	3-3
D	1-4	30000	4-2
	5-8	30000	3-3
E	1-4	60000	4-2
	5-8	60000	3-3

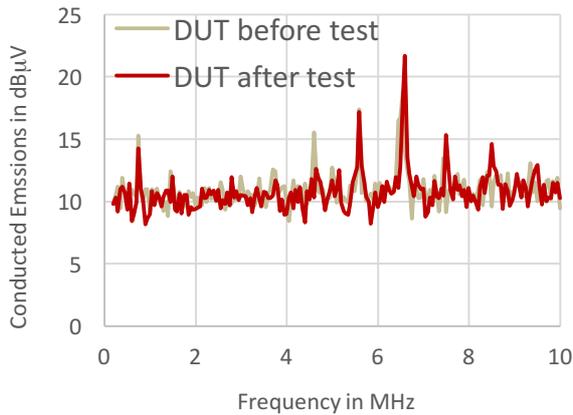
TABLE 1. Parameters of the switching tests

Fig. 1 shows the test platform and the eight DUTs being tested.



Figure 1. Ageing platform with 8 DUTs being tested

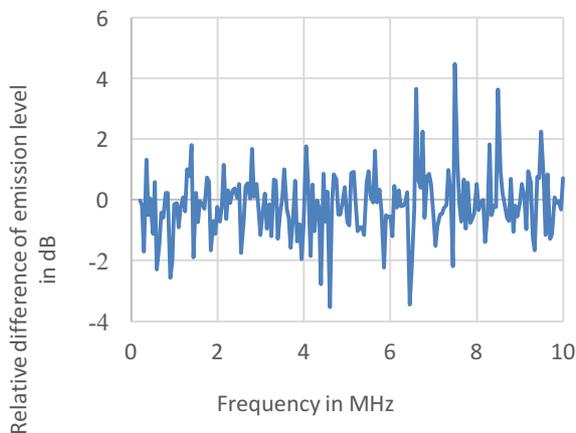
### 3. Results



**Figure 2.** Conducted emissions of one SMPS before and after 90k cycles. Grey: Emissions before ageing, red: emissions after ageing.

The results of the test in Fig. 1 show a frequency shift in the spectrum of the conducted emissions, as well as an increased magnitude of some spectral components. While all regulatory limits in [2] are not exceeded, this effect could prove problematic for more rigid standards [3] that are applied to medical electronic hardware.

The ageing effects due to switching become even more pronounced in Fig. 2, where the relative difference between the emission spectra is shown. While the difference is not too large for most spectral components, differences up to 4 dB appear for some frequencies. The rationale behind these changes still needs to be clarified.



**Figure 3.** Relative changes in conducted emissions of one SMPS after 90k cycles in dB.

### 4. Future work

In this paper first results are published. Additional tests with improved statistics are scheduled next, aiming at the following points:

1. Identification of a model to predict the changes of ageing by switching, e.g. a lumped element model for the input circuit of an SMPS, which will be used to run Monte Carlo simulations to quantify worst case effects.
2. Re-evaluation of the data to identify changes in the density distribution of the emission spectrum.

Additionally, other causes for ageing of electronic devices will be considered.

### 5. References

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