

P r a c t i c a l E x e r c i s e

E l e c t r o m a g n e t i c C o m p a t i b i l i t y

Exercise 10 EMC-Measurements on emissions into the mains network (Room L102)

Group-Nr.: Minute taker:	Participant names:
Reviewed and approved by participants: (signed by all participants)	Stamp

Exercise 10

EMC-Measurements on emissions into the mains network

1 Relevant standards

The European Community (EC) has published a Directive¹ and supporting guidelines² about requirements on electromagnetic compatibility (EMC) for any kind of equipment. In order to bring equipment to the market the manufacturer has to perform an assessment and declare the conformity of the apparatus with the essential requirements of the EMC directive. Finally the "CE" marking is applied by the manufacturer to the device in order to attest its compliance. The technical requirements are specified in harmonised European standards. Those are adopted by the various European standardisation bodies, European Committee for Standardisation (CEN), European Committee for Electro-technical Standardisation (CENELEC) and European Telecommunications Standards Institute (ETSI). The references to the standards have been published in the Official Journal of the European Union.

Harmonised standards for electric and electronic equipment			
Emission		Immission	
Relevant for all equipment not addressed by product specific standards			
EN 61000-6-x		EN 61000-6-x	
EN 61000-6-3 Standard for residential, commercial and light-industrial environments	EN 61000-6-4 Emission standards for industrial environments	EN 61000-6-1 Immunity for residential, commercial and light-industrial environments	EN 61000-6-2 Immunity for industrial environments

Emission, Electromagnetic interference (EMI)

Radiated emission

The standards cover emission requirements in the frequency range 0 Hz to 400 GHz. Equipment that is attached to the public mains network (EN61000-6-3) or to industrial supply networks (EN61000-6-4) has to fulfil the respective requirements. These standards refer also to other standards, e.g. for the definition of test methods:

EN 55011 Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement

EN 55013 Sound and television broadcast receivers and associated equipment. Radio disturbance characteristics. Limits and methods of measurement

EN 55014 Electromagnetic compatibility. Requirements for household appliances, electric tools and similar apparatus. Emission.

EN 55015 Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

EN 55022 Information technology equipment. Radio disturbance characteristics. Limits and methods of measurement.

¹ DIRECTIVE 2004/108/EC (<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:390:0024:0037:EN:PDF>)

² Guide for the EMC Directive 2004/108/EC (http://ec.europa.eu/enterprise/sectors/electrical/files/emc_guide_updated_20100208_v3_en.pdf)

Emissions into the mains supply system

About limitations on emissions into power supply networks the standards EN 61000-3-2 (harmonic current emissions) and EN 61000-3-3 (voltage fluctuations and flicker) are relevant. According to EN 61000-3-2 (equivalent to IEC 61000-3-2) all equipment with rated current ≤ 16 A per phase is classified into one of four classes A, B, C or D, which limit the maximum harmonic current:

Limits for **class A and class B** equipment according to EN 61000-3-2

Harmonic order	Maximum permissible harmonic current	
	class A	class B
n	A	A
Odd harmonics		
3	2,30	3,45
5	1,14	1,71
7	0,77	1,155
9	0,40	0,6
11	0,33	0,495
13	0,21	0,315
$15 \leq n \leq 39$	$0,15 \cdot 15 / n$	$0,225 \cdot 15 / n$
Even harmonics		
2	1,08	1,62
4	0,43	0,645
6	0,30	0,45
$8 \leq n \leq 40$	$0,23 \cdot 8 / n$	$0,345 \cdot 8 / n$

Limits for **class C** equipment:

Harmonic order n	Maximum permissible harmonic current expressed as a percentage of the input current at the fundamental frequency (%)
2	2
3	$30 \cdot \lambda$
5	10
7	7
9	5
$11 \leq n \leq 39$ (odd harmonics only)	3

Limits for **class D** equipment:

Harmonic order n	Maximum permissible harmonic current per watt in mA/W	Maximum permissible harmonic current in A
3	3,4	2,3
5	1,9	1,14
7	1,0	0,77
9	0,5	0,40
11	0,35	0,33
≥ 13	linear extrapolation : $3,85/n$	see class A

2 Explanation for harmonic waves.

A non-continuous power flow and a non-sinusoidal load current result in harmonic waves with respect to a 50 Hz fundamental sine wave. By means of harmonic analysis any periodic non-sinusoidal waveform can be represented by superposition of multiple sinusoidal waves, i.e. harmonic waves. Usually it is sufficient to consider the fundamental wave plus a certain number n of odd and even harmonic waves: For common electric devices up to $n = 40$, for mains supply networks up to $n = 50$.

Certain loads can also create sub- and intermediate harmonic signals in the spectrum. In the measurement setup the signals are recorded, digitized and harmonic signals in current or voltage are calculated by means of FFT (fast Fourier transformation). The FFT result can be displayed as amplitude spectrum or numerical data.

3 Harmonic waves causing undesired feedback into the mains network

Each single harmonic current wave will create a voltage drop across the network impedance and cause a distortion of the total resulting voltage. In an ideal situation a pure sinusoidal voltage multiplied with an in-phase sinusoidal current will result only in true power. In general all the harmonic current waves multiplied with the mains voltage signal will create apparent power according their respective frequency.

The power factor (defined for sinusoidal voltage) is adapted by a factor g_i :

$$\lambda = \frac{P}{S} = g_i \cdot \cos\varphi_1$$

Where g_i denotes the ratio of fundamental current to total current:

$$g_i = \frac{I_1}{I_{\text{ges}}}$$

4 Measurement task

4.1 Investigation on sinusoidal half-wave control (setting 700h = 1/3 power resp.. 800h = 2/3 power) The current response in time domain is to be measured and analysed with various test loads. Determine the input power of the test load. Choose representation as well with setting of 12 periods as with setting for 16 periods (only once for 700h resp. 800h, in order to depict any failure in non-periodic window range).

4.2 Measurement of input current for electronic devices, a PC or display.

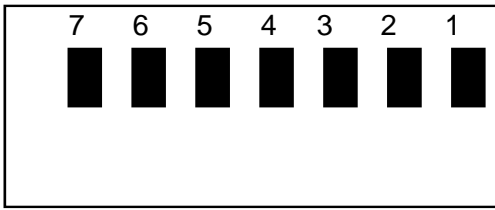
4.3 Analysis and interpretation

Based on measurements done in 4.1 and 4.2 prepare test reports: **assign each tested load to a characteristic device class**, display the line diagram and amplitude spectrum of the device class. Calculate the rms (root mean square) values. Verify if the test loads comply with EMC requirements according to EN 61000-3-2. **Include only the necessary evaluation into your report. Place the additional results into the appendix of your report!**

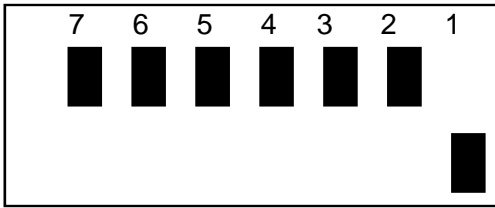
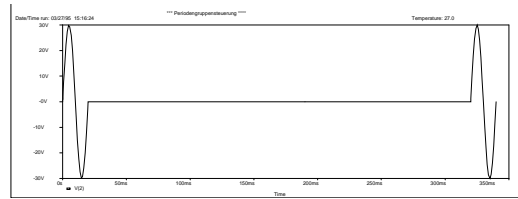
Based on fundamental and harmonic waves measured with test loads in 4.1 calculate true power, apparent power and power factor. Compare the calculated with measured data (multimeter). **Calculate** the idealised current behaviour of harmonic currents. **(either for setting 700h or 800h) and compare those with measured data. The complete and understandable approach for the calculation should be added to your report!**

Explain the observed current behaviour in measurement with PC system.

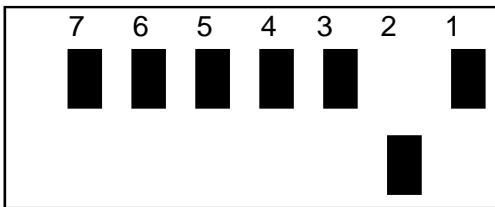
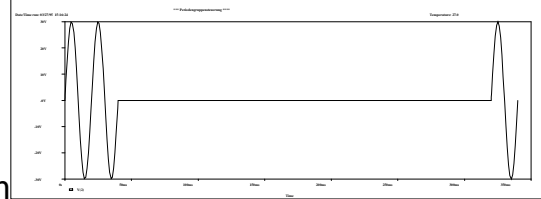
Generator settings (switch position)



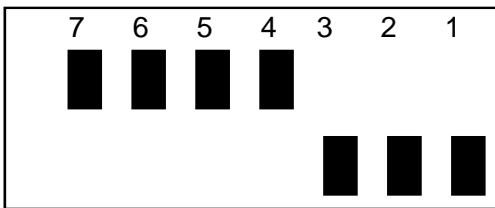
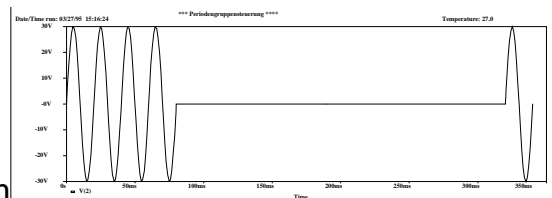
= 000h



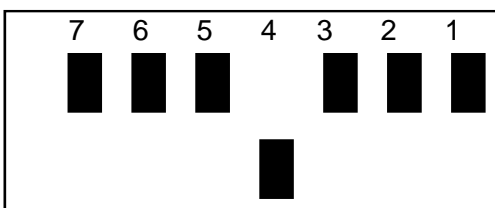
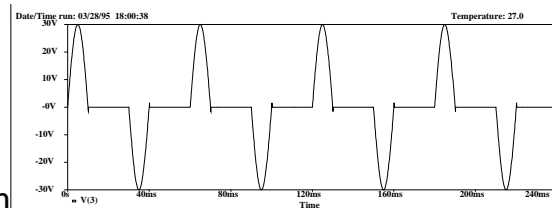
= 100h



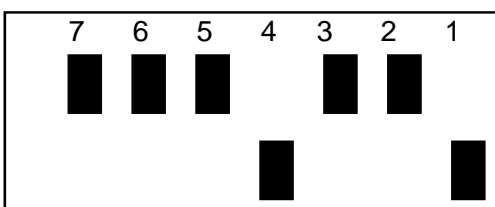
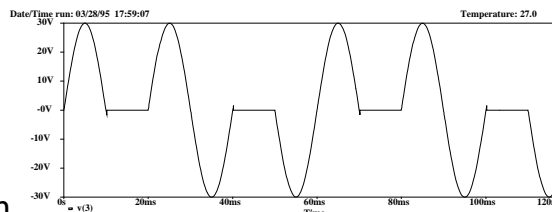
= 200h



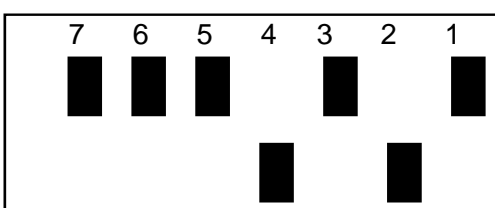
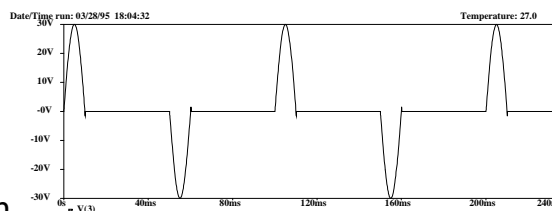
= 700h



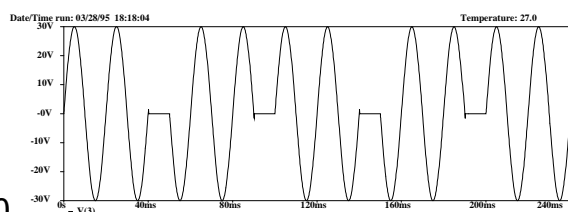
= 800h



= 900h



= A00



Operating instruction for exercise 10

Attention: It is mandatory to inform the supervisor before any changes are done on the test circuit!

Take care of proper switch-on sequence:

- a) Switch on PC and display
- b) Switch on the simulator (device with 7 switches on front panel)
- c) Switch on PLL and adapter for data logging interface (device with 10 BNC-ports and 3 Sub-D-plugs) Switch is placed on rear panel!
- d) Start the program for recording of harmonics by command "V10"

Please save your results in the sub-folder "Ergebnis" and choose your own file name. The saving process is indicated by an hourglass symbol.

Note: The voltage applied to the wattmeter is amplified by factor of 4.65 (in order to improve the reading accuracy)! In case this factor is enabled it needs to be considered in the corrected calculation! **(Check with supervisor if factor is actually enabled or not!)**

Only in the partial exercise with simulator it is required to record the power!

Measurement Phase L1(=PC) Channel 0 = Voltage (PC); Channel 3 (Strom)

Measurement Phase L2(=simulator) Channel 1 = Voltage; Channel 4 (Strom)

All remaining channels are not used during this exercise!

Following settings need to be adjusted in the software:

	Simulator (Version1)	Simulator(Version 2)	PC	PC2
Voltage	1:10	1:4.54655	1:100	1:100
Current	0.1	0.1024	0.5	0.166666

Version 1 : DOLCH PC (left side) ; Version 2 (TetraPac) → right side

Software operating instructions:

Menu structure:

50Hz-OS!	Save!	Halt!	ZOOM	LOG!	o.Grdschw.!	o.Grenzw.!	Quit
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Menu items marked by "!" are directly processed once clicked by mouse button!

- 50Hz-OS = View as multiples of fundamental frequency
Save = save graphics screen and the file containing all measured values
Halt = Stop measurement (same as single measurement →first page)
Zoom = zoom into range delimited by cursors
LOG = logarithmic representation of the harmonic spectrum
o.Grdschw = Representation with suppressed fundamental
o.Grenzw. = Representation of the harmonic spectrum without limits
QUIT = end program

You are supposed to perform all measurements of class A (it is possible to perform additional measurements in other classes).

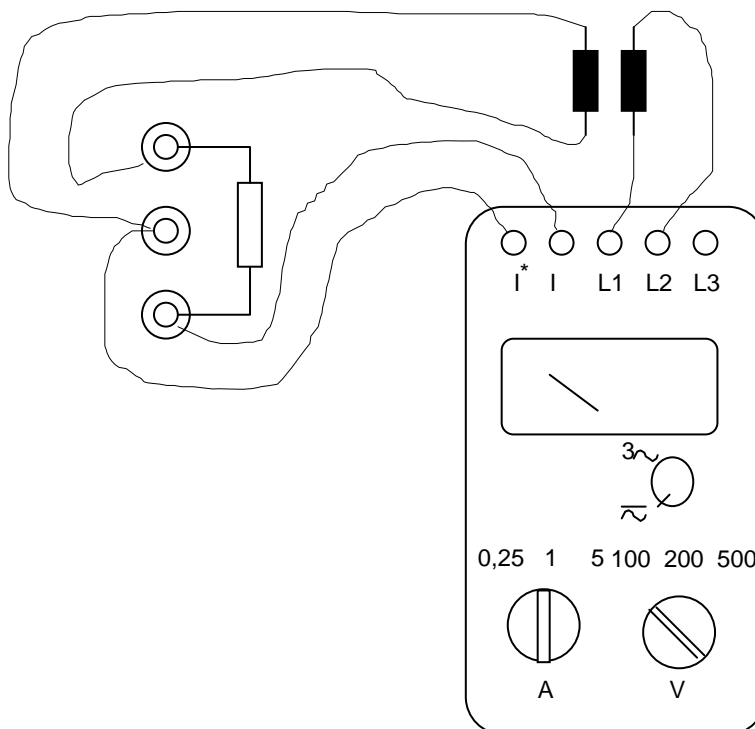


Figure 1 – Test setup with wattmeter