

ETAP Harmonic Analysis

The ETAP V&V process for the Harmonic Analysis program has over 1300 test case scenarios that are run before each ETAP release. The following cases are excerpts from the Harmonic Analysis V&V documentation.

Harmonic Analysis Comparison Case # 1

Comparison of ETAP Harmonic Analysis Results Against IEEE Example

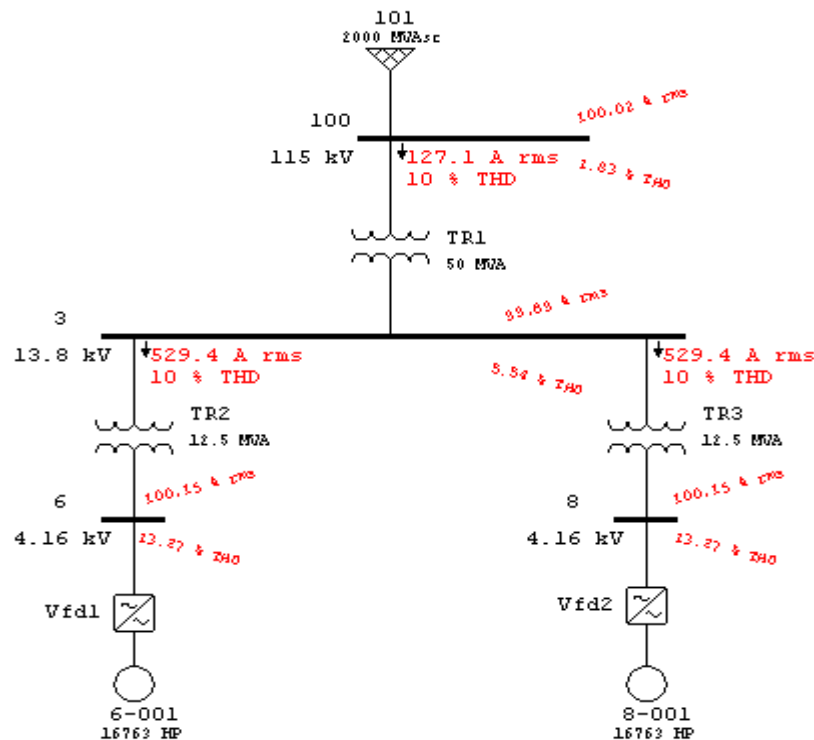
Excerpts from Validation Cases and Comparison Results (TCS-HA-001)

Highlights

- Comparison between ETAP Harmonic Analysis (HA) results against those published on IEEE Standard 519-1992 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 RMS, ASUM, THD, and TIF.

System Description

This is a large industrial plant system furnished at utility transmission voltage. The system is composed of multiple transformers, induction motors, variable frequency drives (as harmonic sources) and utility.



Comparison of Results

The following tables of comparison show the differences between ETAP results and those published in the textbook example. Please notice that the percent difference for all branch flows and bus voltages is less than 1%.

HARM ORDER	HARMONIC CURRENT (A)			HARMONIC VOLTAGE (%)		
	(from Bus 3 to Bus 100)			(Bus 100)		
	STD 519	ETAP	% Diff	STD 519	ETAP	% Diff
5	2.4	2.4	0	0.12	0.12	0.0
7	1.65	1.64	0.0	0.12	0.12	0.0
11	9.12	9.07	0.1	1	1	0.0
13	7.12	7.18	-0.1	0.92	0.93	-0.0
17	0.44	0.38	0.1	0.08	0.07	0.0
19	0.34	0.38	-0.0	0.06	0.06	0.0
23	2.51	2.52	-0.0	0.57	0.57	0.0
25	2	2.01	-0.0	0.5	0.5	0.0
29	0.17	0.13	0.0	0.05	0.05	0.0
31	0.15	0.13	0.0	0.05	0.05	0.0
35	1.37	1.39	-0.0	0.48	0.48	0.0

Table 20: Comparison between ETAP and IEEE STD 519 for Harmonic Load Flow

Note: 1. The harmonic currents listed in Table 13.1 of IEEE Std. 519, for the Static Power Converter (SPC) harmonic source have errors. The correct values used by ETAP are given below:

Harmonic	PU Value	Harmonic	PU Value	Harmonic	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		

- Errors results are given in absolute value due to small results values and insufficient number of digits.
- ETAP gives branch harmonic currents in percentage of fundamental current.
- The larger discrepancy in harmonic voltage values between the ETAP calculated and IEEE Std 519 values is due to insufficient number of digits in ETAP output. In the ETAP output, the harmonic voltage components are reported to second digit after the decimal point.

Below you can find tables of comparison between voltage and current on bus “100” and branch “TR1” for RMS, ASUM, THD, and TIF in ETAP against hand calculated values and reported errors for this comparison.

Parameter to be Compared	Hand Calculation (in MathCad)	ETAP	% Diff
RMS	100.02	100.02	0.0
ASUM	105.40	105.40	0.0
THD	1.83	1.83	0.0
TIF	108.35	108.44	-0.1

Table 21: Comparison on bus “100” for voltage RMS, ASUM, THD and TIF

Parameter to be compared	Hand Calculation (in MathCad)	ETAP	% Diff
RMS	126.63	127.05	-0.3
ASUM	156.62	157.16	-0.3
THD	9.99	10.00	-0.1
TIF	346.55	345.16	0.4

Table 22: Comparison on “TR1” for current RMS, ASUM, THD and TIF

Reference

1. IEEE Standard 519-1992 Example 13.1, page 89-92.
2. ETAP Harmonic Analysis V&V Documents, Case Number TCS-HA-001.