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TECHNICAL REPORT

Short-circuit currents in three-phase a.c.systems -VIEW Part 2: Data of electrical equipment for short-circuit current calculations (standards.iten.ai)

> <u>IEC TR 60909-2:2008</u> https://standards.iteh.ai/catalog/standards/sist/f5ef6599-11c6-47b1-9910-333568ee2ae6/iec-tr-60909-2-2008





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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SHORT-CIRCUIT CURRENTS IN THREE-PHASE AC SYSTEMS -

Part 2: Data of electrical equipment for short-circuit current calculations

FOREWORD

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IEC 60909-2, which is a technical report, has been prepared by IEC technical committee 73: Short-circuit currents.

This technical report is to be read in conjunction with IEC 60909-0 and IEC 60909-3.

This second edition cancels and replaces the first edition published in 1992. This edition constitutes a technical revision.

The significant technical changes with respect to the previous edition are as follows:

- Subclause 2.5 gives equations and examples for the calculation of the positive-, the negative and the zero-sequence impedances and reduction factors for high-, medium and low-voltage cables with sheaths and shields earthed at both ends.
- Subclause 2.7 gives equations and figures for the calculation of the positive-sequence _ impedances of busbar configurations.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
73/142/DTR	73/145/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60909, published under the general title Short-circuit currents in three-phase a.c. systems, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- iTeh STANDARD PREVIEW reconfirmed.
- withdrawn,
- replaced by a revised edition, standards.iteh.ai)
- amended.

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A bilingual version of this publication may be issued at a fater date?b1-9910-333568ee2ae6/iec-tr-60909-2-2008

SHORT-CIRCUIT CURRENTS IN THREE-PHASE AC SYSTEMS -

Part 2: Data of electrical equipment for short-circuit current calculations

1 General

1.1 Scope and object

This part of IEC 60909 comprises data of electrical equipment collected from different countries to be used when necessary for the calculation of short-circuit currents in accordance with IEC 60909-0.

Generally, electrical equipment data are given by the manufacturers on the name plate or by the electricity supplier.

In some cases, however, the data may not be available. The data in this report may be applied for calculating short-circuit currents in low-voltage networks if they are in accordance with typical equipment employed in the user's country. The collected data and their evaluation may be used for medium- or high-voltage planning purposes and also for comparison with data given by manufacturers or electricity suppliers. For overhead lines and cables the electrical data may in some cases also be calculated from the physical dimensions and the material following the equations given in this report. **(Data)**

Thus this technical report is an addition to EC 60909-0. It does not, however, change the basis for the standardized calculation procedure given in EC 60909-0 and IEC 60909-3.

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1.2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60909-0:2001, Short-circuit currents in three-phase a.c. systems – Part 0: Calculation of currents

IEC 60909-3:-1, Short-circuit currents in three-phase a.c. systems – Part 3: Currents du-ring two separate simultaneous line-to-earth short-circuit currents and partial short-circuit currents flowing through earth

2 Data for electrical equipment

2.1 General

The data presented are necessary for the calculation of short-circuit currents. They are sometimes presented in the form of curve sheets and sometimes in the form of examples in tables. In the case of easy equations they are given for the calculations of positive-sequence and zero-sequence short-circuit impedances for overhead lines and cables.

¹ To be published.

In all, 15 National Committees provided information in response to a questionnaire sent out before the first edition of this report. Table 1 of the first edition of this report is given in Annex A.

In some cases, average values or characteristic trends as function of rated power, rated voltage, etc. are given.

2.2 Data of typical synchronous machines

Characteristic data of synchronous machines are listed in Table 1. The reactances are given as relative values related to $Z_{rG} = U_{rG}^2 / S_{rG}$ (see IEC 60909-0). Sometimes they are given in %.

In Figure 1 the sub-transient reactances of synchronous machines (generators, motors and condensers) in the direct axis of 50 Hz or 60 Hz machines are plotted as a function of the rated power.

No	Type a)	Rated appar. power	Rated a devia	voltage nd tion ^{b)}	Power factor	Power Relative values of reactances factor and d.c time constant							
		S_{rG}	U_{rG}	± <i>p</i> g1	cos <i>q</i> rG	NxD/	<i>x</i> ₍₂₎		х _d	, X _{dsat}	$T_{\sf DC}$		
					(sts	ndar	c)	eh ^{d)} ai	e)	f)	g)		
	-	MVA	kV	%	(300	-		-	-	-	s		
1	TG2	64	13,8	±5	0,85	<u>10,1798 (</u>	090,9-7.020	<mark>0@</mark> ,104	1,87	1,87	0,220	60 Hz	USA
2	TG2	100	10,50	://s <u>t</u> a 5 daı	dsotebai/	catəlqg/atar	dards/sist/f	5ef6599-1	l 1 <mark>r;67</mark> 47	1, <mark>45</mark> 10	0,246	50 Hz	Germany
3	TG2	125	10,5	±5	0,80	0,160	0,180	0,08	2,13	1,87	0,460	50 Hz	ex-GDR
4	TG2	180	10,5	±5	0,90	0,250	0,230	0,14	1,83	1,77	0,480	50 Hz	Austria
5	TG2	353	18,0	±5	0,85	0,167	0,204	0,089	2,26	2,17	0,194	50 Hz	China
6	TG2	388,9	17,5	±5	0,90	0,203	0,202	0,099	2,42	2,19	0,250	50 Hz	Australia
7	SG14	48	10	±5	0,90	0,16	0,17	0,05	0,78	-	0,16	50 Hz	Italy
8	SG20	290	18,0	±5	0,90	0,22	0,22	0,14	1,03	0,96	0,36	60 Hz	Japan
9	SM2	1,45	10	+5	0,90	0,166	0,166	0,046	1,63	-	0,04	50 Hz	ex-USSR
				-10									
10	SM3	3,40	4,0	±5	0,80	0,249	0,303	-	2,675	2,675	0,116	60 Hz	USA
11	SC10	40	13,8	±5	0	0,119	0,129	-	1,33	1,33	0,1425	60 Hz	USA
12	SC6	100	10,5	±5	0	0,20	0,25	0,095	1,78	1,60	0,57	50 Hz	ex- Czechos- lovakia
a)	TG2: ⁻	Two-pole	turbo g	generator			c) Negative-sequence reactance						
	SG: S	alient po	le gene	rator			d) Zero-sequence reactance						
	SM: S	ynchrond	ous mot	or			e) Unsaturated synchronous reactance						
	SC: S	alient pol	e synch	nronous	condense	r i	f) Saturated synchronous reactance						
b)	U _G =	$= U_{rG} \left(1 \right)$	$\pm \frac{p_{\rm G}}{100\%}$	//o)		1	g) DC tin	ne consta	nt for a	three-ph	ase tern	ninal sh	ort circuit

Table 1 – Actual data of typical synchronous generators, motors and condensers



Figure 1 – Subtransient reactance of synchronous machines 50 Hz and 60 Hz (Turbogenerators, salient pole generators, motors SM and condensers SC)

In Figure 2 the rated voltages and power factors of 50 Hz or 60 Hz synchronous machines (generators, motors) are plotted as a function of the rated power.

In Figure 3 unsaturated and saturated (x_{dsat}/x_d) synchronous reactances for 50 Hz and 60 Hz turbogenerators, used for the calculation of the steady state short-circuit current, are plotted as a function of the rated power.

Data are also given for the zero-sequence reactance. It is recommended that the relationship $X_{(0)} / X_{d}^{"} = 0.5$ is used.

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Figure 2 – Rated Voltage U_{rG} and rated power factor $\cos \varphi_{rG}$ of synchronous machines (Turbo generators, salient pole generators, motors and condensers 50 Hz and 60 Hz)



Figure 3 – Unsaturated and saturated synchronous reactance of two-pole turbo generators 50 Hz and 60 Hz (relative values)

2.3 Data of typical two-winding, three-winding and auto-transformers

In Tables 2, 3 and 4 characteristic data of two-winding, three-winding and auto-trans-formers are listed.

No	Rated appar. power	Rated voltage		Rated voltage		Rated voltage		Rated voltage		Rated Rated voltage short-circuit voltage		Winding connec- tion symbol HV LV	Side of Earth- ing	$\frac{X_{(0)}}{X_{(1)}}$	Tap-changer			Notes	National Commit- tee
	S _{rT}	$U_{\rm rTHV}$	U_{rTLV}	u _{kr}	u _{Rr}				$\pm p_{\mathrm{T}}$	u_{k+}	u_{k-}								
	MVA	kV	kV	%	%	_		-	%	%	%								
1	0,63	20	0,4	6,0	1,2	Dyn5	LV	≈1	±5	off-l	load	NT, 50 Hz,	ex-GDR						
												3 limb							
2	24	33	11	24,2	1,12	YNyn0	HV, LV	0,7	±10	24,1	25,3	NT, 50 Hz,	UK						
												3 limb							
3	31,5	112	22,2	12,8	0,37	YNd5	ΗV	≈1	±18	13,9	10,5	NT, 50 Hz	Germany						
4	80	121	6,3	10,5	_	YNd5	HV	0,71	2×2,5	-		NT, 50 Hz,	Bulgaria						
				•T								3 limb							
5 ^{a)}	500	400	132	26,1	0,30	YNynd5	HV, LV	≈1,6	±13		L vv	NT, 50 Hz	Denmark						
6	20	138	13,2	10,58	0,49	S byn 1 C		0,93	+2,5	i)		ST, 60 Hz,	USA						
									- 7,5			3 limb							
7	25	132	6,3	10,5	adanda i	YNd1	TR 6090	9-2:200	<u>8</u>	<u>}</u>		ST, 59 Hz,	Hungary						
			nı	ips7/sta	idards.1	333568ee2	g/standard lae6/iec-ti	15/5151/15 1-60909	-2-200	8 8	/01-99	3 limb							
8	180	110	10,5	12,0	0,221	Yd11		0,78	±12			ST, 50 Hz	Austria						
9	390	350	23,0	15,92	0,554	YNd1	ΗV	1,0	+10	16,7	15,5	ST, 50 Hz,	Australia						
									- 15			3 limb							
10	780	230	21,0	15,3	0,2	YNd5	HV	≈ 0,8	±15	16,7	14,3	ST, 50 Hz	Germany						
a) _{Tv}	vo-windir	ng trans	former	with an	auxilia	ry winding	in delta-c	onnect	ion (see	e Table	3).	-							

Table 2 – Actual data of typical two-winding transformers (NT: network; ST: power station)

No	Rated apparent powers			Rated apparent Rated powers voltages					circuit s	Winding connection symbol	Zero-sequence reactances related to side A			Note	National Commit- tee
	S _{rTAB}	S _{rtac}	S _{rTBC}	U _{rTA}	U_{rTB}	U_{rTC}	^{<i>u</i>} krAB	^{<i>u</i>} krAC	^{<i>u</i>} krBC		Х ₍₀₎ А	Х _{(0)В}	X _{(0)C}		
	MVA	MVA	MVA	kV	kV	kV	%	%	%	HV MV LV	Ω	Ω	Ω		
1	7,5	7,5	7,5	34,5	13,8	13,8	3,65	3,58	7,96	YN d1 d1	-	-	-	60 Hz	USA
														3 limb	
2	25	16	16	120	22	11	11,0	14,5	3,5	YN yn0 d11	99,0	-	3,15	50 Hz	Hungary
														3 limb	
3	31,5	31,5	31,5	110	38,5	6,3	10,5	17,5	6,5	YN yn0 d11	6,13	17,23	18,24	"	China
4	94	94	94	239	130	13,8	11,79	11,31	12,44	YN yn0 d11	32,39	39,23	36,31	"	Italy
5	125	42	42	230	63	20	11,7	10,6	5,9	YN yn0 d11	124,6	-	5,74	50 Hz	ex-GDR
														5 limb	
6	600	150	150	400	230	30	17,5	16,5	11,3	YN yn0 d5	50,5	-3,8	125,3	"	Austria

 Table 3 – Actual data of typical three-winding transformers

For the transformer No. 6 in Table 3 the following Figure 4 gives additional information. The low-voltage winding C (30 kV) is laying near the iron core, the medium-voltage winding B (230 kV) between the windings A and C. The high-voltage winding A has a main part and an additional tap winding connected to the on-load tap changer (see b in Figure 4) near the star point at the high-voltage side of the transformer.

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The reactances X_A , X_B , X_C in the positive sequence system can be calculated from the shortcircuit voltages given in Table 3.3 Related to the high-voltage side A ($U_{rTA} = 400 \text{ kV}$) the results are: $X_A = 51, 1\Omega$, $X_B = -4, 4\Omega$ and $X_C = 124,93 \Omega$ without impedance correction factors (see IEC 60909-0). The value X_C has a small negative value similar to $X_{(0)B}$ given in Table 3.

If only the star point at the high-voltage side is earthed then $X_{(0)T} = X_{(0)A} + X_{(0)C}$ shall be used. If, on the other side, only the star point at the medium-voltage side is earthed, then $X_{(0)T} = X_{(0)B} + X_{(0)C}$ is valid related to the high-voltage side or related to the medium-voltage side: $X_{(0)Tt} = (X_{(0)B} + X_{(0)C}) \times (230 \text{ kV})^2 / (400 \text{ kV})^2$.