



## **Tutorial**

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# Welcome to the Harmonee Harmonics Calculation Software Tutorial!

## Introduction

Harmonics is noise or distortion induced onto the utility by some equipment sharing the same utility. It can cause equipment to fail, or worse yet, damage equipment. All 6 pulse drives inherently create or cause harmonics - so the solution to deal with it is to minimize harmonics, not eliminate it.

Siemens SED2 Variable Frequency Drives are designed specifically for the HVAC market. These drives have been designed for limited overload capabilities, do not allow operation of the motor above base speed, and most importantly, provide a new method of reducing the input line harmonic currents without the addition of extra components.

Harmonee™, the Harmonics Analysis tool is a software program that evaluates and calculates harmonics (THD) in a facility. It also demonstrates the projected harmonics spectrum, showing the primary fundamentals and their respective values against IEEE519 standards tolerances.

### Why was Harmonee developed?

Engineers write specifications that state: "VFD supplier must supply harmonic calculations based on facility specific data". This tool allows that. It was developed for job bids and projects that require a full **harmonics analysis** of a facility. In plan and spec work, this type of statement is the norm. It is usually the electrical contractor or specifying engineer that supplies the required transformer information.

Harmonee also provides the ability to run **comparative data** that measures our SED2 drive harmonics results against other typical 6 pulse drives and how they both measure up to IEEE519 standards. From a promotional and marketing aspect, this is powerful information, as our SED2 drives outperforms all other 6-pulse drives.

Harmonee is a prediction tool--- NOT a solution tool. It is the facility design engineer's job to determine the level that is acceptable. We put the ability to compare the SED2 drive against standard 6-pulse drives as an aside (sales value) -- "look how much worse "X-Manufacturer" would be".

Solutions can be wide ranging, complex and . . . extremely expensive. Sometimes they can even be more cost than the drives that cause them. Harmonee lets the engineer determine, based on his application, electrical system, sensitivity of other equipment if he needs or wants to reduce the levels.

## Step-by-Step Through the Analysis

1. Load and install Harmonice on your computer.
2. Reboot your computer and open the program.
3. The main menu and interface will appear – you'll notice the simplicity of the interface.
  - a. A **Drive Configuration** and **System Configuration** tab for data entry are on the left. (See Figure 1) System Configuration defaults as the active tab.

The screenshot displays the 'Configuration Data' window for SIEMENS HARMONEE. The window title is 'Configuration Data' and the menu bar includes 'File', 'Calculate Harmonics', 'Print Data', 'Help and Information', and 'Exit Program'. The main title is 'SIEMENS HARMONEE Harmonic Calculation for SED2 Drives'. On the left, there are two tabs: 'Drive Configuration' and 'System Configuration', both of which are circled in red. The 'System Configuration' tab is active and contains the following sections:

- Harmonic Standard:** Radio buttons for IEEE 519 (selected), UK G5/4, and IEC (AS/NZS) 61000-3-6.
- Source Data:** A table with fields for Typical Fault Capacity @ Bus 1 (10 MVA), System Frequency (60 Hz selected, 50 Hz), Power Units (Hp selected, kW), and Source Demand Current I<sub>d</sub> at Bus 1 (0.0 Amps).
- Source Transformer T1:** A table with fields for Transformer T1 KVA (0), Transformer T1 Primary KV (0), Transformer T1 Sec Volts (0), and Transformer T1 % Impedance (0).
- Other Loads at Bus 2 (Not Drives):** Radio buttons for Default (selected) and Custom.

On the right, a 'Single Line Diagram' shows a power source connected to Bus 1 (0.00 kV) through 'System Impedance'. A transformer T1 (0 kVA) connects Bus 1 to Bus 2 (0 Volts). Bus 2 is connected to a '6 Pulse AC Drive' (0.0 Hp) and 'Other Loads 2' (0 Hp).

Figure 1 -- Main Menu

- On the right is a **Single Line Diagram** of the electrical system. Once you input the system variables, this data is inserted and displayed into the system diagram. (See Figure 2)

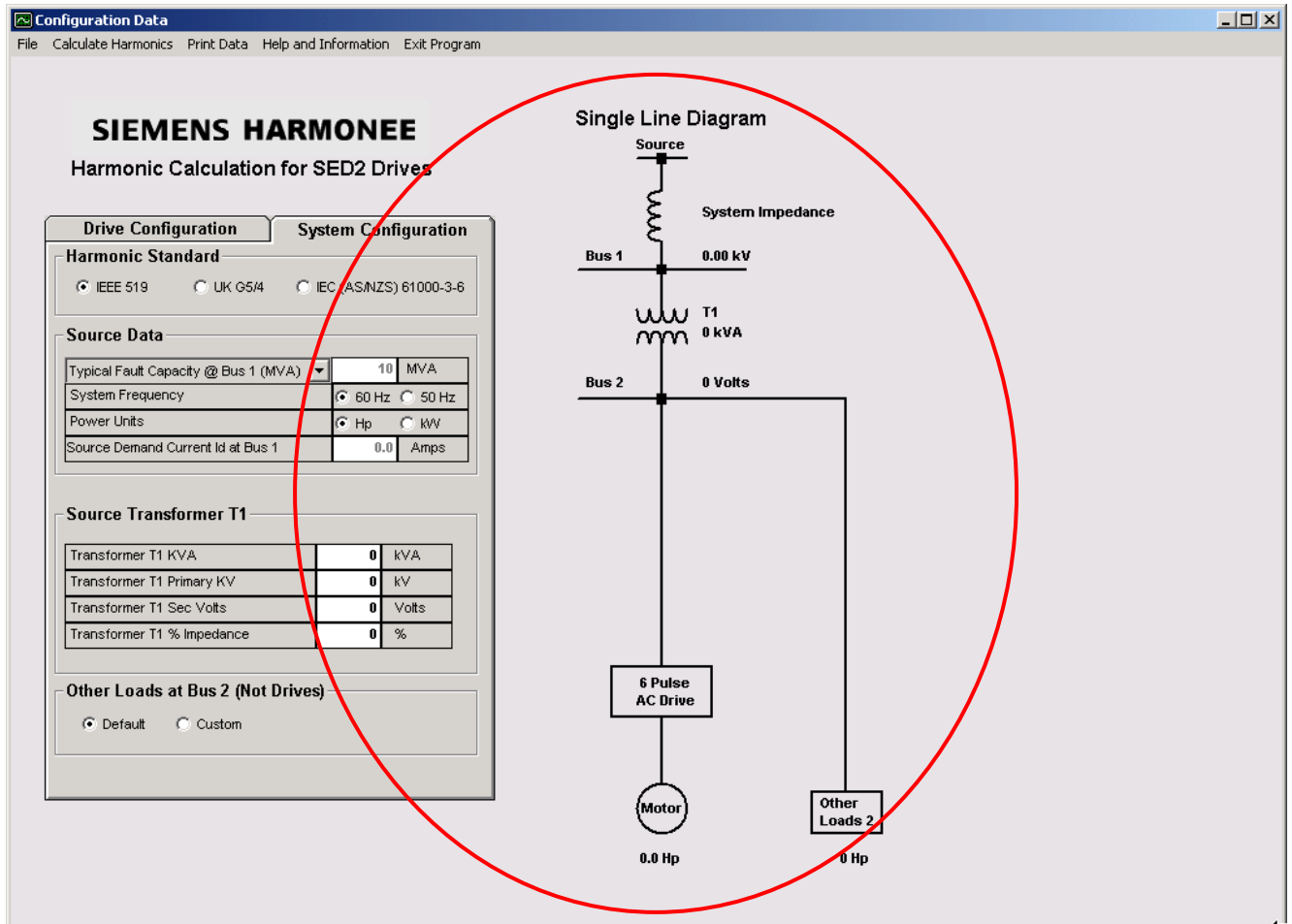


Figure 2 -- Single Line Diagram

- Up top, there is a tool bar menu. **File, Calculate Harmonics, Print Data, Help and Information.** Click on **Step-by-Step Instructions** and they will appear along side the Single Line Diagram to assist and direct you when inputting data and system variables from the job site. (See Figure 3)

**Click Help and Information for Step-by-Step Instructions**

**SIEMENS**

**Basic Step by Step Directions System Configuration Tab**

- Click the "System Configuration" tab
- Determine the Standard / Regulation you wish to show comparisons: e.g. IEEE 519, G5/4, or IEC (AS/NZS) 61000-3-6.
- Input "Source Data"
- Input "Source Transformer T1" information
- If applicable, add "Other Loads at Bus 2"

**Drive Configuration Tab**

- Click the "Drive Configuration" tab
- Input "Customer Name"
- Input "SED2 Drive Configuration" information, if required
- Click the "Drive Selection" button
- Input number of drives to be included in the calculation
- Click "Continue"
- Click "Calculate Harmonics" and follow the pages through to determine the results.

Figure 3 -- Help and Info, Step-by-Step Instructions Link

- The **Help File** section provides you with a detailed description of each and every line item and options on the System Configurations tab.
- Also within this important menu item is a **Harmonics Information** section (see Figure 4). This section covers key IEEE519 standard definitions and explanations (somewhat like a glossary of key terms). For example, Point of Common Coupling, in laymen terms is where a utility connects or meets up with the outside world, which is the key area of concern for IEEE519 standards.

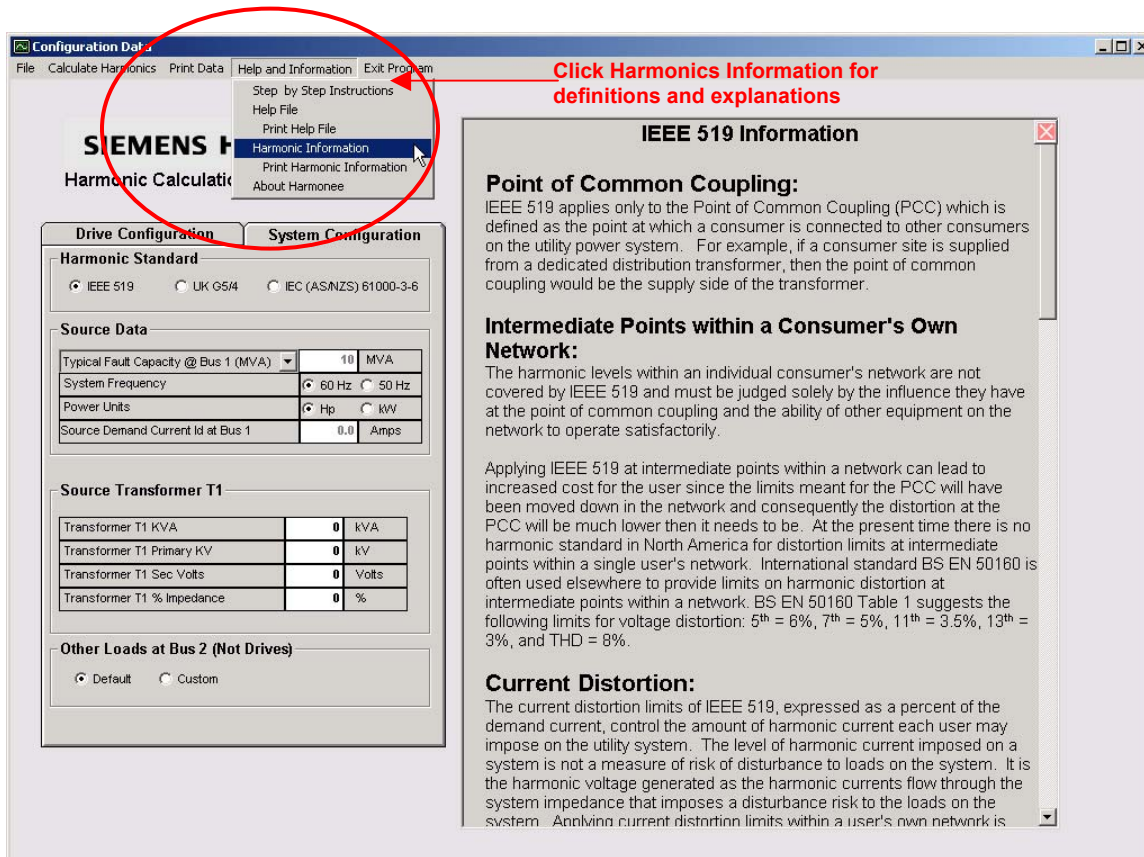


Figure 4 -- Help and Info, Harmonics Information Link

8. Now you are ready to input electrical system data. The software defaults to the **System Configuration** tab for important electrical system information. The System Configuration tab has 4 main sections: **Harmonics Standard**, **Source Data**, **Source Transformer T1** and **Other Loads at Bus 2 (Not Drives)**. All of these sections except for Source Transformer T1 offer default settings that you will usually work from. (See Figure 5)

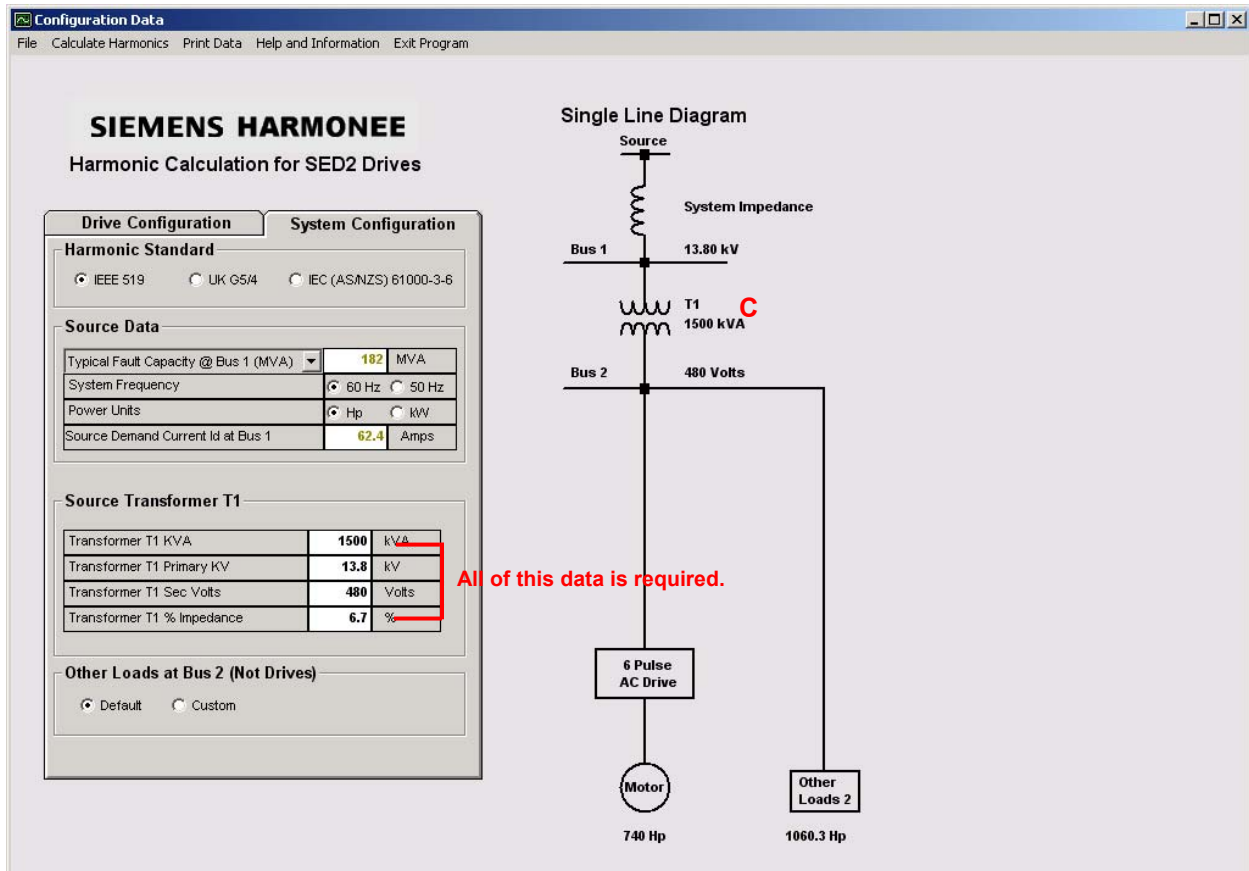


Figure 5 -- System Configuration Tab

- A. **Harmonics Standard** - The default setting is IEEE519 which is the standard for North America, but since this tool was developed for global use, there are also standards options for Europe (UK G5/4) and Asia-Pacific (IEC (AS/NZS) 61000-3-6).
- B. **Source Data** - Here again, most data is preset for North American usage, basing the system on 60Hz frequency and power units in HP, however it also offers options for Europe and Asia-Pacific usage as well.
- The Typical Fault Capacity @ Bus 1 (MVA) offers a pull down menu option. You can either let Harmonee calculate typical faulty capacity based upon the transformer info you input in Source Transformer T1 section below, or select and enter the specific Typical Fault Capacity @ bus1 Amps, KA or MVA information if you have it available.
- C. **Source Transformer T1** - You'll notice here this section requires specific job site data. This can only be obtained from your customer. To run a harmonics analysis, you need to enter the electric data available off the main distribution transformer of the facility. Specific data required is KVA, Primary KV, Secondary Voltage and % Impedance.
- D. **Other Loads at Bus 2 (Not Drives)** - The program is set to a default setting, assuming the transformer is fully loaded. It also offers a custom option, requiring additional HP information for other loads. Typically, you will be working off the default setting.
9. Now click the **Drive Configuration Tab** to enter specific drives data. The first section contains three check boxes. You will have to specify whether or not a drive isolation transformer or line reactor is

required for the system and if you want to compare the results against other 6 pulse drives. (See Figure 6)

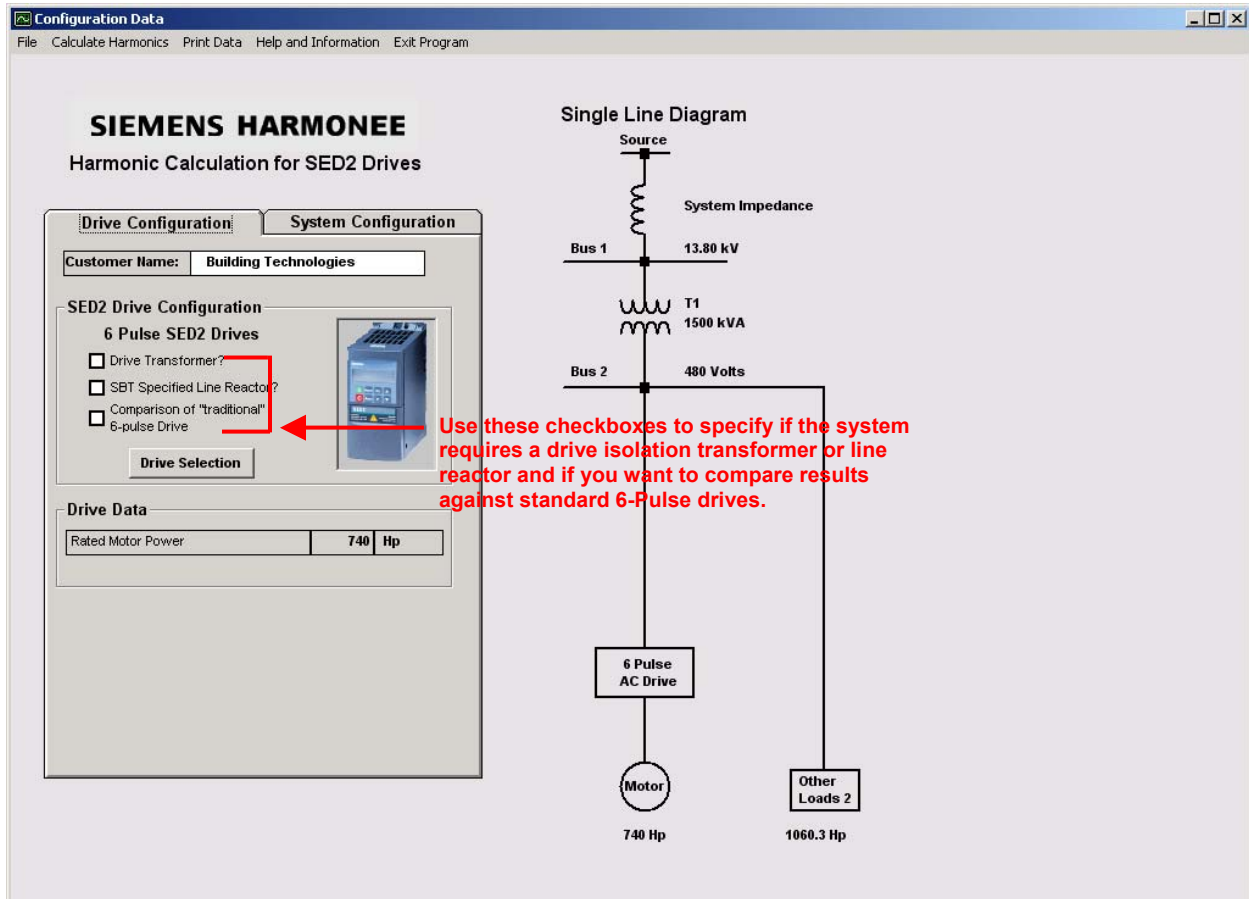


Figure 6 -- Drive Configuration Tab

- In the past, isolation transformers were commonly specified to supply ground fault protection and to add line impedance. Most drives today have built in ground fault protection and the isolation transformer is not required to supply this function. Additionally, a line reactor will add required line impedance at a fraction of the cost of an isolation transformer.
- a. If you specify a **Drive Transformer**, you will have to enter rated kVA, secondary voltage and % impedance. Other Loads at Bus 3 will have default to **None**, but will also offer **Default** and **Custom** as well. Checking "Custom" will require additional load info. (See Figure 7)

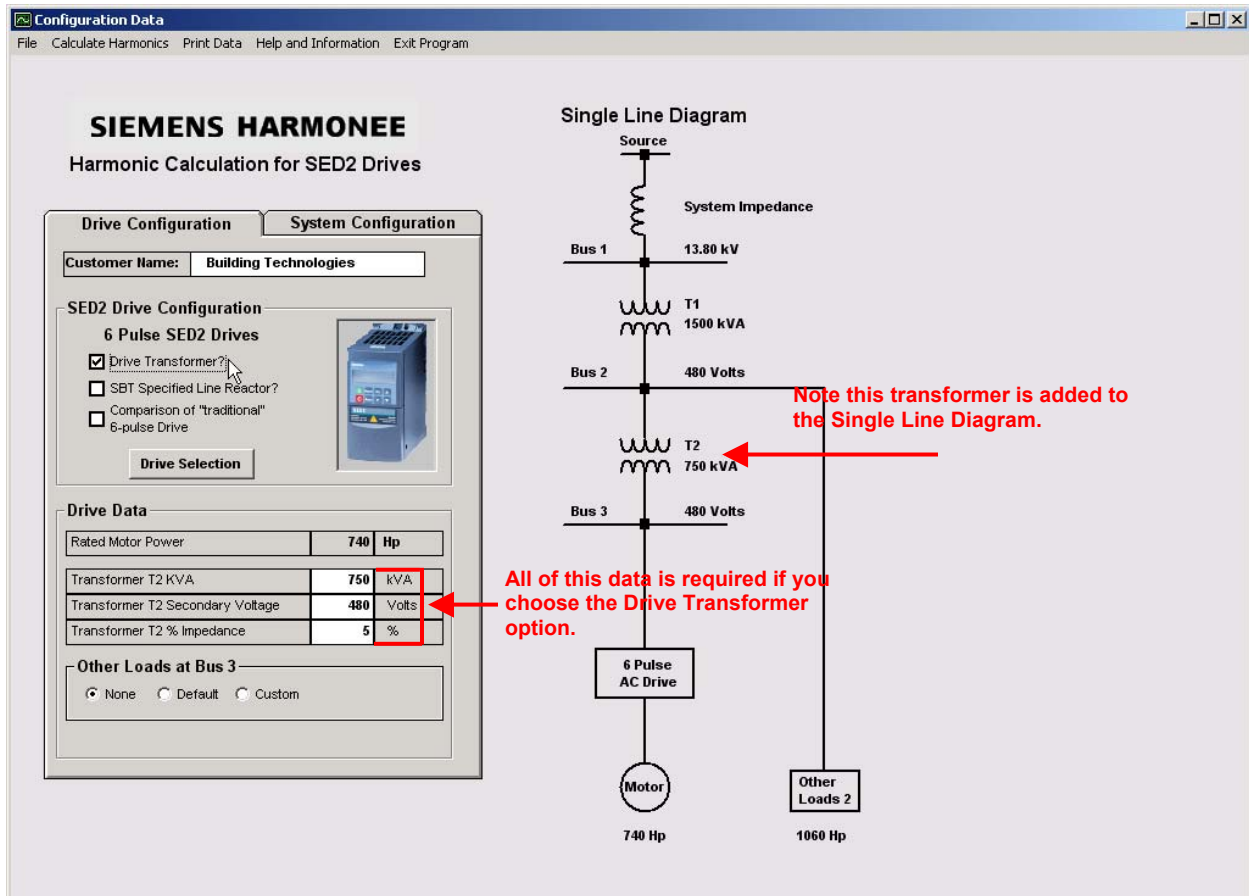


Figure 7 -- Drive Transformer Option

10. The **SBT Specified Line Reactor** check box will insert an SBT specified line reactor into the equation and onto the system diagram, but will require no additional information beyond that. (See Figure 8)
  - a. The **Drive Data** will calculate and show the rate horsepower based upon the drives selected.  
**Note:** system configuration tab data must be filled out first.

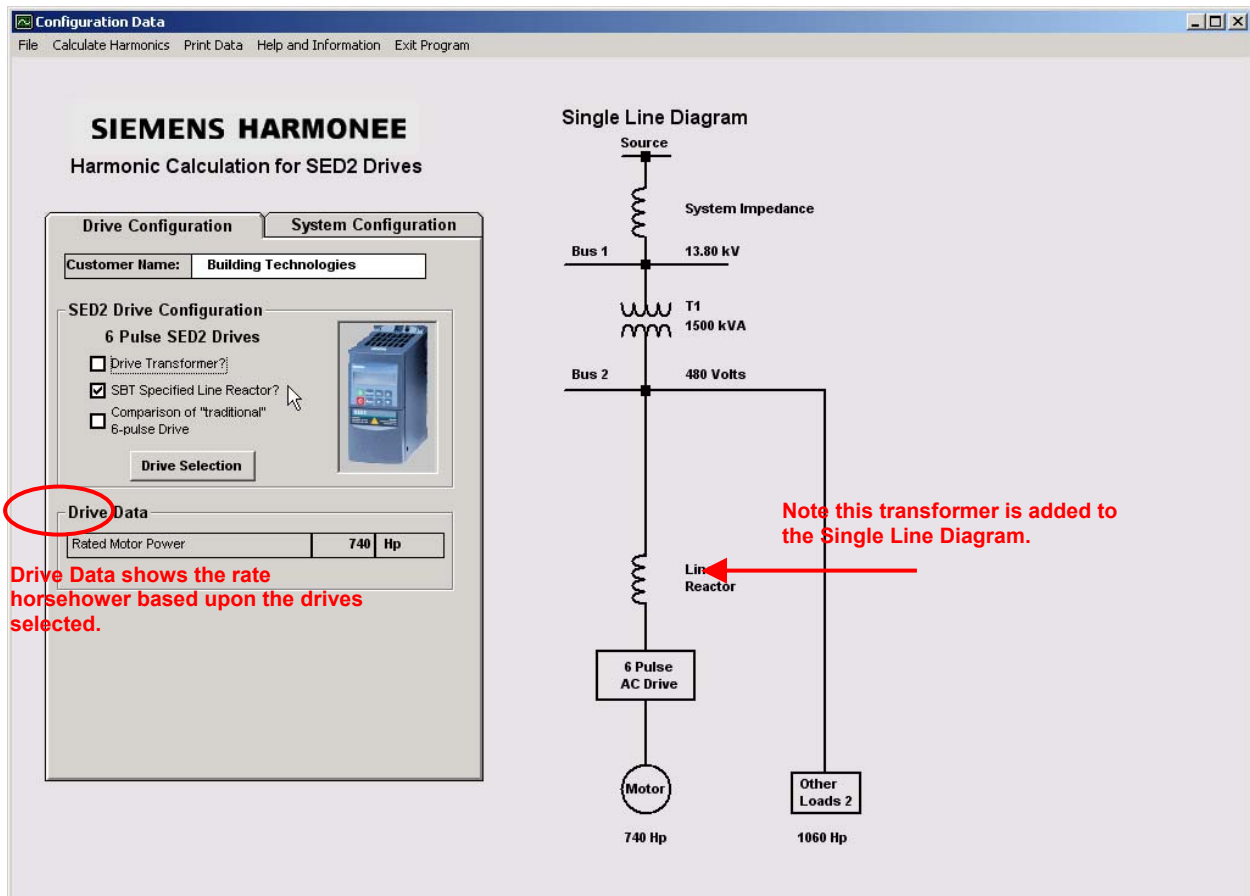


Figure 8 -- SBT Specified Line Reactor Option

- Once you check the appropriate boxes and enter the data on the Drives configuration tab, click on the **"Drive Selection"** button just below the three check boxes. Here you select the number of drives required at the appropriate HP/Kw ratings that are connected to AC source. (See Figure 9) Click **Continue** and it will return you to the Drives Configuration page to enter more data or run your harmonics analysis.

Drive Selection (380 V - 480 V) X

Clear All Drives   Print Data   Exit Program

## SIEMENS HARMONEE

**380 Volt - 480 Volt  
SED2 Drives**

Rating		Number of Drives	Rating		Number of Drives
HP	Kw		HP	Kw	
0.5	0.37	0	15	11	0
0.75	0.55	0	20	15	8
1	0.75	0	25	18.5	0
1.5	1.1	0	30	22	0
2	1.5	0	40	30	0
3	2.2	0	50	37	0
4	3	0	60	45	0
5	4	16	75	55	0
7.5	5.5	0	100	75	5
10	7.5	0	125	90	0

Fill in the number of drives connected to the AC Source and then press "Continue".

Fill in the number of drives connected to the AC Source and then press "Continue".

**Figure 9 -- Drive Selection**

- a. Once you have selected all desired options, you are ready to run your analysis. Click the **Calculate Harmonics** button in the top navigation to view your results. (See Figure 10)

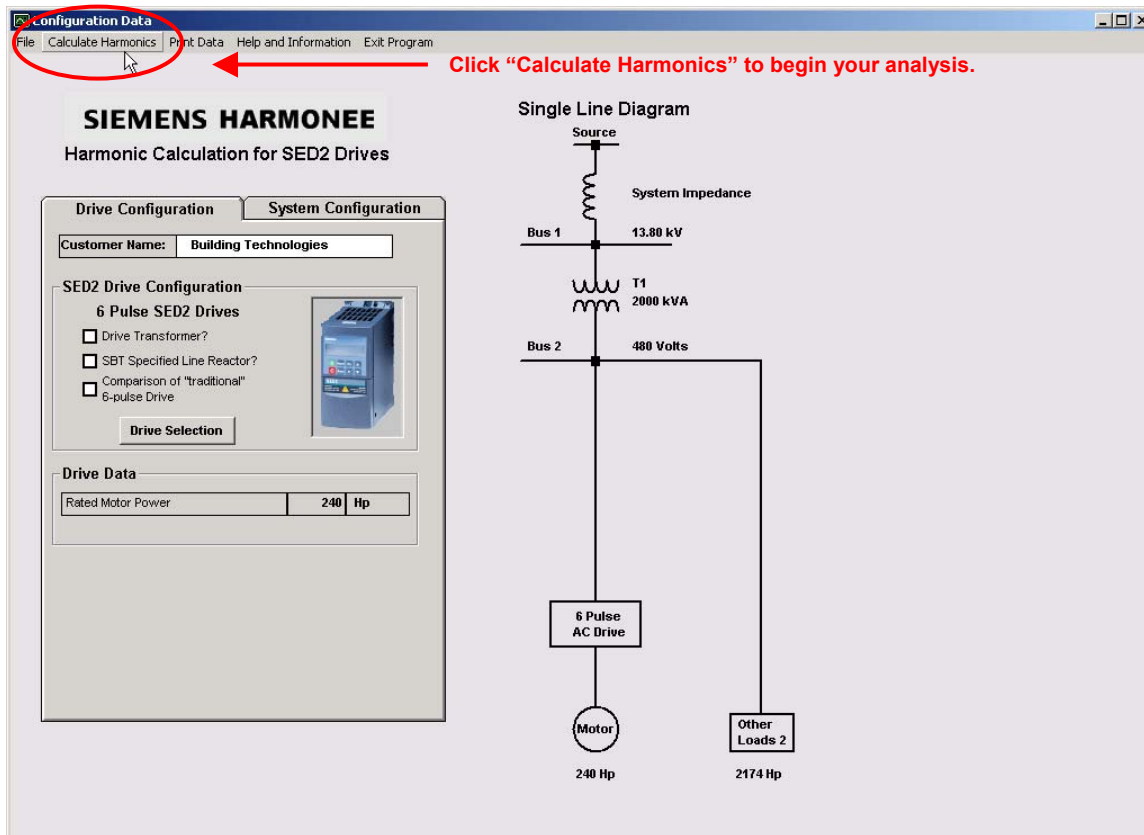


Figure 10 -- Calculate Harmonics Button

12. The **Calculate Harmonics** button will bring you to a screen that looks like Figure 11.

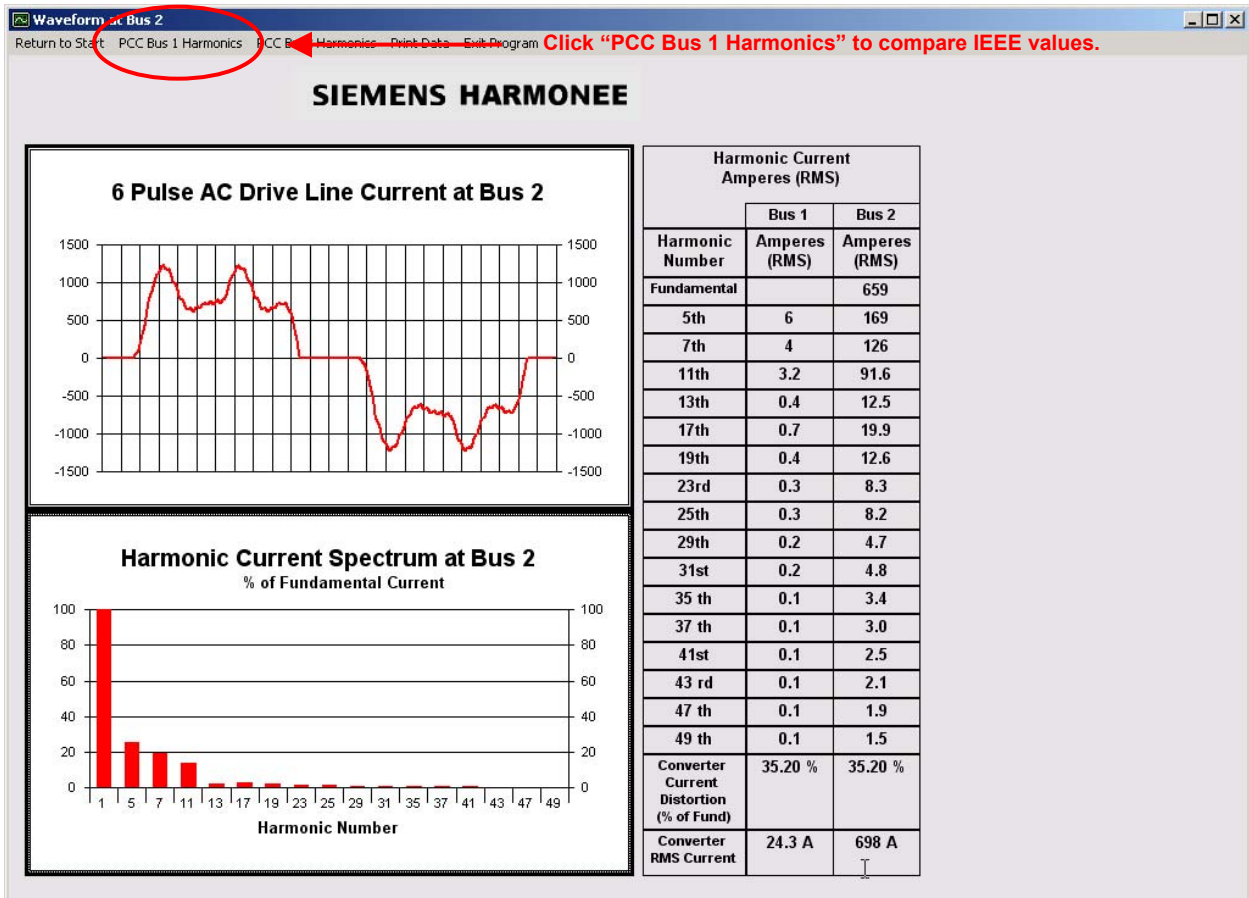


Figure 11 -- Calculate Harmonics Results

- a. Click the **PCC Bus 1 Harmonics** button to compare SBT IEEE values. (See Figure 11). Figure 12 below shows what the results will look like.

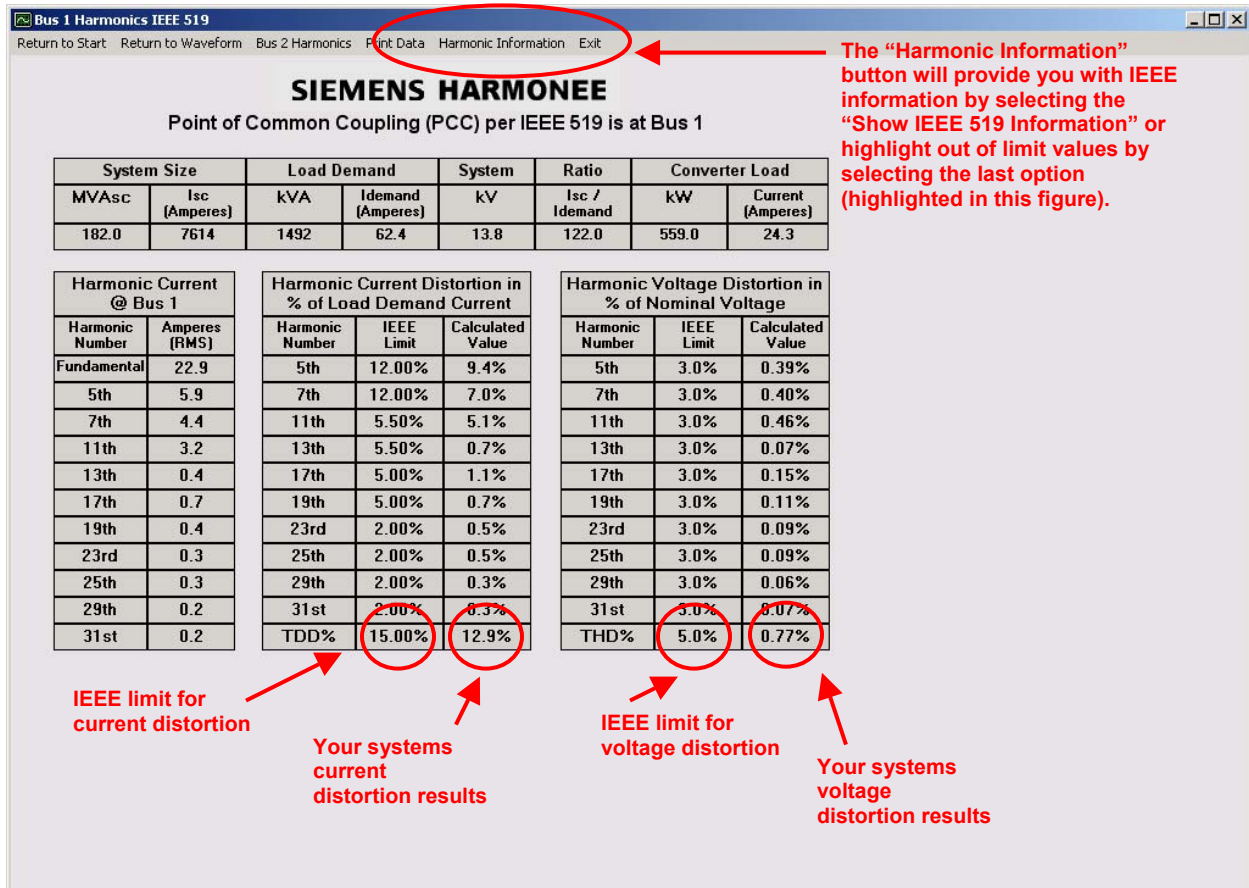


Figure 12 -- SBT Drive Results from Clicking “PCC Bus 1 Harmonics”

- At this point, you may select the **Harmonic Information** button for IEEE information, to print IEEE information or to highlight any out of limit values in the calculation. (See above Figure 12) Notice that because the above result shows that our system’s current distortion result is 12.9%, this system configuration meets IEEE guidelines.

## Harmonic Comparison

- a. An additional function is available in the Harmonee software that allows you to do a harmonics comparison of the Siemens SED2 VFD with other standard 6-pulse drives. To do this, select the **Comparison of “Traditional” 6-Pulse Drive** checkbox on the Drives Configuration Tab. In our following example, we did not change any system configuration values. We simply checked the “Comparison” box. (See Figure 13)

The screenshot displays the 'SIEMENS HARMONEE' software interface. The main window is titled 'Configuration Data' and contains a menu bar with 'File', 'Calculate Harmonics', 'Print Data', 'Help and Information', and 'Exit Program'. The main content area is divided into two tabs: 'Drive Configuration' and 'System Configuration'. The 'Drive Configuration' tab is active and shows the following settings:

- Customer Name: Building Technologies
- SED2 Drive Configuration: 6 Pulse SED2 Drives
- Drive Transformer?
- SBT Specified Line Reactor?
- Comparison of "traditional" 6-pulse Drive...  (indicated by a red arrow)
- Drive Selection button
- Drive Data: Rated Motor Power 740 Hp

To the right of the configuration panel is a 'Single Line Diagram'. It shows a 'Source' connected to 'Bus 1' (13.80 kV) through 'System Impedance'. A transformer 'T1' (1500 kVA) connects 'Bus 1' to 'Bus 2' (480 Volts). From 'Bus 2', the circuit splits into two paths: one leading to a '6 Pulse AC Drive' connected to a 'Motor' (740 Hp), and another leading to 'Other Loads 2' (1060 Hp).

A red arrow points from the text 'Select the Comparison checkbox to compare Siemens SED2 drives to other drives.' to the 'Comparison of "traditional" 6-pulse Drive...' checkbox in the software interface.

Figure 13 – Drive Comparison Option

18. Then click **Calculate Harmonics** to view results like below (see Figure 14) for a standard drive.

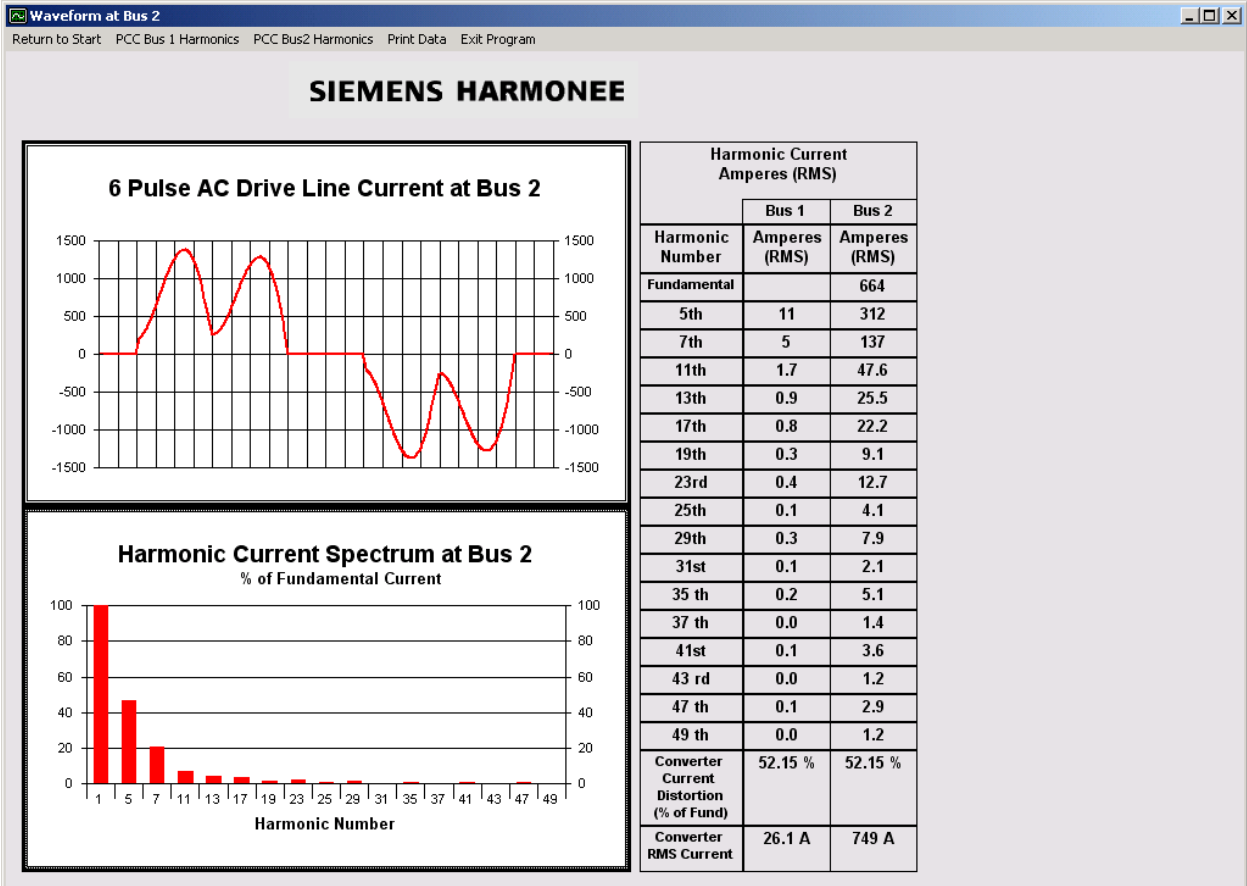


Figure 14 – Traditional Drive Results



b. You can also click the **Harmonic Information** button to view the **Out of Limit** values (Figure 15).

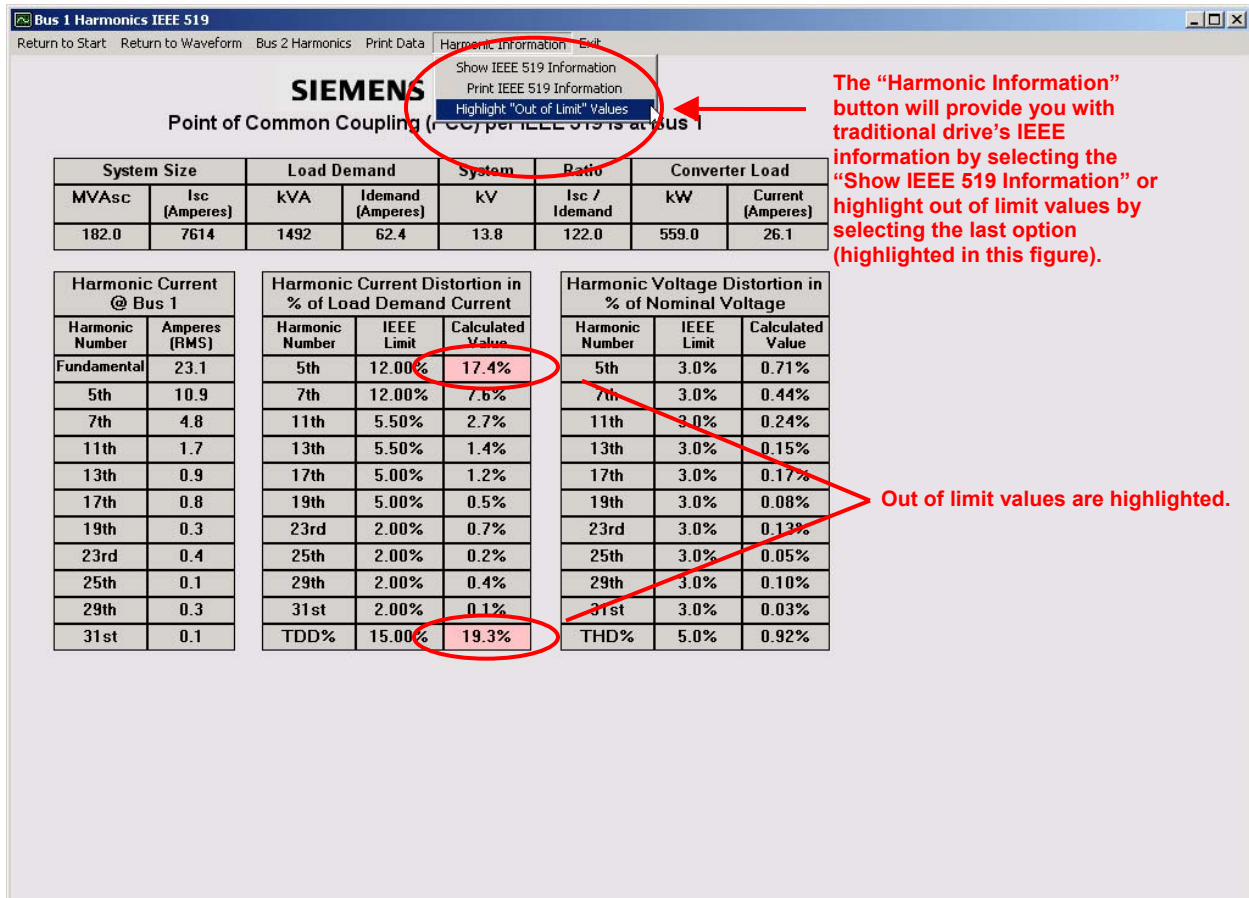


Figure 15 -- Out of Limit Values for Traditional Drives

This example shows the advantage of the SED2 VFD as compared to standard six-pulse drives. In the example, the SED2 waveform (see Figure 11) more closely resembles the ideal square waveform than that of a standard 6-pulse drive as shown in Figure 14. The SED2 waveform does not have a large valley generated by a traditional drive. The SED2 waveform is then shown numerically, as represented by the harmonic orders, to comply with IEEE levels. The same system set up, operating with conventional six-pulse drives, shows that the installation would exceed IEEE limits. The results are clear – the SED2 has superior harmonic performance vs. comparable products.

## Interpreting Your Results

As we said in the beginning, Harmonee is a prediction tool--- NOT a solution tool. IEEE519-1992 is the generally accepted guideline for determining satisfactory harmonic levels. Levels higher or lower than IEEE listed values are not a guarantee for success or failure of equipment when subjected to harmonic distortion. Harmonee™ allows for analysis of these harmonic levels and provides the data necessary to create solutions.

The best person to accurately interpret the results produced by Harmonee is a facility electrical engineer who has a full understanding of the system in question. He/she should know the full capabilities of the system and of all its installed equipment.

Following are some typical solutions to use when you have **higher than expected** or **allowed harmonic levels**:

- Install line reactors
- Electrically split up the drive loads
- Add an additional transformer for the drive loads
- Increase the size of the presently specified transformer
- Install a harmonic trap filter tuned to the 5<sup>th</sup> and 7<sup>th</sup> harmonics (these are the prominent harmonics produced by a 6-pulse drive)
- Install other harmonic reduction equipment as required to meet requirements
- Remove the use of drives on systems that will be operating a great deal at higher speeds (possibly substitute soft starters)
- Electrically remove or isolate harmonically sensitive equipment from the drives circuit

You've reached the end of the tutorial – we hope you found this to be a useful guide in using Harmonee and in interpreting the results from the tool.

For more information on Harmonics and SED2 Variable Frequency Drives, visit [www.sbt.siemens.com/hvp/drives](http://www.sbt.siemens.com/hvp/drives).