ETAP Harmonic Analysis

This document provides an ETAP validation case. This is just one of many test case scenarios for Harmonic Analysis (HA) which are part of ETAP V&V program. This case is a validation case based on comparisons against published IEEE Standards on harmonic analysis.

Harmonic Analysis Validation Case # 1

Comparison of ETAP Harmonic Analysis Results Against IEEE Example

Excerpt from Validation Cases and Comparison Results (TCS-HA-001 [2])

Highlights

- Comparison between ETAP Harmonic Analysis results against those published on IEEE Standard 519-1992 [B1] Example 13.1 page. 89-92.
- Comparison of Current Total and Individual Harmonic Distortion.
- Comparison of Voltage Total and Individual Harmonic Distortion.
- Comparison of voltage and current harmonic indices such as RMS, ASUM, THD, TIF and TPF.

System Description

This is an industrial plant system serviced from a utility transmission voltage. The system is composed of transformers, induction motors, variable frequency drives (to be used as harmonic sources).

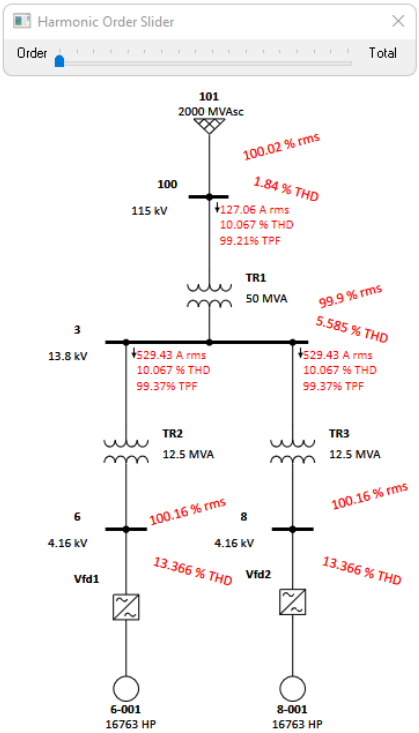

Fig 1: ETAP One-Line Diagram based on Fig. 13.1 from [1]

Comparison of Results

The following tables of comparison show the differences between ETAP results and those published in the standard. Percent deviation for all branch flows and bus voltages is less than 2%.

Table 1: Comparison between ETAP and IEEE STD 519 for Harmonic Load Flow

Harmonic Order	Harmonic current (A)[1] (From Bus 3 to Bus 100)			Harmonic Voltage (%) (Bus 100)		
	Std 519	ETAP	% Dev[2]	Std 519	ETAP	% Dev[2]
5	2.40	2.40	**0.00**	0.12	0.12	**0.00**
7	1.65	1.67	**-1.21**	0.12	0.12	**0.00**
11	9.12	9.23	**-1.20**	1.00	1.01	**0.00**
13	7.12	7.21	**-1.26**	0.92	0.93	**-0.00**
17	0.44	0.44	**0.00**	0.08	0.07	**0.00**
19	0.34	0.34	**0.00**	0.06	0.06	**0.00**
23	2.51	2.53	**-0.79**	0.57	0.58	**-1.75**
25	2.00	2.02	**-1.00**	0.50	0.50	**0.00**
29	0.17	0.17	**0.00**	0.05	0.05	**0.00**
31	0.15	0.15	**0.00**	0.05	0.05	**0.00**
35	1.37	1.39	**-1.45**	0.48	0.48	**0.00**

1. ETAP gives branch harmonic currents in percentage of fundamental current.
2. The discrepancy in harmonic current and voltage results between the ETAP calculated and IEEE Std 519 values is due to rounding off.

The harmonic currents listed in Table 13.1 of [1] for the Static Power Converter (SPC) harmonic source specifies pu magnitudes of harmonic orders that do not exist in the spectrum of 12 pulse drive such as 5th, 7th, 17th, and 19th etc. (in bold type font in the standard) are taken as 10% of the magnitudes. ETAP's interpretation of the harmonic distortion spectrum is provided in Table 2.

Table 2: Harmonic Distortion Spectrum used in the ETAP Validation System

Harmonic Order	PU Value	Harmonic Order	PU Value	Harmonic Order	PU Value
1	1	19	0.0027	37	0.01
5	0.0192	23	0.02	41	0.0009
7	0.0132	25	0.016	43	0.0008
11	0.073	29	0.00136	47	0.008
13	0.057	31	0.0012	49	0.007
17	0.0035	35	0.011		

Tables 3 and 4 provide comparisons between voltage and current on bus "100" and branch "TR1" for RMS, ASUM, THD, TIF and TPF in ETAP against hand calculated values and reported deviations for this comparison.

Table 3: Comparison on bus "100" for voltage RMS, ASUM, THD and TIF

Parameter to be Compared	Hand Calculation (in Mathcad)	ETAP	% Dev
RMS	100.02	100.02	0.00
ASUM	105.44	105.44	0.00
THD	1.84	1.84	0.00
TIF	109.21	109.23	-0.01

Table 4: Comparison on "TR1" for current RMS, ASUM, THD, TIF and TPF

Parameter to be compared	Hand Calculation (in Mathcad)	ETAP	% Dev
RMS	127.04	127.06	-0.01
ASUM	156.62	157.16	-0.29
THD	10.067	10.067	0.00
TIF	347.64	347.64	0.00
TPF	99.21	99.21	0.00

References

[1] IEEE Standard 519-1992 Example 13.1, page 89-92.

[2] ETAP Harmonic Analysis V&V Documents, Case Number TCS-HA-001.