ETAP IEC Short-Circuit

This document provides an ETAP validation case. This is just one of many test case scenarios for IEC Short-Circuit (SCIEC) which are part of ETAP V&V program. This case is a validation case based on comparisons against published results in the IEC TR 60909-4:2021 document for Short-Circuit analysis.

Short-Circuit IEC Comparison Case # 2

Comparison of ETAP Short-Circuit IEC Calculations against Published Example

Excerpt from Validation Cases and Comparison Results (TCS-SCIEC-201)

Highlights

- Comparison of ETAP SCIEC results against published results in IEC TR 60909-4:2021 [1] Example-8 (Page 59-72).
- Comparisons for:
  - Initial symmetrical current (I”k).
  - Peak current (Ip) for both method B and C.
  - Breaking Current (Ib)

System Description

Example 8 of [1] examines 3-phase fault current results for conventional and IBR (Inverter Based Resource) wind power plant combinations. The one-line diagram shown in Figure 1 was generated using the data provided in [1]. A detailed breakdown of three-phase fault results for each wind turbine technology combination is provided in Table 1. Detailed short-circuit results for each combination are provided in Tables 2 to 7.

Table 1: Summary of Wind Turbine Technology Combinations

Case #	Tables Listing Comparisons	Scenario Description
Case 1	Table 2	Wind power plant consists of ten wind power station units with doubly fed asynchronous generators.
Case 1B	Table 3	Case 1 with cables L2 to L12 are neglected.
Case 2	Table 4	Wind power plant consists of ten wind power station units with full size converters.
Case 2B	Table 5	Case 2 with cables L2 to L12 are neglected.
Case 3	Table 6	Wind power plant consists of five wind power station units with doubly fed asynchronous generators (W1 to W5 in Figure 1) and five wind power station units with full size converter (W6 to W10 in Figure 1).
Case 3B	Table 7	Case 3 now with cables L2 to L12 are neglected.

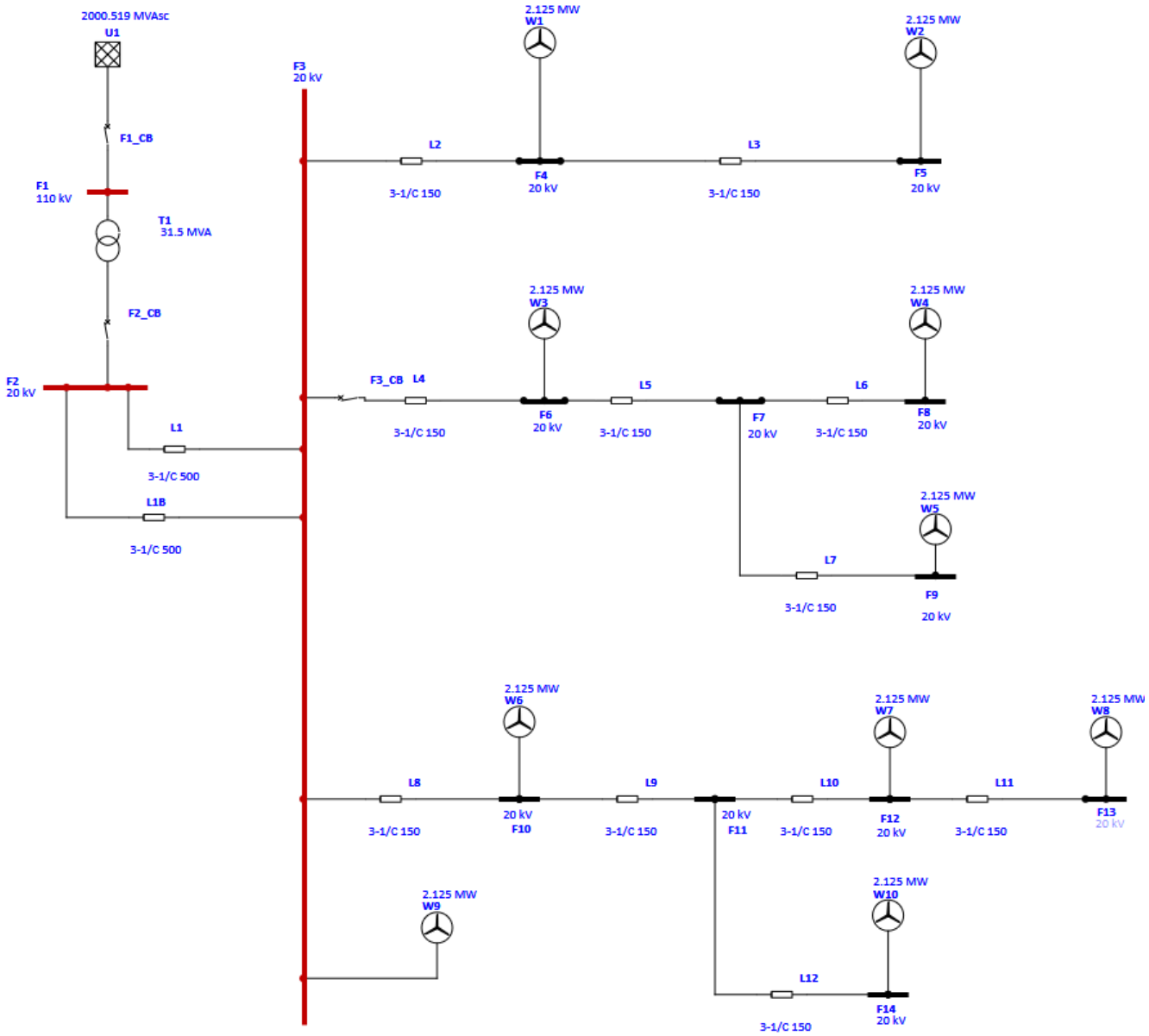

Figure 1: ETAP One line diagram showing the example from section 8 of IEC60909-4-2021

Comparison of Results

Table 2 to Table 7 list comparisons between the ETAP and the results published in example 8 of [1].

The maximum deviation in the results is less than 2% for cases 2 to 3B. WTGs with the full converters in ETAP are modeled as voltage dependent current sources and is an iterative process. The proportion of active and reactive components of the current are based on the reactive current priority option in ETAP. This option uses the fault ride through (FRT) characteristics which depend on the pre-fault loading conditions and are not provided in the example. However, if the manufacturer data for the Short-Circuit power factor is available then the percent deviation in the ETAP results would be reduced.

Table 2: Initial Symm. and Peak Currents (method B and C) for Case 1

	IEC	ETAP		IEC	ETAP		IEC	ETAP	
Fault Location	**I"k (kA)**	**I"k (kA)**	**% Diff.**	**Ip(kA) Method B**	**Ip (kA) Method B**	**%Diff**	**Ip(kA) Method C**	**Ip (kA) Method C**	**%Diff**
F1	10.745	10.745	0.00	26.503	26.503	0.00	26.504	26.504	0.00
F2	9.045	9.045	0.00	23.085	23.085	0.00	23.129	23.128	0.00
F3	6.978	6.978	0.00	15.403	15.403	0.00	15.469	15.469	0.00
F4	6.385	6.385	0.00	14.816	14.816	0.00	12.974	12.974	0.00
F5	6.095	6.095	0.00	13.629	13.629	0.00	11.945	11.945	0.00
F6	6.568	6.568	0.00	13.604	13.604	0.00	13.698	13.698	0.00
F7	6.478	6.478	0.00	13.249	13.250	0.00	13.348	13.348	0.00
F8	6.262	6.262	0.00	14.307	14.307	0.00	12.540	12.540	0.00
F9	6.184	6.184	0.00	13.986	13.986	0.00	12.262	12.262	0.00
F10	6.513	6.513	0.00	13.402	13.402	0.00	13.517	13.517	0.00
F11	6.394	6.394	0.00	14.892	14.892	0.00	13.075	13.075	0.00
F12	6.247	6.247	0.00	14.273	14.273	0.00	12.542	12.542	0.00
F13	5.993	5.993	0.00	13.271	13.270	0.00	11.670	11.670	0.00
F14	6.313	6.313	0.00	14.546	14.545	0.00	12.773	12.773	0.00

Table 3: Initial Symm. and Breaking Currents for Case 1B

	IEC	ETAP		IEC	ETAP	
Fault Location	**I"k (kA)**	**I"k (kA)**	**%Diff.**	**Ib (kA)**	**Ib (kA)**	**% Diff.**
F1	10.747	10.747	0.00	10.679	10.679	0.00
F2	9.056	9.056	0.00	8.383	8.383	0.00
F3	6.988	6.988	0.00	6.083	6.083	0.00

Table 4: Initial Symm. and Peak Currents (method B and C) for Case 2

	IEC	ETAP		IEC	ETAP		IEC	ETAP	
Fault Location	I"k (kA)	I"k (kA)	% Diff.	Ip (kA) Method B	Ip (kA) Method B	% Diff.	Ip(kA) Method C	Ip(kA) Method C	% Diff.
F1	10.671	10.642	-0.27	26.168	26.168	0.00	26.168	26.168	0.00
F2	8.387	8.222	-1.97	20.785	20.785	0.00	20.785	20.785	0.00
F3	6.161	6.075	-1.40	14.183	14.053	-0.92	12.506	12.377	-1.03
F4	5.728	5.677	-0.90	12.341	12.267	-0.60	10.894	10.820	-0.68
F5	5.522	5.482	-0.72	11.583	11.526	-0.49	10.230	10.173	-0.55
F6	5.852	5.775	-1.32	12.817	12.701	-0.91	11.312	11.198	-1.01
F7	5.787	5.711	-1.31	12.304	12.442	1.12	11.083	10.971	-1.01
F8	5.633	5.585	-0.87	11.977	11.907	-0.58	10.576	10.506	-0.66
F9	5.577	5.531	-0.82	11.773	11.708	-0.55	10.397	10.332	-0.63
F10	5.797	5.723	-1.27	12.580	12.470	-0.88	11.106	10.997	-0.98
F11	5.708	5.654	-0.94	12.230	12.154	-0.62	10.799	10.724	-0.70
F12	5.600	5.552	-0.85	11.829	11.762	-0.57	10.448	10.381	-0.64
F13	5.419	5.378	-0.74	11.199	11.141	-0.51	9.895	9.838	-0.57
F14	5.651	5.600	-0.89	12.018	11.947	-0.59	10.614	10.542	-0.68

Table 5: Initial Symm. and Breaking Currents for Case 2B

	IEC	ETAP		IEC	ETAP	
Fault Location	I"k (kA)	I"k (kA)	% Diff.	Ib (kA)	Ib (kA)	% Diff.
F1	10.671	10.642	-0.27	10.671	10.642	-0.27
F2	8.387	8.222	-1.97	8.387	8.222	-1.97
F3	6.161	6.075	-1.40	6.161	6.075	-1.40

Table 6: Initial Symm. and Peak Currents (method B and C) for Case 3

	IEC	ETAP		IEC	ETAP		IEC	ETAP	
Fault Location	**I”k (kA)**	**I"k (kA)**	**% Diff.**	**Ip(kA) Method B**	**Ip (kA) Method B**	**%Diff**	**Ip(kA) Method C**	**Ip (kA) Method C**	**%Diff**
F1	10.713	10.695	-0.17	30.197	30.171	-0.09	26.365	26.339	-0.10
F2	8.734	8.646	-1.01	24.072	23.945	-0.53	22.075	21.948	-0.58
F3	6.570	6.519	-0.77	15.948	15.874	-0.46	13.992	13.919	-0.52
F4	6.078	6.059	-0.30	12.008	11.981	-0.22	12.073	12.047	-0.22
F5	5.834	5.822	-0.21	12.762	12.744	-0.14	11.244	11.226	-0.16
F6	6.232	6.183	-0.79	14.379	14.308	-0.50	12.654	12.583	-0.56
F7	6.157	6.137	-0.32	12.307	12.278	-0.23	12.380	12.351	-0.24
F8	5.976	5.961	-0.25	11.659	11.637	-0.19	11.734	11.712	-0.18
F9	5.910	5.896	-0.23	13.059	13.039	-0.15	11.510	11.490	-0.18
F10	6.124	6.091	-0.54	13.796	13.749	-0.34	12.115	12.067	-0.39
F11	6.015	5.985	-0.51	13.339	13.296	-0.33	11.715	11.672	-0.37
F12	5.884	5.856	-0.48	12.823	12.783	-0.32	11.264	11.223	-0.36
F13	5.666	5.643	-0.40	12.024	11.991	-0.27	10.563	10.531	-0.31
F14	5.946	5.916	-0.50	13.066	13.023	-0.33	11.476	11.433	-0.37

Table 7: Initial Symm. and Breaking Currents for Case 3B

	IEC	ETAP		IEC	ETAP	
Fault Location	**I"k (kA)**	**I"k (kA)**	**% Diff.**	**Ib (kA)**	**Ib (kA)**	**% Diff.**
F1	10.714	10.695	-0.18	10.661	10.650	-0.10
F2	8.739	8.651	-1.01	8.348	8.292	-0.67
F3	6.574	6.523	-0.77	6.122	6.111	-0.19

References

[1] IEC TR 60909-4:2021, Short-circuit currents in three-phase AC systems –Part 4: Examples for the calculation of short-circuit currents, Geneva, Switzerland: IEC

[2] ETAP Short Circuit IEC V&V Documents, Case Number TCS-SCIEC-201.