project No. 2: Power System Harmonic Analysis

System Description

Note: you will have considerable difficulties to complete this project if you don't have some knowledge on power flow calculations.

This test case consists of 13 buses and is representative of a medium-sized industrial plant. The system is extracted from a common system that is being used in many of the calculations and examples in the IEEE Color Book series. The plant is fed from a utility supply at 69 kV and the local plant distribution system operates at 13.8 kV. The system is shown in Figure 3.1 and described by the data in Tables 3.1-4. Due to the balanced nature of this example, only positive sequence data is provided. Capacitance of the short overhead line and all cables are neglected.

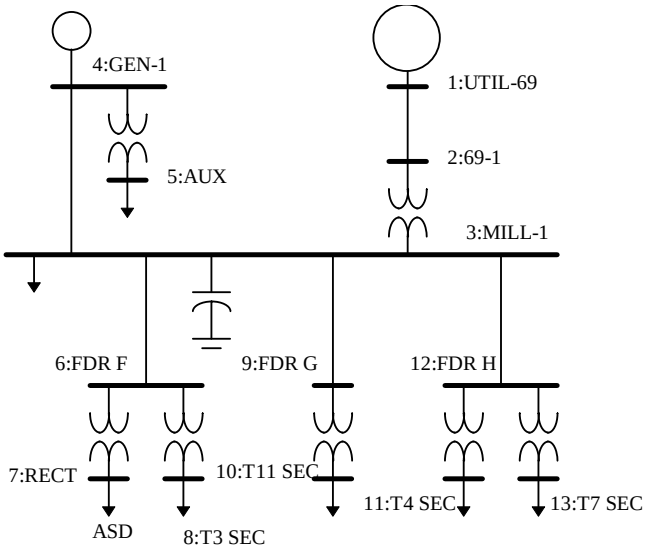

Figure 3.1. A sample industrial system.

Table 3.1. Per-Unit Line and Cable Impedance Data
(base value: 10,000 kVA)

From	To	R	X
UTIL-69	69-1	0.00139	0.00296
MILL-1	GEN-1	0.00122	0.00243
MILL-1	FDR F	0.00075	0.00063
MILL-1	FDR G	0.00157	0.00131
MILL-1	FDR H	0.00109	0.00091

Table 3.2. Transformer Data (R & X are in % !)

From	To	Voltage	kVA	%R	%X
69-1	MILL-1	69:13.8	15000	0.4698	7.9862
GEN1	AUX	13.8:0.48	1500	0.9593	5.6694
FDR F	RECT	13.8:0.48	1250	0.7398	4.4388
FDR F	T3 SEC	13.8:4.16	1725	0.7442	5.9537
FDR G	T11 SEC	13.8:0.48	1500	0.8743	5.6831
FDR H	T4 SEC	13.8:0.48	1500	0.8363	5.4360
FDR H	T7 SEC	13.8:2.4	3750	0.4568	5.4810

Table 3.3. Load Flow Input Data
('-' are load flow results to be determined)

Bus	V_{mag} (p.u.)	θ (deg)	P_{gen} kW	Q_{gen} kVar	P_{load} kW	Q_{load} kVar
UTIL-69	1.000	0.00	-	-		
69-1	-	-				
MILL-1	-	-			2240	2000
GEN1	0.995	-	2000	-		
Aux	-	-			600	530
FDR F	-	-				
RECT	-	-			1150	290
T3 SEC	-	-			1310	1130
FDR G	-	-				
FDR H	-	-				
T4 SEC	-	-			370	330
T7 SEC	-	-			2800	2500
T11 SEC	-	-			810	800

Table 3.4. Harmonic Source Data (ASD)

Harmonic #	Percent	Relative Angle
1	100.00	0.00
5	18.24	-55.68
7	11.90	-84.11
11	5.73	-143.56
13	4.01	-175.58
17	1.93	111.39
19	1.39	68.30
23	0.94	-24.61
25	0.86	-67.64
29	0.71	-145.46
31	0.62	176.83
35	0.44	97.40
37	0.38	54.36

Additional data needed to conduct a harmonic analysis of the example industrial system include the following:

1. The supply system (utility) equivalent impedance (transient and sub-transient) is 0.05+j1 per unit based on 100 MVA. (That is the fault level of the supply system is 100MVA.) Enter 1/3 of the value for zero sequence impedance cells.

2. The local (in-plant) generator has an internal impedance of X=0.25 per-unit based on the generator rated kVA which is 2000kVA.

3. The plant power factor correction capacitors are rated at 5000 kVar.

The harmonic source is an ASD connected to bus #7 (REC). The above data is sufficient to build a system model for simple harmonic analysis by the PSA-H program. You should be aware that a number of assumptions have been made to the data and in the program.