EREC G5 Stage 2 Sub-group

Meeting No. 5

Held at National Grid House, Warwick Technology Park, Gallows Hill, Warwick, United Kingdom CV34 6DA

On Wednesday 9th November 2016 10:00-15:30

Meeting Notes

Attendee	**Affiliation**	**Initials**	**Role**
Forooz Ghassemi	National Grid	FGh	Member
Frank Griffiths	ABB	FG	Member
Andrew Oliver	TNEI	AO	Member
Simon Scarbro	WPD	SPS	Chair
Ahmed Shafiu	Siemens	AS	Secretary
Apologies	**Affiliation**	**Initials**	**Role**
Ben Gomersall	National Grid	BG	Member

Item	**Topic & Note**	**Action**
2.	**Agree Notes of Previous Meeting** Agreed.	
3.	**Actions from Meeting 3**	
3.1	**ECRC Report 1681** SPS has circulated a copy. The frequency range limitation up to the 20th harmonic was noted. FG highlighted the variation in the slope of the curve after the first resonance and contrasted it with the assumed k=0.5.	
3.2	**Definition of Converter Types** AS has circulated a draft. This was discussed. Some changes were agreed. SPS will update the draft & send it to AS for review. FG highlighted that a glossary may be needed.	SPS AS
4	**$\sum S_{equ}$ Derivation (replacement for EREC G5/4-1 Table 6 & 10)**	
4.1	**IEC 61000-2-6 Typical 6-pulse Values** SPS highlighted BS IEC 1000-2-6 'Electromagnetic compatibility (EMC) — Part 2: Environment — Section 6: Assessment of the emission levels in the power supply of industrial plants as regards low-frequency conducted disturbances' which gives guidance on calculating harmonic emissions in Annex A…	

A.2.1 Three-phase bridge convertors feeding a d.c. load where the d.c. current is smoothed inductively

Table A.1 — Relative harmonic current at low d.c. ripple. $R_{sc} = 20$

$\frac{U_d}{U_{di}}$	α	$\frac{I_{d6}}{I_d}$	h	5	7	11	13	17	19	23	25
0	90°	0,021	$\frac{I_h}{I_1}$	0,21	0,13	0,09	0,07	0,06	0,05	0,04	0,04
0,84	30°	0,012		0,21	0,13	0,09	0,07	0,05	0,04	0,04	0,03
0,975	0°	0,005		0,19	0,12	0,08	0,05	0,02	0,02	0,01	0,01

Table A.2 — Relative harmonic current at medium d.c. ripple. $R_{sc} = 20$

$\frac{U_d}{U_{di}}$	α	$\frac{I_{d6}}{I_d}$	h	5	7	11	13	17	19	23	25
0	90°	0,11	$\frac{I_h}{I_1}$	0,27	0,06	0,09	0,04	0,05	0,03	0,04	0,03
0,84	30°	0,06		0,24	0,10	0,09	0,06	0,05	0,04	0,03	0,03
0,975	0°	0,03		0,20	0,11	0,06	0,05	0,02	0,02	0,01	0,01

Table A.3 — Relative harmonic component at high d.c. ripple. $R_{sc} = 20$

$\frac{U_d}{U_{di}}$	α	$\frac{I_{d6}}{I_d}$	h	5	7	11	13	17	19	23	25
0	90°	0,43	$\frac{I_h}{I_1}$	0,48	0,17	0,09	0,05	0,04	0,02	0,02	0,01
0,85	30°	0,23		0,35	0,04	0,09	0,01	0,04	0,01	0,03	0,01
0,98	0°	0,11		0,25	0,09	0,06	0,04	0,02	0,02	0,01	0,01

A.2.3 Three-phase bridge convertor feeding a d.c. load with a capacitor smoothing

Table A.4 — Relative harmonic current of a diode rectifier (B6) feeding a high capacitance

$\frac{U_d}{U_{di}}$	R_{sc}	h	5	7	11	13	17	19	23	25
1,02	500	$\frac{I_h}{I_1}$	0,86	0,70	0,35	0,22	0,09	0,09	0,07	0,05
1,00	100		0,64	0,40	0,09	0,09	0,05	0,04	0,02	0,02
0,97	20		0,30	0,09	0,06	0,04	0,02	0,02	0,01	0,01
0,94	10		0,24	0,07	0,04	0,03	0,014	0,01	0,01	0,01

SPS highlighted that this should be compared with values FG is using based on ABB Drivesize software.

5	**Stage 1 & 2 Draft**	
5.1	**Siemens AFE Emission Data & Impact** AS showed emission data for 6-pulse and AFE technologies. The emissions depend upon the R_{sce} and loading. AS to share values with FG. FG to review Siemens data and that from latest version of (BS) IEC 1000-2-6; see item 4.1 above.	AS FG
5.2	**Stage 1 & 2 Draft – Update (see Meeting 4 Action Notes under Item 5.4)**	

	SPS displayed Meeting 4 Action Notes Item 5.4. Some of the actions are on the agenda. For those that are not on the agenda, SPS has made the various editorial changes to his working draft (with the exception of the point about Tables 4a and 4b interphase/split-phase).	
5.3	**Aggregation & Derivation of $\sum I_{equ}$ values in Fig 2 – New Analysis** SPS tabled a paper 'Item 5-3' and explained the basis of the Class A limits in IEC 61000-3-2, the impact of those limits and the problem with using the normal 25% of PL assumption. After discussion it was agreed to examine inclusion of minimum R_{sce} and $\sum I_{equ}$ = 16A in Fig 2.	
5.4	**Aggregation & Derivation of $\sum_{Iequ}$ values in Fig 3 – New Analysis** SPS tabled a paper title 'Item 5-4' and explained the basis of R_{sce} = 33 adopted in IEC 61000-3-12 and that the presumption that the maximum voltage drop is 3% phase-neutral is not correct; a 6% value for voltage regulation is used by WPD, previously 8%. SPS also explained the basis of the current limits in IEC 61000-3-12 and showed the difference in assumptions compared with EREC G5/4-1. The assumptions have a bearing on the $\sum I_{equ}$ values in our Fig 3. After discussion it was agreed to examine inclusion of minimum R_{sce} and in Fig 3 and suitable $\sum I_{equ}$ values. Harmonic impedance K-values were discussed. For LV there is limited information published. FGh raised the possibility of resonance, like at HV, with the aggregate effect of capacitance via equipment such as compact fluorescent lighting and other products with EMC filter. SPS referred to a paper covering the issue of network impedance/k-values; this is published as 'Guide to Assessing Network Impedance', Robert A & Deflandre, CIRED 97, 2-5 June 1997, Conference Publication 438. This a condensed version of the full paper published in Electra No. 167, August 1996, 96-131. FGh circulated a paper 'Harmonic Voltage Measurements in the Low Voltage Distribution Grid', Kaspirek M & Mezera D, 978-1-4673-6788-2/15, 2015 IEEE. SPS asked that all see if they can find any more published on harmonic impedance of LV networks. FGh tabled an email including the following: …there are two main options to consider: 1- The proposal for Stage 1 and subsequent Stage 2 and supporting analysis you have provided is around defining rated currents, e.g. 32 A etc that can be used to allow an equipment connection. Because not all emissions in IEC 61000-3-2 and -3-12 can meet the criteria, such as Rsce=33 and 25% of PL, then some other proposals have been suggested, see your Option 2 and Option 2A in your emails with their subsections. Suggestions of using compatibility levels for even harmonics and treplen and planning levels for odd is also part of the proposal. 2- The other avenue that can be explored is to follow the approach in IEC 61000-3-2 and -3-12. This seems to be straight forward, unless I have overlooked something, in that emissions, in terms of percentage of	All

	rating, and required Rsce and the source fault level are defined and the equipment rating that is allowed to connect is determined. Alternatively, one can say that for a given rating and harmonic emission profile from equipment and defined Rsce, e.g. 33 , 66 etc, the required source impedance at the point of connection can be determined. If the source impedance at the point of connection is not equal or smaller than the calculated value then the connection is not allowed. This may imply that some k used for harmonic impedances may not be the same as k in G5/4 table but has the advantage that we are following IEC document or at least we are not deviating from it. One may say that due to lack of information and data about and also very large variety of LV systems, to avoid using k as the main dominant parameter in the analysis may be advantageous. See item 5.3.	
5.5	**Stage 2C – Impact of 77A/926/CDV Compatibility Levels beyond 40th** SPS highlighted the IEC proposals to extend Compatibility Levels beyond the 40th harmonic to 150kHz, with 200Hz bands used up to the 180th harmonic 9kHz: **4.5 Voltage distortion in differential mode above the 40th harmonic up to 9 kHz** In this standard, voltage distortion above the 40th harmonic up to 9 kHz is considered in relation to long-term effects, i.e. for duration of 10 min or longer. In the case of voltage distortion at frequencies above the 40th harmonic, it is generally not relevant whether they are at harmonic or interharmonic frequencies. They can occur both at discrete frequencies and in relatively broad bands of frequencies. The compatibility levels for voltage distortion in the frequency range from the 40th harmonic (exclusive) up to 9 kHz are given in Table 2. These compatibility levels are related to voltage distortion levels in differential mode in a bandwidth of 200 Hz, defined as follows: $$u_{b,F} = \frac{1}{U_1} \times \sqrt{\sum_{n=1-(100/\Delta f)}^{100/\Delta f} U^2(F + n \cdot \Delta f)}$$ It was noted that this will have implications for the Planning Levels above the 40th in EREC G5 and the Stage 2C currently under consideration. It also has implications for treatment of interharmonics. FGh to consider.	FGh
5.6	**Contrast suggested text with draft G5 v8-1 text** It was agreed that it was not necessary to review the G5 v8-1 text. FGh suggested that the Stage 1 and 2 text needs to be more concise with Figures in an annex. SPS suggested that once we have the issues covered to our satisfaction then editorial changes can follow to improve clarity.	
5.7	**Stage 1 & 2 Draft Worked Examples - Review** SPS explained the structure of the worked examples. It was agreed these would fit into a replacement for ETR122. The examples need to be updated to align with the changes to the draft Stage 1	

	& 2 text. A Thevenin calculation example is required – see item 5.8.	SPS
5.8	**Stage 2C Thevenin Equivalent Example** FG explained the concepts behind the Thevenin equivalent calculation. FG agreed to produce a worked example. FGh showed 6-pulse converter simulation using EMTP. This appeared to show a constant current performance with variation in source impedance. FG attributed this to the internal impedance assumptions relative to the source impedance.	FG
6	**Agree Further Work** See the actions recorded above.	
7	**AOB** None.	
7.1	**IEC TR 61400-21-3 Thevenin Model** SPS showed the text in this wind farm technical report that referred to a Thevenin model.	
7.2	**Maintenance of IEC 61000-3-12** The IEC maintenance report was tabled.	
8	**Future meetings** • Dates The date of the next meeting was agreed as 30 November. Venue to be arranged by FGh if a room can be found at National Grid House, Warwick. Post-meeting Note: A room was not available at National Grid House. Frank Griffith kindly arranged for a room at ABB Warrington WA4 4BT for 30th November. SPS to send out agenda. • Agenda items Not discussed.	~~FGh~~ SPS