Problem 1.1. (5 pts) Explain the difference between THD and TDD, and how each of these indices is used in a harmonic evaluation.

Problem 1.2. (10 pts) A single-phase rectifier has a perfect sinewave voltage input, and a perfect square wave current input that is in-phase with the voltage input, i.e. their zero crossings occur at the same instant in time. Calculate the displacement power factor (DPF) and the True Power Factor (PF) for this rectifier.

Problem 1.3. (5 pts) For a three-phase balanced source, explain why the fifth harmonic voltage is considered to be a negative sequence component.

Problem 1.4. (5 pts) For some non-linear load, the RMS value of the load's distorted current is 100A, and the fundamental component of this current is 89A (AC-RMS). What is the distortion power factor (PFdist) for this load?

Problem 1.5. (5 pts) What is the current THD for a load with a distortion power factor of 0.83?

Problem 2: (15 pts) Explain how a saturated transformer produces current harmonics even when its input voltage is perfectly sinusoidal. Use an appropriate diagram and a sample B vs. H curve or V versus I curve in your explanation.

Problem 3: The harmonic spectrum through the 25th harmonic, normalized to the fundamental is provided in column 2 of the table on the next page. The RMS value of the fundamental component of the variable speed drive current is 87.4A. This is a 60Hz system with a nominal line-to-line voltage of 480V. Isc = 3100A at the PCC (the 480V service panel) and the variable speed drive described above is the only non-linear load at this location. The balance of the load at this location is balanced, three-phase, resistive load. The maximum fundamental load current demand with the variable speed drive and the resistive load running was 130A RMS. Assume that these loads run continuously.

3.1. (5 points) Calculate the THD for the variable speed drive.
3.2. (10 points) Calculate the TDD for the combined VSD and resistive load.
3.3. (10 points) What are the current distortion limits, in amps, according to IEEE 519-2014, table 2 for each of the 25 harmonics in Table 1 at this location?
3.4. (10 points) Does this installation comply with the current distortion limits of IEEE 519-2014, Table 2? In your answer list the specific current harmonics that do and do not meet these current distortion limits.

Problem 4. Assume the current harmonic spectrum given in table 1 describes the shape of the current in each phase for the entire load served by a 3-phase, 480V line-to-line, dry transformer rated 100kVA. The magnitude of the fundamental component is 87.4A, as it was for the VSD in problem 3. There is no additional linear load in this problem.

4.1. (10 points) Calculate the appropriate K-factor for a 100kVA K-factor transformer to serve this load.
4.2 (10 points) Calculate the transformer “derating” the allowable loading on a standard dry transformer less than 1MVA as a percentage of its nameplate rating to avoid overheating the transformer with this load current.

Current waveform and nomalized harmonic magnitudes for problems 3 and 4

Figure 1 - Current Waveform

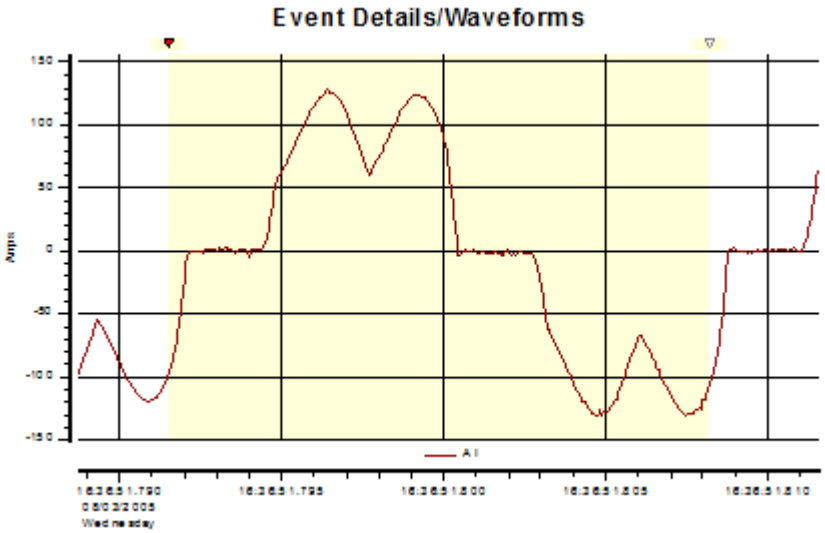

Table 1 - Harmonic Spectrum of Current Normalized to the Fundamental

Harmonic	Percent
FND	100
2	1.0597
3	0.5536
4	0.9274
5	31.077
6	0.30839
7	7.957
8	0.1904
9	0.3996
10	0.08423
11	6.245
12	0.1863
13	3.337
14	0.31299
15	0.07087
16	0.0624
17	2.6597
18	0.25832
19	2.1161
20	0.3283
21	0.19112
22	0.09556
23	1.1652
24	0.23416
25	1.3813