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# Design of a Computer Code To Evaluate the Influence of the Harmonics in the Electrical Networks

**A. Souli\*, A. Hellal\*\***
\*Nuclear Research Center of Birine-Algeria,
\*\* LACoSERE Laboratory, Electrical engineering Department, Laghouat University- Algeria,

| Article Info | ABSTRACT |
|---|---|
| | This paper aims to present the design of a computer code (HPFCODE), for calculate a power flow and power losses in power systems under the influence of harmonics, using the GUI in MATLAB. After described the program was run for two networks IEEE 6 nodes and IEEE 14 nodes. The power flow by Newton-Raphson method was calculated as the losses of active and reactive power in the lines, respectively, where the loads are linear and nonlinear (Static Var Compensator(SVC), Thyristor controlled Reactor(TCR), and Unified Power Flow Controller ((UPFC)), The results were almost consistent and show the influence of higher harmonics on power losses in electrical networks<br><br> |

***Corresponding Author:***

A. Souli
Researcher in Nuclear Research Center of Birine,
Laghouat University- Algeria,
e-mail:souliaissa@yahoo.fr

## 1.    INTRODUCTION

Power system harmonic analysis is to determine the impact of harmonic producing loads on a power system [1]. Harmonic analysis has been widely used for system planning, operation criteria development, equipment design, troubleshooting, verification of standard compliance, and so on. Over the past two decades, significant efforts and progresses have been made in the area of power system harmonic analysis. Well-accepted component models, simulation methods and analysis procedures for conducting harmonic studies have been established. Harmonic studies are becoming an important component of power system analysis and design.

The HPFCODE "Code Harmonics Power Flow" is a program of simulation and calculation of power flow [2], power grids, can give the results of power flow in the nodes, power flow and power losses in the lines, in the network system to select IEEE 6 nodes, or IEEE 14 nodes. The HPFCODE calculates of the harmonics power flow [3] in the nodes, lines, power losses in the lines, and also in the normal case (no harmonics). Through the HPFCODE code, we can calculate the power flow of a power system with linear loads or with a nonlinear load any (SVC TCR, UPFC……), by the choice of a preferred network and the nonlinear load which we prefer, and running the program.

## 2.    STRUCTURE OF HPFCODE

Our program is called HPFCODE was developed to calculate the power flow and power losses [4] in the lines for various systems of the power grids. HPFCODE can analyzed and calculate the power flow (power flow) in two cases: PFNormal where the loads are linear and PFHarmonic where there are non-linear loads (SVC, TCR, and UPFC) [5].
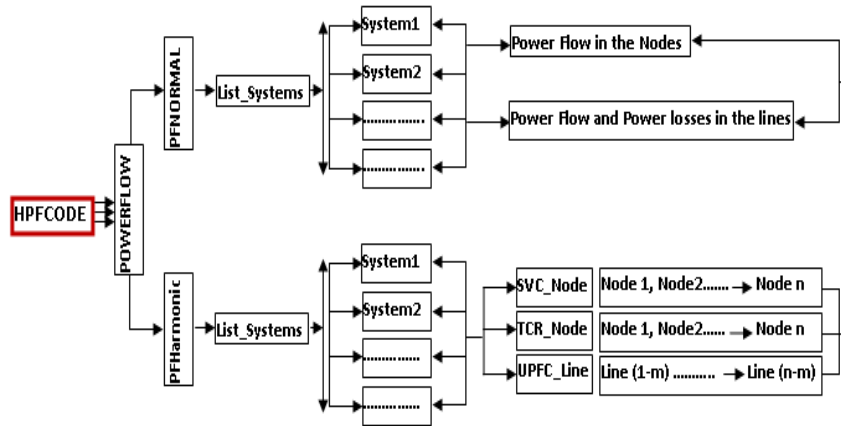
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Figure 1. Structure of program HPFCODE

HPFCODE is a computer code produced in MATLAB [6], and allows you to run multiple applications and functions (MATLAB files). HPFCODE structure is based on graphical interfaces [7] performed by MATLAB (GUI).
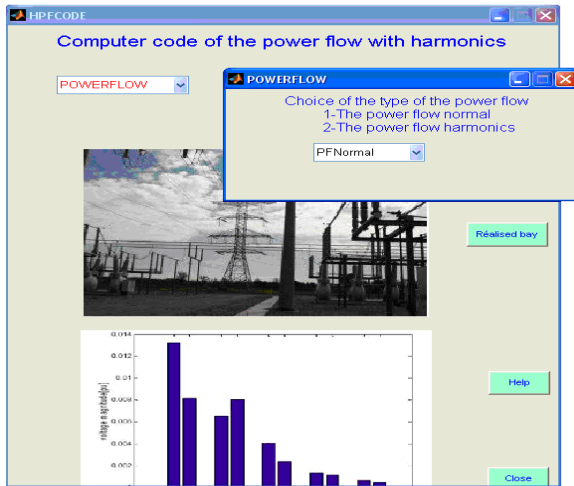


Figure 2. Principal Window of HPFCODE program
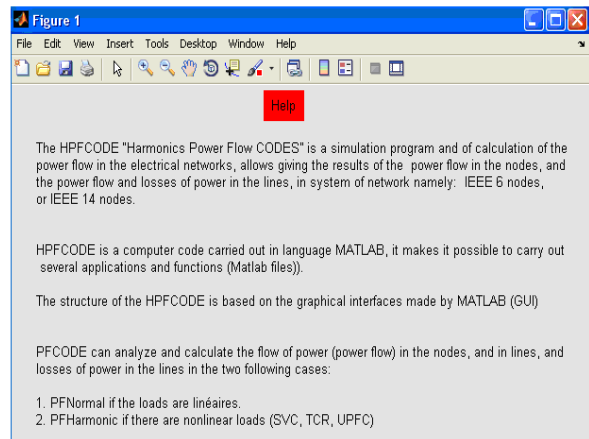


Figure 3. Help Window of HPFCODE program
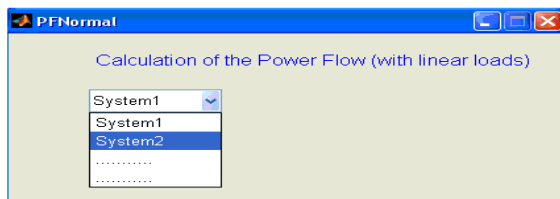


Figure 4. Network System selection with PFNormal
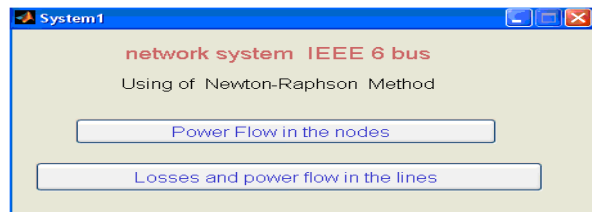


Figure 5. Results of the network system 1

First, the GUI displays a HPFCODE home page that mentions the objective of this program code for calculating the harmonic power flow with " a subroutine is called POWERFLOW, and three buttons:
-   The first button is "Directed by" the author of this program HPFCODE.
-   The second button is "Help" gives an overview of the program.
-   The third button "Close" to exit the HPFCODE program.

If you click on the first function PFNormal the following window. If you click on System1, System2, etc.., another window appears, and you can select one of two functions: Perform a power calculation in normal nodes (without the presence of harmonics) or calculate the normal power and power losses in the lines of the network system that was chosen. By cons, if you press on the first function PFHarmonic the following window is:

Figure 6. Network System selection with PFHarmonic
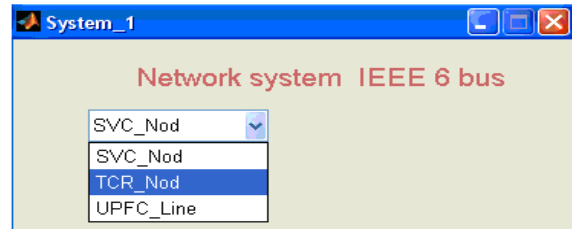
Figure 7. Network System 1 with non Linear Loads

Then click on System1 [8], System2 [9], or System (the study system available in the database), gives a window of a choice for non-linear loads on power system chosen

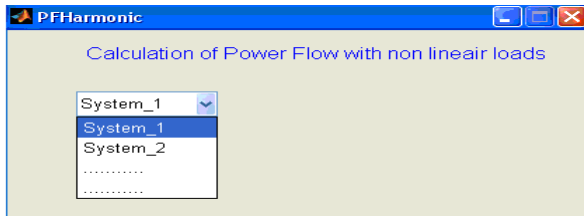If you selected the first non-linear load SVC represented by "SVC_Nod" window of Figure 8 appears with a choice of location of SVC node to select. If you click on other nonlinear loads TCR represented by " TCR_Nod " or UPFC represented by " UPFC_Line "a window similar to Figure 8 appears. For "UPFC_Line, the siting of UPFC is compared to the lines of the system studied.

## 3.    DEVICES OF GENERATION OF HARMONICS

The Harmonics are created by devices, the voltage / current is not linear [10], as is the case with power electronic converters and motor drives.  Among the harmonic generators, we can mention: Non-linear loads: Static Var Compensator (SVC), Thyristor controlled Reactor (TCR), Unified Power Flow Controller (UPFC):

- Six-phase Rectifier Bridge.
- Switch Mode type computer.
- Lighting load.
- Variable speed.

Among the non-linear loads used in power systems, which generate harmonics, we distinguish mainly FACTS systems "Flexible Alternating Current Transmission System" [11].  These devices are in general use of power electronics, microprocessors, automation, telecommunications and software to achieve control power systems.  These are some fast answers.  They are, in principle more flexible control of power flow. They also can load the transit lines to values near their thermal limit, and increase the ability to transfer power from one region to another.  They also limit the effects of faults and equipments failures, and stabilized the network behavior.  But they are a source of harmonics currents often undesirable.

Figure 8. Possible Nodes of Hiring of the SVC in the Study System

Figure 9. SVC connected to a transmission line

## 4.   STATIC VAR COMPENSATOR (SVC) DESCRIPTION AND MODELING:
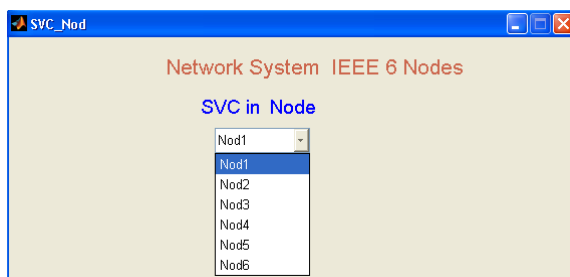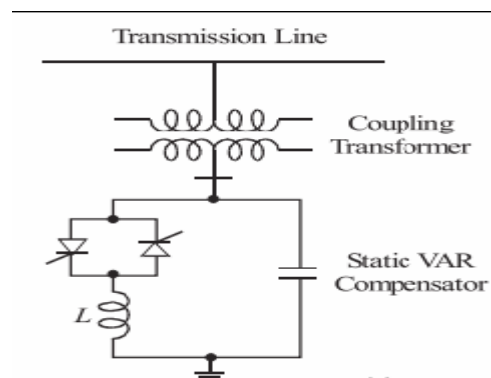
The SVC uses conventional thyristors to achieve fast control of shunt-connected capacitors and reactors. The configuration of the SVC is shown in Figure 9, which basically consists of a constant capacitor(C) and a thyris-tor controlled reactor (L).The delay angle control of the thyristor banks determines the equivalent shunt admittance presented to the power system [12].

New version of SVC is basically a shunt connected static var generator/load whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific power system variables; typically, the controlled variable is the SVC bus voltage [13].One of the major reasons for installing a SVC is to improve Dynamic voltage control and thus increase system load ability. An additional stabilizing signal, and supplementary control, super imposed on the voltage control loop of a SVC can provide damping of system oscillation as discussed .In this paper, the SVC is basically represented by a variable reactance with maximum inductive and capacitive limits to control the SVC bus voltage, with an additional control block and signals to damp oscillations, as shown in Figure 10.
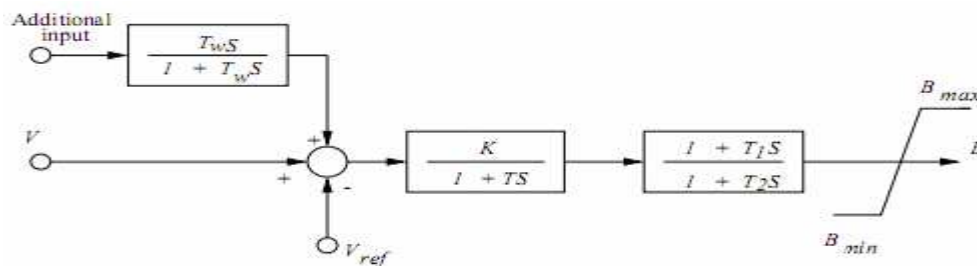


Figure 10: Structure of SVC controller with oscillation damping, where B is the equivalent shunts susceptance of the controller

The model considers SVC as shunt-connected variable susceptance, BSVC which is adapted automatically to achieve the voltage control. The equivalent susceptance, Beq is determined by the firing angle "of the thyristors that is defined as the delay angle measured from the peak of the capacitor voltage to the firing instant.The fundamental frequency equivalent neglecting harmonics of the current results [14].

$$B_{eq} = B_L(\alpha) + B_c \tag{1}$$

$$B_L(\alpha) = -\frac{1}{\omega L}\left(1 - \frac{2\alpha}{\pi} - \frac{\sin(2\alpha)}{\pi}\right), B_c = \omega C \text{ and } 0^0 \le \alpha \le 90^0 \tag{2}$$

If the real power consumed by the SVC is assumed to be zero, then:

$$P_{svc} = 0 \tag{3}$$

$$Q_{svc} = -B_{svc} * V^2 \tag{4}$$

That, "V" is the bus voltage magnitude

As the reactive power demand at the bus varies, the susceptance is varied subject to the limits. However, the reactive power is a function of the square of the bus voltage. Hence the reactive power generated decreases as the voltage decreases.

## 5.   CALCULATION OF THE HARMONIC POWER FLOW

A regular program for calculated the load flow was used to calculate the harmonic active and reactive power, currents and amplitudes and phases of nodal voltages. This program implements the Newton – Raphson[15] for calculating the system of equations that represent the balance of active and reactive nodal powers.

The process of compute the flow of harmonic power grid is as follows:

1. First, a load flow is calculated for a fundamental frequency. The nodal voltage magnitudes obtained are used to convert the power load admittances.

$$Y_{ia} - jY_{ir} = \frac{P_i}{V_i^2} - j\frac{Q_i}{V_i^2} \tag{5}$$

2. Then the admittances, load modeling, have been recalculated for the harmonic of order $h$

$$Y_{ia}^h - jY_{ir}^h = \frac{P_i}{V_i^2 \sqrt{h}} - j\frac{Q_i}{V_i^2 \sqrt{h}} \tag{6}$$

3. The impedance of the transformer for the harmonic of order $h$ is given like [10]

$$Z_{tf} = R_t\sqrt{h} + jX_t h \tag{7}$$

With $R_t$ and $X_t$ impedances of transformer at the fundamental frequency.

4. For the circuit $\pi$ equivalent of the line of transmission, its specific impedance for the harmonic of order h is calculated by the relation:

$$Z_0 = R_0 + jX_0 h = R_0 + j2\pi L_0 h \tag{8}$$

and the specific admittance by:

$$Y_0 = G_0 + jB_0 h = G_0 j2\pi C_0 h \tag{9}$$

The impedance $Z_e$ and admittance $Y_e$, of the circuit $\pi$ in a long line are determined as

$$Z_e = R_e + jX_e = real\ (Z_e) + j.imag\ (Z_e)$$
$$= Z_c\ sh\ (\gamma_0 l) = Z_c\left(\frac{e^{\gamma_0 l} - e^{-\gamma_0 l}}{2}\right) \tag{10}$$

Where $Z_c = \sqrt{\dfrac{Z_0}{Y_0}}$ is the impedance of the wave $\gamma_0 = \sqrt{Z_0 Y_0}$, is a factor of wave propagation and L the length of the line.

The data corrected on the parameters of the electrical supply elements of the network were transferred to the calculation program from flow from load.

## 6. SIMULATIONS WITH HPFCODE

### 6.1. Nomenclature

| Symbols | Description |
|---------|-------------|
| SVC | Static Var Componsator |
| TCR | Thyristor Controlled Reactor |
| UPFC | Unified Power Flow Control |
| $Y$ | The Admittance |
| $Y^h$ | The harmonic Admittance of order $h$ |
| $V_i$ | The voltage magnitudes of the node $i$ |
| $P_i$ | The Active Power of the node $i$ |
| $Q_i$ | The Reactive Power of the node $i$ |

## 6.2. The Network Systems of the Test
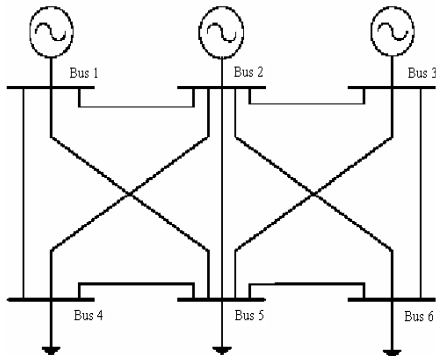


Figure 9. Network System 6 bus, 11Lines
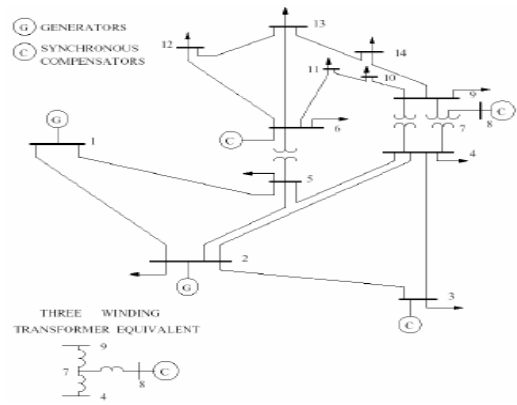


Figure 10. Network System 14 bus, 20 Lines

## 6.3. Power Flow (PFNormal)

6.3.1. Example1: Network System 6 bus, 11 Lines

Table 1. Power Flow of Nodes

| Newton Raphson Loadflow Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bus | V | Angle | Injection | | Generation | | Load | |
| No | pu | Degree | MW | MVar | MW | Mvar | MW | MVar |
| 1 | 1.0500 | 0.0000 | 1.427 | -48.609 | 1.427 | -48.609 | 0.000 | 0.000 |
| 2 | 1.0800 | -0.6399 | 0.500 | 4.926 | 0.500 | 4.926 | 0.000 | 0.000 |
| 3 | 1.0800 | -0.6270 | 0.600 | -13.289 | 0.600 | -13.289 | 0.000 | 0.000 |
| 4 | 1.0758 | -0.4899 | -0.700 | -0.700 | -0.000 | -0.000 | 0.700 | 0.700 |
| 5 | 1.0832 | -0.6745 | -0.700 | -0.700 | 0.000 | 0.000 | 0.700 | 0.700 |
| 6 | 1.0840 | -0.7046 | -0.700 | -0.700 | 0.000 | 0.000 | 0.700 | 0.700 |
| Total | | | 0.427 | -59.072 | 2.527 | -56.972 | 2.100 | 2.100 |

Table 2. Power flow and power losses in the lines

| Line FLow and Losses | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| From | To | P | Q | From | To | P | Q | Line Loss | |
| Bus | Bus | MW | MVar | Bus | Bus | MW | MVar | MW | MVar |
| 1 | 2 | -1.220 | -15.105 | 2 | 1 | 1.428 | 15.521 | 0.208 | 0.417 |
| 1 | 4 | 1.365 | -13.857 | 4 | 1 | -1.277 | 14.209 | 0.088 | 0.352 |
| 1 | 5 | 1.282 | -11.929 | 5 | 1 | -1.177 | 12.321 | 0.104 | 0.392 |
| 2 | 3 | -0.101 | 0.020 | 3 | 2 | 0.101 | -0.020 | 0.000 | 0.000 |
| 2 | 4 | -0.611 | 4.862 | 4 | 2 | 0.621 | -4.842 | 0.010 | 0.021 |
| 2 | 5 | -0.132 | -1.101 | 5 | 2 | 0.133 | 1.105 | 0.001 | 0.003 |
| 2 | 6 | -0.084 | -2.129 | 6 | 2 | 0.087 | 2.137 | 0.003 | 0.008 |
| 3 | 5 | -0.195 | -1.231 | 5 | 3 | 0.197 | 1.235 | 0.002 | 0.003 |
| 3 | 6 | 0.694 | -4.456 | 6 | 3 | -0.691 | 4.474 | 0.003 | 0.017 |
| 4 | 5 | -0.044 | -1.966 | 5 | 4 | 0.051 | 1.979 | 0.007 | 0.013 |
| 5 | 6 | 0.097 | -0.327 | 6 | 5 | -0.096 | 0.327 | 0.000 | 0.000 |
| Total Loss | | | | | | | | 0.427 | 1.226 |

### 6.3.2. Example 2: Network System 14 bus, 20 Lines

Table 3. Power Flow of Nodes

```
                    Newton Raphson  Loadflow Analysis
-------------------------------------------------------------------
|Bus|  V  |Angle  |  Injection   |   Generation   |    Load     |
|No |  pu |Degree |  MW  | MVar  |  MW  | Mvar   |  MW  | MVar  |
-------------------------------------------------------------------
 1  1.0600   0.0000  232.593  -15.233  232.593  -15.233   0.000   0.000
-------------------------------------------------------------------
 2  1.0450  -4.9891   18.300   35.228   40.000   47.928  21.700  12.700
-------------------------------------------------------------------
 3  1.0100 -12.7492  -94.200    8.758    0.000   27.758  94.200  19.000
-------------------------------------------------------------------
 4  1.0132 -10.2420  -47.800    3.900    0.000    0.000  47.800  -3.900
-------------------------------------------------------------------
 5  1.0166  -8.7601   -7.600   -1.600   -0.000   -0.000   7.600   1.600
-------------------------------------------------------------------
 6  1.0700 -14.4469  -11.200   15.526    0.000   23.026  11.200   7.500
-------------------------------------------------------------------
 7  1.0457 -13.2368    0.000    0.000    0.000    0.000   0.000   0.000
-------------------------------------------------------------------
 8  1.0800 -13.2368    0.000   21.030    0.000   21.030   0.000   0.000
-------------------------------------------------------------------
 9  1.0305 -14.8201  -29.500  -16.600   -0.000   -0.000  29.500  16.600
-------------------------------------------------------------------
10  1.0299 -15.0360   -9.000   -5.800   -0.000    0.000   9.000   5.800
-------------------------------------------------------------------
11  1.0461 -14.8581   -3.500   -1.800    0.000    0.000   3.500   1.800
-------------------------------------------------------------------
12  1.0533 -15.2973   -6.100   -1.600    0.000    0.000   6.100   1.600
-------------------------------------------------------------------
13  1.0466 -15.3313  -13.500   -5.800    0.000    0.000  13.500   5.800
-------------------------------------------------------------------
14  1.0193 -16.0717  -14.900   -5.000   -0.000    0.000  14.900   5.000
-------------------------------------------------------------------
Total                 13.593   31.009  272.593  104.509 259.000  73.500
-------------------------------------------------------------------
```

Table 4. Power flow and power losses in the lines

```
                        Line FLow and Losses
-------------------------------------------------------------------
|From |To |  P   |  Q   | From|To |  P    |   Q   |  Line Loss   |
|Bus |Bus|  MW  | MVar | Bus |Bus|  MW   | MVar  |   MW  | MVar |
-------------------------------------------------------------------
 1  2  157.080  -17.484   2   1  -152.772   30.639   4.309  13.155
-------------------------------------------------------------------
 1  5   75.513    7.981   5   1   -72.740    3.464   2.773  11.445
-------------------------------------------------------------------
 2  3   73.396    5.936   3   2   -71.063    3.894   2.333   9.830
-------------------------------------------------------------------
 2  4   55.943    2.935   4   2   -54.273    2.132   1.670   5.067
-------------------------------------------------------------------
 2  5   41.733    4.738   5   2   -40.813   -1.929   0.920   2.809
-------------------------------------------------------------------
 3  4  -23.137    7.752   4   3    23.528   -6.753   0.391   0.998
-------------------------------------------------------------------
 4  5  -59.585   11.574   5   4    60.064  -10.063   0.479   1.511
-------------------------------------------------------------------
 4  7   27.066  -15.396   7   4   -27.066   17.327   0.000   1.932
-------------------------------------------------------------------
 4  9   15.464   -2.640   9   4   -15.464    3.932   0.000   1.292
-------------------------------------------------------------------
 5  6   45.889  -20.843   6   5   -45.889   26.617   0.000   5.774
-------------------------------------------------------------------
 6 11    8.287    8.898  11   6    -8.165   -8.641   0.123   0.257
-------------------------------------------------------------------
 6 12    8.064    3.176  12   6    -7.984   -3.008   0.081   0.168
-------------------------------------------------------------------
 6 13   18.337    9.981  13   6   -18.085   -9.485   0.252   0.496
-------------------------------------------------------------------
 7  8   -0.000  -20.362   8   7     0.000   21.030   0.000   0.668
-------------------------------------------------------------------
 7  9   27.066   14.798   9   7   -27.066  -13.840   0.000   0.957
-------------------------------------------------------------------
 9 10    4.393   -0.904  10   9    -4.387    0.920   0.006   0.016
-------------------------------------------------------------------
 9 14    8.637    0.321  14   9    -8.547   -0.131   0.089   0.190
-------------------------------------------------------------------
10 11   -4.613   -6.720  11  10     4.665    6.841   0.051   0.120
-------------------------------------------------------------------
12 13    1.884    1.408  13  12    -1.873   -1.398   0.011   0.010
-------------------------------------------------------------------
13 14    6.458    5.083  14  13    -6.353   -4.869   0.105   0.215
-------------------------------------------------------------------
Total Loss                                          13.593  56.910
-------------------------------------------------------------------
```

## 6.4. Harmonic Power Flow (Pfharmonic)
6.4.1. Example1: Network System 6 bus, 11 Lines
*6.4.1.1. Our example is the SVC in nodes 5*

Table 5. Power Flow of Nodes

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Newton Raphson Loadflow Analysis | | | | | | | |
| Bus | V | Angle | Injection | | Generation | | Load |
| No | pu | Degree | MW | MVar | MW | Mvar | MW | MVar |
| 1 | 1.0500 | 0.0000 | 1.502 | -52.528 | 1.502 | -52.528 | 0.000 | 0.000 |
| 2 | 1.0800 | -0.6918 | 0.500 | 6.978 | 0.500 | 6.978 | 0.000 | 0.000 |
| 3 | 1.0800 | -0.6997 | 0.600 | -11.243 | 0.600 | -11.243 | 0.000 | 0.000 |
| 4 | 1.0755 | -0.5240 | -0.700 | -0.700 | -0.000 | -0.000 | 0.700 | 0.700 |
| 5 | 1.0795 | -0.6952 | -0.700 | -0.700 | -0.000 | -0.000 | 0.700 | 0.700 |
| 6 | 1.0835 | -0.7648 | -0.700 | -0.700 | 0.000 | -0.000 | 0.700 | 0.700 |
| Total | | | 0.502 | -58.894 | 2.602 | -56.794 | 2.100 | 2.100 |

Table 6. Power flow and power losses in the lines

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Line FLow and Losses | | | | | | | | | | |
| From | To | P | Q | From | To | P | Q | Line Loss | | |
| Bus | Bus | MW | MVar | Bus | Bus | MW | MVar | MW | MVar | |
| 1 | 2 | -0.807 | -15.305 | 2 | 1 | 1.020 | 15.732 | 0.213 | 0.426 | |
| 1 | 4 | 1.714 | -13.799 | 4 | 1 | -1.627 | 14.149 | 0.088 | 0.351 | |
| 1 | 5 | 0.594 | -15.707 | 5 | 1 | -0.415 | 16.155 | 0.179 | 0.448 | |
| 2 | 3 | 0.062 | -0.012 | 3 | 2 | -0.062 | 0.012 | 0.000 | 0.000 | |
| 2 | 4 | -0.781 | 5.243 | 4 | 2 | 0.793 | -5.219 | 0.012 | 0.024 | |
| 2 | 5 | 0.126 | 0.183 | 5 | 2 | -0.126 | -0.183 | 0.000 | 0.000 | |
| 2 | 6 | 0.073 | -1.919 | 6 | 2 | -0.071 | 1.926 | 0.002 | 0.006 | |
| 3 | 5 | 0.111 | 0.224 | 5 | 3 | -0.111 | -0.224 | 0.000 | 0.000 | |
| 3 | 6 | 0.550 | -3.898 | 6 | 3 | -0.547 | 3.911 | 0.003 | 0.013 | |
| 4 | 5 | 0.134 | -1.534 | 5 | 4 | -0.130 | 1.540 | 0.004 | 0.006 | |
| 5 | 6 | 0.082 | -1.090 | 6 | 5 | -0.081 | 1.094 | 0.001 | 0.004 | |
| Total Loss | | | | | | | | 0.502 | 1.279 | |

6.4.2.    Example 2: Network System 14 bus, 20 Lines
*6.4.2.1. Our example is the SVC in nodes 7*

Table 7. Power Flow of Nodes

### Newton Raphson Loadflow Analysis

| Bus No | V pu | Angle Degree | Injection MW | MVar | Generation MW | Mvar | Load MW | MVar |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.0600 | 0.0000 | 232.596 | -17.825 | 232.596 | -17.825 | 0.000 | 0.000 |
| 2 | 1.0450 | -4.9814 | 18.300 | 27.702 | 40.000 | 40.402 | 21.700 | 12.700 |
| 3 | 1.0100 | -12.7104 | -94.200 | 4.497 | -0.000 | 23.497 | 94.200 | 19.000 |
| 4 | 1.0203 | -10.3508 | -47.800 | 3.900 | 0.000 | 0.000 | 47.800 | -3.900 |
| 5 | 1.0222 | -8.8158 | -7.600 | -1.600 | 0.000 | 0.000 | 7.600 | 1.600 |
| 6 | 1.0800 | -14.2033 | -11.200 | -10.702 | 0.000 | -3.202 | 11.200 | 7.500 |
| 7 | 1.0670 | -13.3825 | -0.000 | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 |
| 8 | 1.0900 | -13.3825 | 0.000 | 14.211 | 0.000 | 14.211 | 0.000 | 0.000 |
| 9 | 1.0664 | -14.9423 | -29.500 | -16.600 | 0.000 | -0.000 | 29.500 | 16.600 |
| 10 | 1.0614 | -15.0920 | -9.000 | -5.800 | -0.000 | -0.000 | 9.000 | 5.800 |
| 11 | 1.0671 | -14.7772 | -3.500 | -1.800 | 0.000 | 0.000 | 3.500 | 1.800 |
| 12 | 1.0750 | -15.1924 | -6.100 | -1.600 | 0.000 | 0.000 | 6.100 | 1.600 |
| 13 | 1.0785 | -15.6254 | -13.500 | -5.800 | -0.000 | -0.000 | 13.500 | 5.800 |
| 14 | 1.0872 | -17.0226 | -14.900 | -5.000 | 0.000 | 0.000 | 14.900 | 5.000 |
| Total | | | 13.596 | -16.417 | 272.596 | 57.083 | 259.000 | 73.500 |

Table 8. Power flow and power losses in the lines

### Line FLow and Losses

| From Bus | To Bus | P MW | Q MVar | From Bus | To Bus | P MW | Q MVar | Line Loss MW | MVar |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 156.848 | -17.430 | 2 | 1 | -152.552 | 30.545 | 4.296 | 13.115 |
| 1 | 5 | 75.748 | 5.335 | 5 | 1 | -72.975 | 6.112 | 2.773 | 11.446 |
| 2 | 3 | 73.116 | 5.964 | 3 | 2 | -70.800 | 3.792 | 2.316 | 9.756 |
| 2 | 4 | 56.181 | -1.229 | 4 | 2 | -54.501 | 6.327 | 1.680 | 5.099 |
| 2 | 5 | 41.556 | 1.442 | 5 | 2 | -40.654 | 1.311 | 0.902 | 2.753 |
| 3 | 4 | -23.400 | 3.591 | 4 | 3 | 23.768 | -2.652 | 68 | 0.940 |
| 4 | 5 | -61.383 | 15.666 | 5 | 4 | 61.897 | -14.043 | 0.515 | 1.623 |
| 4 | 7 | 28.154 | -22.565 | 7 | 4 | -28.154 | 25.123 | -0.000 | 2.558 |
| 4 | 9 | 16.161 | -8.070 | 9 | 4 | -16.161 | 9.760 | 0.000 | 1.689 |
| 5 | 6 | 44.132 | -23.061 | 6 | 5 | -44.132 | 28.634 | 0.000 | 5.573 |
| 6 | 11 | 7.451 | 3.450 | 11 | 6 | -7.396 | -3.335 | 0.055 | 0.115 |
| 6 | 12 | 7.214 | -1.292 | 12 | 6 | -7.157 | 1.409 | 0.057 | 0.118 |
| 6 | 13 | 18.267 | -7.726 | 13 | 6 | -18.044 | 8.165 | 0.223 | 0.439 |
| 7 | 8 | -0.000 | -13.912 | 8 | 7 | 0.000 | 14.211 | 0.000 | 0.299 |
| 7 | 9 | 28.154 | 1.037 | 9 | 7 | -28.154 | -0.270 | 0.000 | 0.767 |
| 9 | 10 | 5.129 | 4.328 | 10 | 9 | -5.116 | -4.295 | 0.013 | 0.033 |
| 9 | 14 | 9.686 | -12.506 | 14 | 9 | -9.40 | 13.101 | 0.280 | 0.595 |
| 10 | 11 | -3.884 | -1.505 | 11 | 10 | 3.896 | 1.535 | 0.013 | 0.030 |
| 12 | 13 | 1.057 | -3.009 | 13 | 12 | -1.038 | 3.027 | 0.019 | 0.018 |
| 13 | 14 | 5.582 | -5.362 | 14 | 13 | -5.494 | 5.541 | 0.088 | 0.179 |
| Total Loss | | | | | | | | 13.596 | 56.930 |

## 7. RESULTS AND ANALYSIS

We observe that for Example 1 where the network system IEEE 6 nodes in normal case ( no non-linear loads ), and after calculated the power flow in nodes and lines by the Newton- Raphson we obtain a value of 0.427MW for Power Losses in the lines, and a value of 1,226 MVar for losses of reactive power by cons if you place a SVC in the node 5, the losses of active power increases a range of 7.5 % and reactive power losses increase by a range of 5.3 % due to harmonic currents generated by the SVC.

For example 2 where the system of networks IEEE 14 Nodes, in normal case (not of nonlinear loads), and after the calculation of the flow of power in the nodes and the lines by the method Newton-Raphson one obtains a value of 13.593 MW for the losses of active power in the lines, and a value of 56.910 MVar for the losses of power reactivates, on the other hand if one places a SVC in the node 7, the losses of active power increase by a range of 0.3%, and the losses of reactive power increase by a range of 2.0%, due to the harmonic currents generate by the SVC. Depending on the location of the SVC in network systems have been studied. The results are acceptable when compared with the work [16, 17].

## 8. CONCLUSION

The HPFCODE program is called «Harmonics Power Flow CODE ", developed in MATLAB environment has been tested on several nonlinear loads such as: SVC, TCR, UPFC, and gaves entire satisfaction for the simulations performed confirming the relevance of this code. The results were almost consistent and show the influence of higher harmonics on power losses in electrical networks. And we have confirmed the possibility to analyze other nonlinear loads with this computer code HPFCODE generating harmonics in power systems.

On the basis of different nonlinear loads simulated on a number of different networks (IEEE 14nodes, IEEE 6nodes), which we consider fairly representative to validate our computer code, we can conclude that the computer code HPFCODE gives better results and can admit the improved graphical interface of this code, reducing the number of windows that are modifying it to simplify its use. Through the HPFCODE code, we can calculate the power flow of a power system with linear loads or with a nonlinear load any (SVC TCR, UPFC……), by the choice of a preferred network and the nonlinear load which we prefer, and running the program.

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## BIOGRAPHIES OF AUTHORS

Aissa Souli, Researcher in Nuclear Research Center of Birine, PHD Student in Power System, Laghouat University- Algeria, e-mail:souliaissa@yahoo.fr

Profesor  Abdelhafid Hellal, LACoSERE Laboratory, Electrical engineering Department, Laghouat University- Algeria, e-mail: a.hellal@mail.lagh-univ.dz