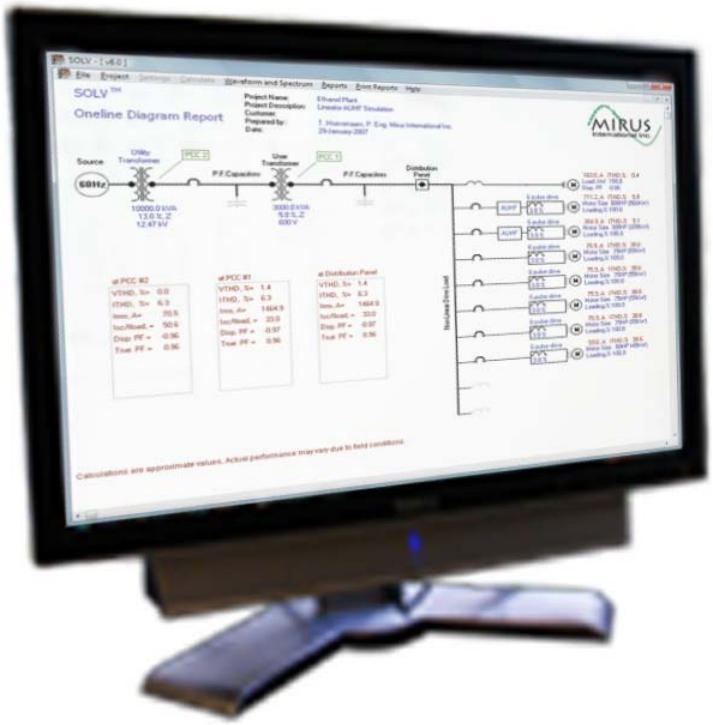
SOLV™

Harmonic Analysis Software



User Guide

MIRUS International Inc.

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Revision History

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Revision: A0	New Release	2011/12/13

1. Table of Contents

2. Introduction to SOLV™

SOLV™ is a powerful and unique computer simulation program that will calculate current and voltage distortion levels based on your load requirements. This complimentary software is a valuable tool for consulting and specifying engineers, utility operators and OEMs who need to evaluate and compare solutions for treating harmonics in VFD applications. Using SOLV™ allows your organization to forgo the costly and lengthy physical testing of harmonic distortion in your particular system by using accurate computer simulations. SOLV™ is easy to use and can quickly produce a variety of reports based on your organization's needs and specifications; simply input the necessary data in the appropriate fields, and let the software do the rest.

This user guide will provide you with step-by-step instructions on how to use SOLV™ and make use of its features. Every task involved with running a simulation is covered, and is listed in the table of contents for quick-reference. It is recommended that you familiarize yourself with this guide before using SOLV™ for the first time.

If you need further assistance using the software, or have an issue that is not covered in this guide, please visit http://www.mirusinternational.com.

3. Getting Started

Before you can begin using SOLV™, you must register for a MIRUS account, download/install the software, and activate the program.

3.1. Registering for a MIRUS Account

In order to download the SOLV™ software, you must first register at the MIRUS International homepage.

1. Visit the MIRUS International homepage at http://mirusinternational.com.
2. Click on the **Register** link in the *Members Sign-Up* area (see Figure 3-1).

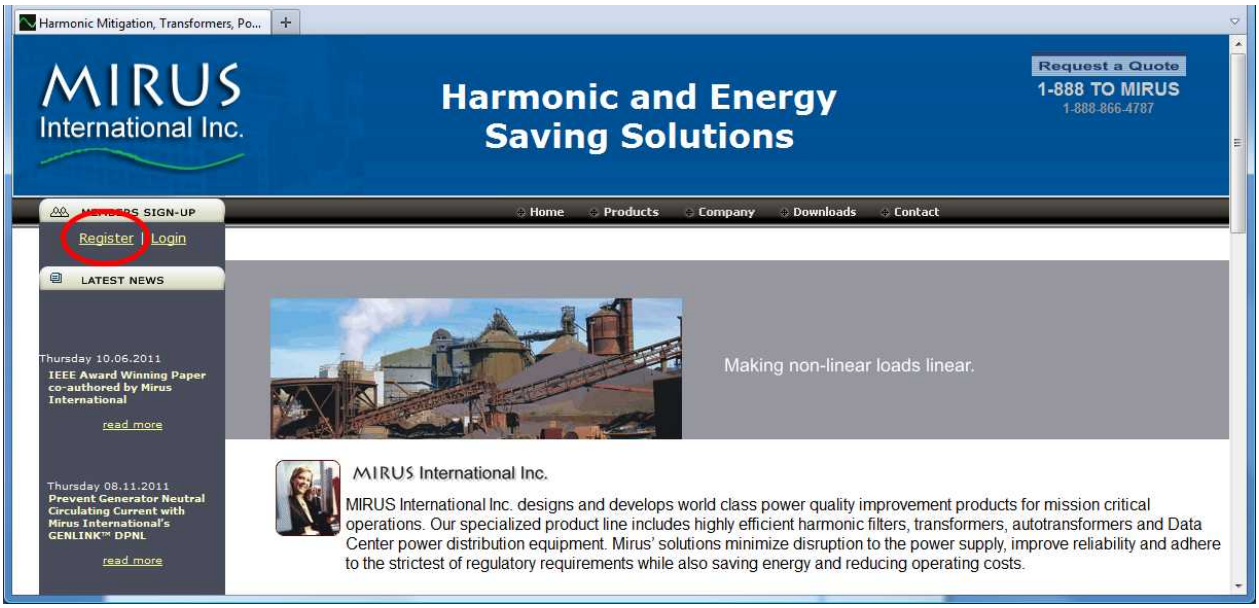


Figure 3-1: The MIRUS homepage. The red circle indicates where you register.

3. Fill in the online registration form—all fields marked with * are required (see Figure 3-2).
4. Click **Submit** when you are finished.

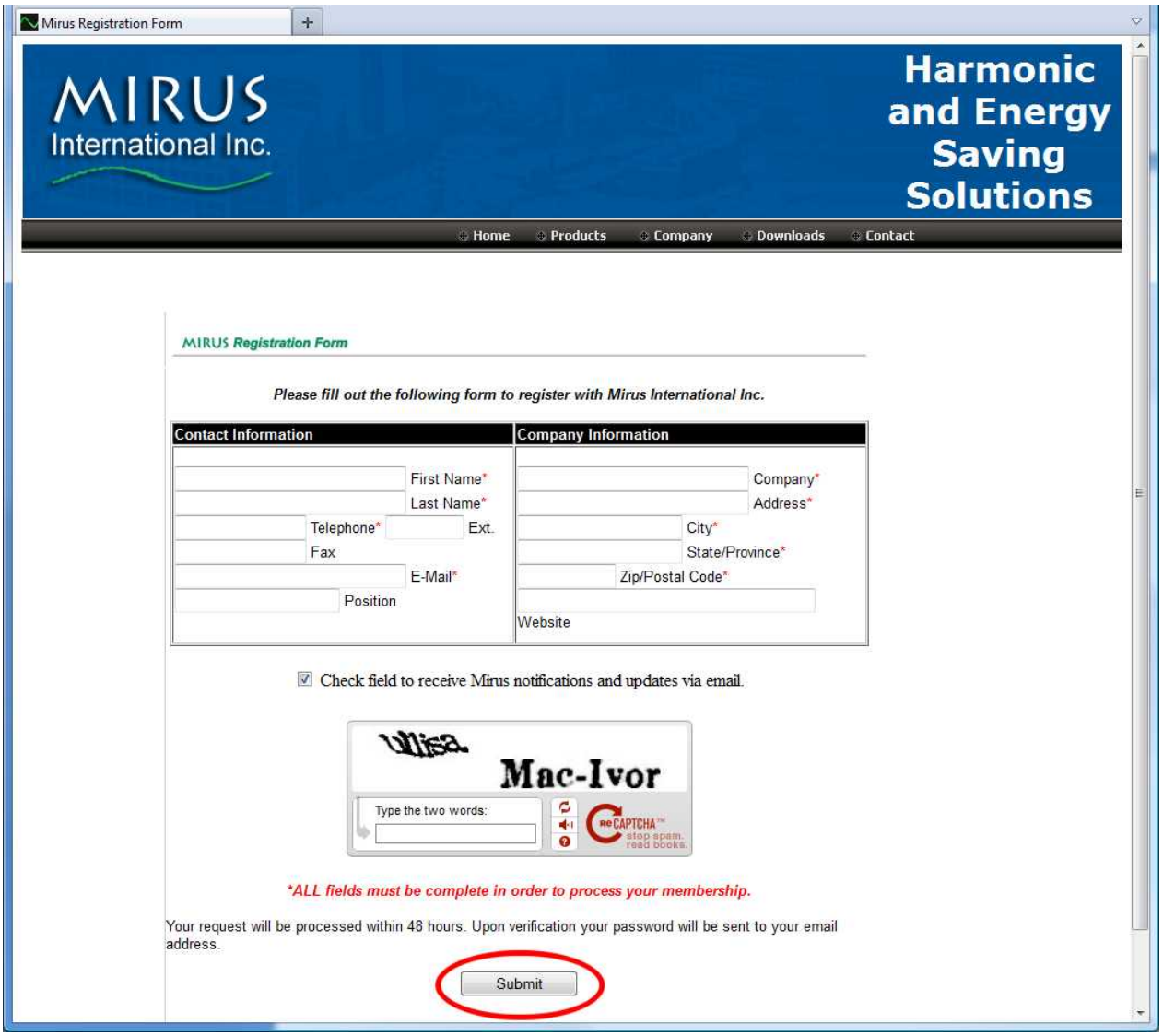


Figure 3-2: The MIRUS registration form. The red circle indicates the submit button.

Note: You will receive an email with your new username and password within 48 hours of registering.

3.2. Downloading SOLV™

To begin downloading the SOLV™ software to your computer, follow these steps:

1. Visit the MIRUS International homepage at http://mirusinternational.com.
2. In the *Members Sign-Up* area, click the **Login** link (see Figure 3-3).

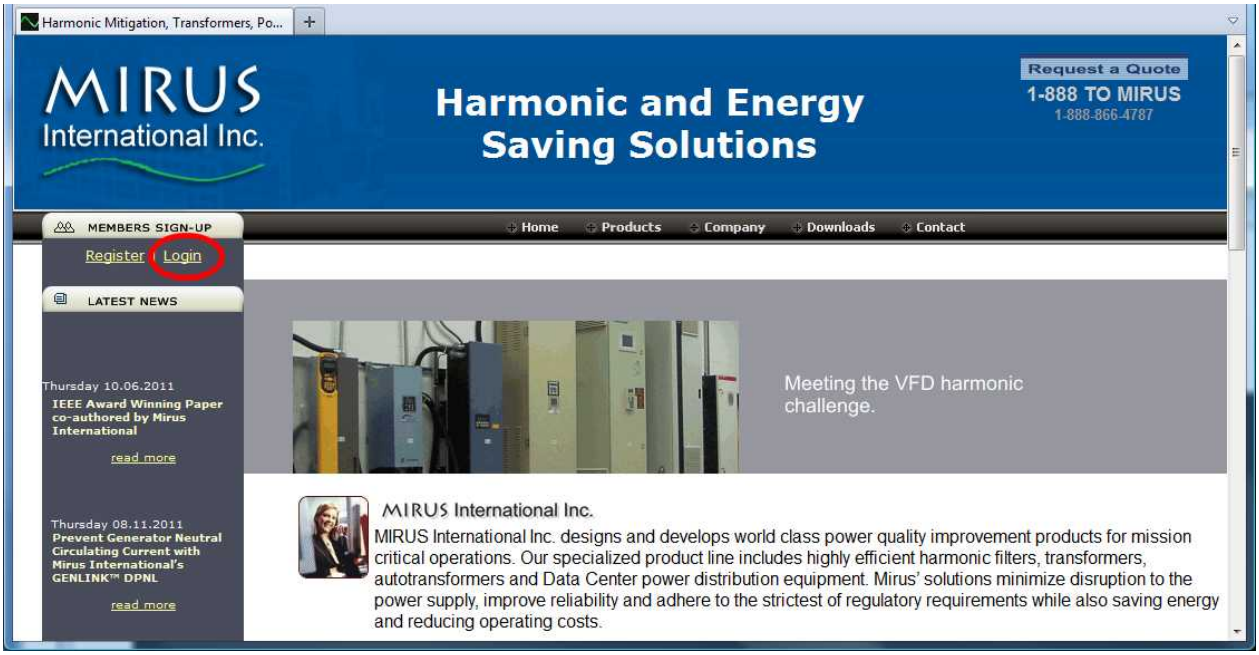


Figure 3-3: The MIRUS homepage. The red circle indicates the Login button.

3. Enter the username and password that you received in the email.
4. Click **Continue** when you are finished—you will now be taken to the *MIRUS Software Downloads* page (see Figure 3-4).

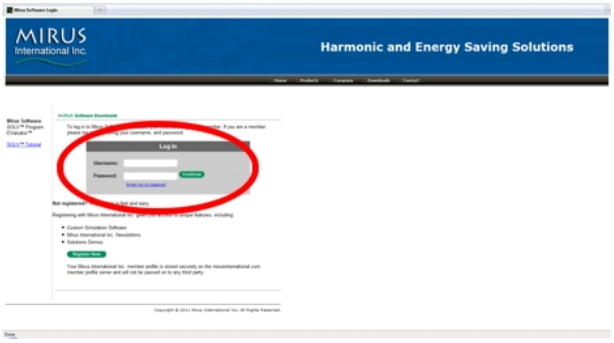


Figure 3-4: The MIRUS Software Downloads page. The red circle indicates the continue button.

5. Right-click on the **SOLV™.MSI** link in the *MIRUS Software Downloads* page and click **Save As** (see Figure 3-5).
6. Choose a download directory.
7. Click **Save** when you are finished.

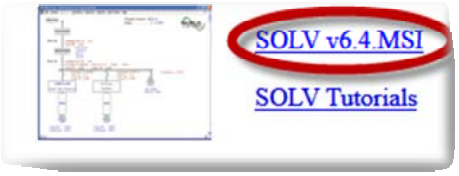


Figure 3-5: The red circle indicates the link to the installation file.

3.3. Installing SOLV™

Once you have downloaded SOLV™, you must install the software to your computer. Follow these steps to complete the installation:

1. Locate the .exe file that you downloaded in the previous steps.
2. Double-click the file to open the installation wizard (see Figure 3-6).
3. Follow the on-screen instructions to complete the installation.

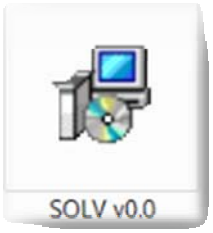


Figure 3-6: The SOLV™ executable file.

3.4. Activating SOLV™

The first time you start SOLV™ you will be prompted for an activation code. This code needs to be entered before you use the software; once activated no further prompts will appear.

1. Select SOLV™ from your program list or double-click on the desktop icon.

2. Select **Click here to retrieve new Activation Code,** located at the bottom of the *SOLV™ Activation* window (see Figure 3-7).
3. Login to the MIRUS International website, and enter your username and password in the *MIRUS Software Downloads* page.

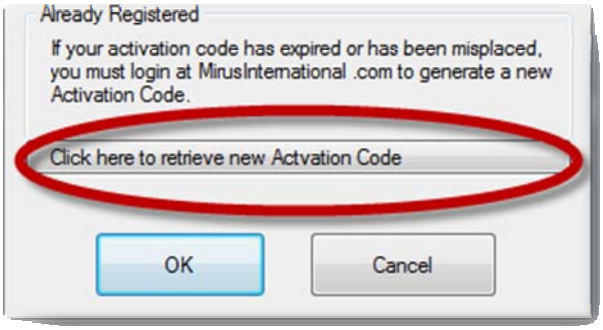


Figure 3-7: The SOLV™ Activation window. The red circle indicates the button that will redirect you to the MIRUS Software Downloads page.

4. Click on **Get activation code** from the *MIRUS Software Downloads* page (see Figure 3-8).

Figure 3-8: The MIRUS Software Downloads page. The red circle indicates the Get activation code button.

5. Copy the **Activation code** from the window (see Figure 3-9).

Figure 3-9: The activation code window will display your activation code.

Note: The activation code will remain valid for 24 hours—after this time, if you have not yet activated SOLV™, you will need to repeat the above steps.

6. Paste—or manually enter—the Activation code into the *SOLV™ Activation* window (see Figure 3-10).
7. Click **OK** when you are finished. You have now activated the SOLV™ software and can begin using the program.

Figure 3-10: The Activation window. The red circle indicates the input space for your activation code.

4. Using SOLV™

This section will guide you in using SOLV™ and running a successful simulation of your system, providing step-by-step instructions for all the tasks involved.

The SOLV™ interface is designed to represent a three-phase system in a one-line diagram form, beginning from a power source to its end loads, and taking into account the generators, cables, transformers, and power factor capacitors that may be present in your system. These are all represented by block symbols; clicking on these symbols will allow you to input data that pertains to your system. As you move through the line, SOLV™ will keep track of the data you have entered, which will then be used to simulate the operation of your current system and detail any resulting harmonic distortion.

4.1. Starting a New Simulation

To start a new simulation, follow these steps:

1. Select SOLV™ from your program list, or double-click on the desktop icon. You will be taken to the *Welcome!* window.
2. Click **Start a New Simulation**.
3. Enter your project details in the *Project Information* window.
4. Click **OK** when you are finished.

4.2. Entering Simulation Data

This section will guide you through SOLV™ to produce an accurate simulation of your system. Some of the inputs are not required to produce usable results; however, if provided, these inputs will produce a more accurate simulation. The *Oneline Diagram Report* (referred to as the *main screen*) contains icons for the data input windows (see Figure 4-1).

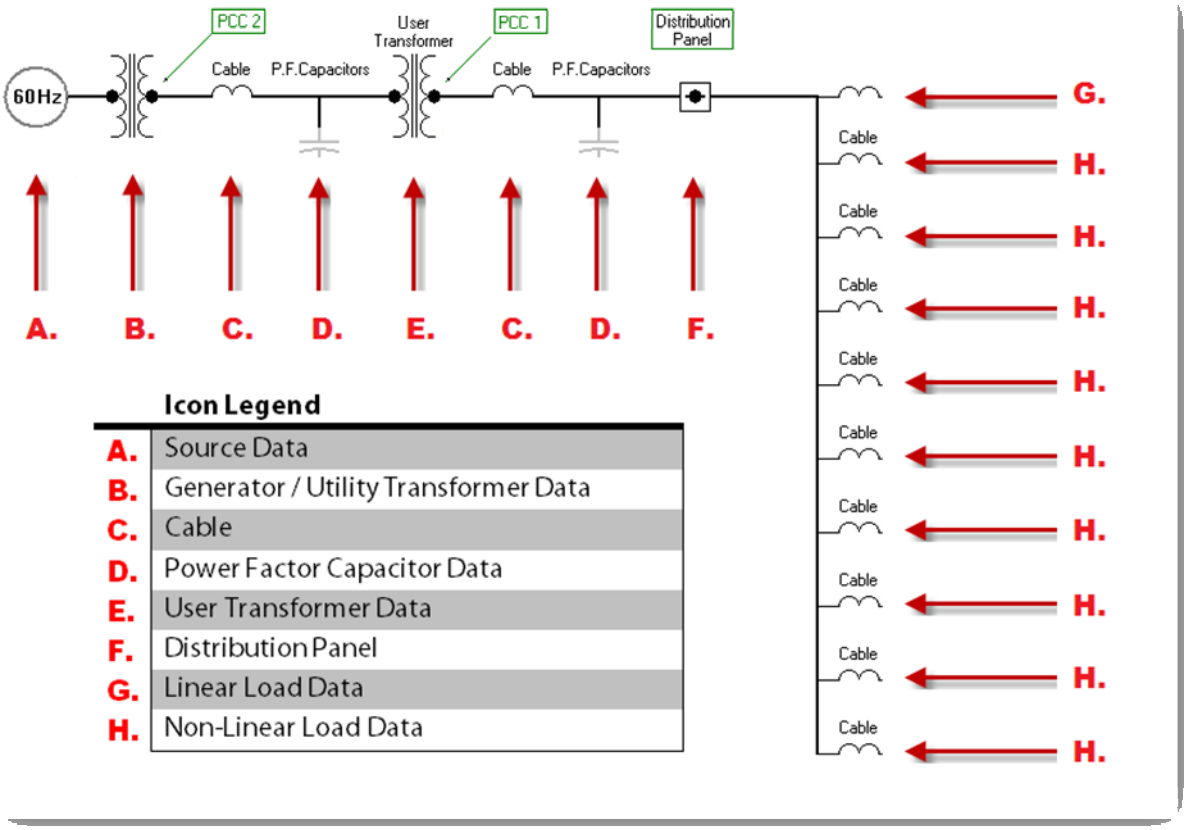


Figure 4-1: The SOLV™ *main screen*. The red letters indicate the icon names.

4.2.1. Choosing Wire Gauge Size Settings

SOLV™ accommodates both the metric and imperial systems for wire gauge size selections. The imperial system is the default setting, allowing the user to select standard American Wire Gauge (AWG) values for cable size selection. Selecting the metric system allows the user to input wire sizes as a cross sectional area in square millimetres. **Settings > Metric**.

4.2.2. Entering Source Data

The *Source Data* window allows you to select a system frequency and input percentages of distortion and imbalance in the supply voltage. To enter source data:

1. Click the **Source** icon 

in the *main screen*.
2. In the *Source Data* window:
    i. Select the **System Frequency (Hz)** value.
    ii. Adjust the **Harmonic # (%)** slider bars to get required voltage source distortion. The adjusted harmonic value is in % of the fundamental component.
    iii. Adjust the **Line Voltage Imbalance (%)** slider bar. The adjusted imbalance value is in % of the nominal.
3. Click **Apply** when you are finished.

4.2.3. Entering Generator or Utility Transformer Data

Depending on your system, SOLV™ allows you to input generator or utility transformer data. To enter the generator data:

1. Hover your cursor over the lower half of the **Generator/Utility Transformer** icon in the main screen. The icon will change *(see Figure 4-2)*.

Figure 4-2: Hovering over the Generator/Utility Transformer icon to enter the generator data.

2. Click the bottom portion of the icon.

3. In the *Generator* window:
   i. Enter either the **(kVA)** or **(kW)** value.
   ii. Enter the **Power Factor** value.
   iii. Enter the **Subtransient Reactance, Xd" (%)** value.
   iv. Select the **Output Voltage (V)** value from the pull-down list.
   Note: It is not possible to enter custom values for generator output voltage.
4. Click **OK** when you are finished.

To enter the utility transformer data:

1. Hover your cursor over the upper half of the **Generator/Utility Transformer** icon in the *main screen*. This will highlight the icon (see Figure 4-3).

Figure 4-3: Hovering over the Generator/Utility Transformer icon to enter the utility transformer data.

2. Click the top portion of the icon.
3. In the *Utility Transformer window*, select either: **Transformer Rating**, **Fault Level**, or **Short Circuit Current**.
   i. If you select **Transformer Rating**, enter the **Transformer Size (kVA)** value and the **(Z, %)** value. You can select one of the pre-programmed values from the pull-down list or enter a custom value from the keyboard.
   ii. If you select **Fault Level**, enter the **(MVA)** value. You can select one of the pre-programmed values from the pull-down list or enter a custom value from the keyboard.
   iii. If you select **Short Circuit Current**, enter the **(Isc, kA)**, value. You can select one of the pre-programmed values from the pull-down list or enter a custom value from the keyboard.

4. Select the **Secondary Voltage (V)** value from the pull-down list.

   Note: Most standard values are pre-programmed and available for output voltage selection. It is not possible to enter custom values for transformer secondary voltage.

5. Click **OK** when you are finished.

4.2.4. Entering Cable Data

To enter cable data:

1. Click on the **Cable** icon 

in the *main screen*.
2. In the *Cable* window:
   i. Enter the **Length (ft)** value.
   ii. Select the **Cond. Size** value from the pull-down list. Values will be in standard AWG sizes for Imperial units and mm^2 for Metric units.
   iii. Enter the **#Cond. (Ph)** value. This is the number of parallel conductors per phase.
3. Click **OK** when you are finished.

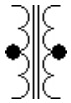
4.2.5. Entering Power Factor Capacitor Data

To input Power Factor Capacitor data:

1. Click on the **P.F Capacitors** icon  in the *main screen*.
2. In the *Power Factor Capacitors* window:
   i. Enter the **Capacitors (kvar)** value. This is the 3-phase value.
   ii. Enter the **Tuned harmonic # with reactor (fo)** value. Normally a reactor is applied in harmonic rich environments to detune the capacitor bank and is often set just below the 5^{th} harmonic.
      a. Select one of the pre-programmed tuned harmonic numbers from the drop-down list: 3.0; 3.8; 4.0; 4.2; 4.4; 4.6; 4.8; or
      b. Enter a custom value from the keyboard and press 'enter' key.
3. Click **OK** when you are finished.

4.2.6. Entering User Transformer Data

To input User Transformer Data:

1. Click on the **User Transformer** icon  in the *main screen*.
2. In the *User Transformer* window, select either: ***Transformer Rating***, ***Fault Level***, or ***Short Circuit Current***.
   i. If you select ***Transformer Rating***, enter the **Transformer Size (kVA)** value and the **Z (%)** value.
   ii. If you select ***Fault Level***, enter the **(MVA)** value.
   iii. If you select ***Short Circuit Current***, enter the **Isc (kA)** value.
3. Select the **Secondary Voltage (V)** value from the pull-down list.
   Note: It is not possible to enter custom values for secondary voltage.
4. Enter the **Efficiency (%)** value.
5. Enter the **Eddy Current Loss (%)** value. This value is in % of total transformer losses.
6. Click **OK** when you are finished.

4.2.7. Entering Linear Load Data

Linear load data is entered through one input. If multiple linear loads are present, enter the sum of all linear loads in the system calculated in kW. To enter linear load data:

1. Click on the **Linear Load** icon in the *main screen (*see Figure 4-4).

Figure 4-4: Clicking on the Linear Load icon.

2. In the *Linear Load* window:
   i. Enter the **Power (KW)** value.

i. Enter the **Displacement PF (Lagging)** value.

Note: Only lagging displacement power factor is considered for linear load (resistive or inductive type load i.e. resistive elements, heaters, motors, etc.). You cannot simulate negative value capacitive type loads.

ii. Add a comment for future reference, if you wish.

3. Click **OK** when you are finished.

4.2.8. Entering Non-Linear Load Data (Up to Nine Supported)

Unlike linear load data, non-linear load data is entered individually. For each non-linear load, create a new input. To create a new input:

1. Click on the **Non-Linear Load** icon in the *main screen*.

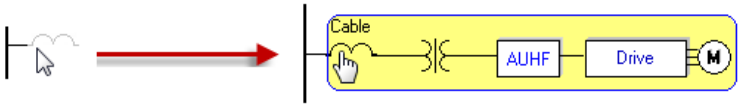


Figure 4-5: Clicking on Non-Linear Load icon.

2. In the *Drive System Input Data* window:

i. Select the **System** type. There are various options for non-linear load selection.

- VFD only: 6 Pulse Rectifier with AC PWM Variable Frequency Converter.
- LINEATOR (AUHF): 6 Pulse AC VFD equipped with LINEATOR AUHF
- 12 Pulse System: VFD with dual rectifiers and built-in phase shifting transformer
- 18 Pulse System: VFD with 3 rectifiers and built-in phase shifting transformer
- 24 Pulse System: VFD with 4 rectifiers and built-in phase shifting transformer
- DC Motor with Thyristor Bridge: SCR based DC Drive
- AUHF with Thyristor Bridge: SCR based DC Drive with LINEATOR AUHF

ii. Cable information can be entered but is not mandatory. Click the **Cable Selection** button. In the *Cable* window:

- Enter the **Length (ft)** value.

- Select the **Cond. Size** value from the pull-down list. Values will be in standard AWG sizes for Imperial units and mm^2 for Metric units.
- Enter the **#Cond. (Ph)** value. This is the number of parallel conductors per phase.
- Click **OK** when finished.

iii. If the load branch includes a transformer, one can be entered. This allows for simulation of phase shifted systems, or more complex electrical one-lines. For complex one-lines, the VFD loads will need to be entered as totals for each branch. Click the **Drive Transformer** button. In the *Drive Transformer* window:

- Enter the **Transformer Size (kVA)** value.
- Enter the **Transformer Z (%)** value.
- Select the **Secondary Voltage (V)** value from the pull-down list.
- Select the **Phase Angle (°)** along the slider bar.
- Enter the **Efficiency (%)** value.
- Click **OK** when finished.

iv. If one exists, enter the **Input Reactor Impedance (%)** value.

v. If one exists, enter the **DC Link Reactor Impedance (%)** value.

vi. Enter the **Smoothing Capacitor (mF)** value. Normally the default value is used unless it is known to be different.

vii. Select the **Motor Rating (HP/kW)** value. This is the motor shaft power rating.

viii. Select or enter the **Motor Loading (%)** value. Worst case voltage distortion will occur at 100% loading.

ix. Enter the **Motor Speed (%)** value. This input box is only available when a thyristor bridge load is selected.

3. Click **OK** when finished.

Note: To view a breakdown of a non-linear load, click on the System Drive Type Icon (see Figure 4-6)

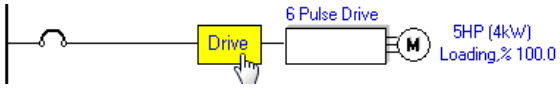


Figure 4-6: Viewing a breakdown of a non-linear load.

4.3. Calculating Data

Based on your specifications, SOLV™ will calculate harmonic current and voltage distortion, energy consumption including harmonic losses, and generate detailed reports. To calculate your data and simulate the results, click **Calculate** in the top menu.

Note: If you receive an error after clicking Calculate, re-examine and adjust your values as required. During the calculation, SOLV is resolving the set of differential equations which may take some time. A line will scroll up and down along the distribution bus while the calculation is ongoing.

4.4. Viewing Data

Once your SOLV™ simulation has been calculated, you can view results. SOLV™ provides a number of reports for you and your organization.

4.4.1. Viewing Waveform and Spectrum Data

To view Waveform and Spectrum Data:

1. Select **Waveform and Spectrum Data** in the top menu.
2. Choose from the following options in the **Waveform and Spectrum Data** window:
    - **On PCC #2**
    - **On PCC #1**
    - **On Distribution Panel**
    - **Current PFC #2**
    - **Current PFC #1**
3. For a detailed harmonic spectrum table, move the cursor over the spectrum graph and click. This spectrum data can then be exported to an Excel Spreadsheet by

simply clicking the 'Export to Spreadsheet' button. This process can be repeated anywhere a harmonic spectrum table appears.

4. Additional waveforms and spectrums can be viewed at any load branch. Simply move the cursor in front of the Drive or Thyristor bridge until the cursor changes to the hand pointer and click. Further details can be reached by clicking on the waveform or harmonic spectrum graphs.

4.4.2. Viewing Reports

SOLV™ generates multiple reports based on your simulation. To view the reports:

1. Select **Reports** in the top menu.
2. Choose from the following options in the **Reports** window:
    - **Simulation Summary Report**
    - **Harmonic Current Distortion IEEE Std 519 Compliance Table**
    - **Harmonic Distortion Report**
    - **Telephone Interference Report: I*T Product and TIF Calculations**
    - **Phasor Diagram**

4.5. Selecting File Options

Creating, loading, and saving simulations in SOLV™ works much in the same way as other popular software programs. Follow the steps below to select file options.

4.5.1. Creating a New Simulation

To create a new simulation:

1. Select **Project > New** in the top menu.
2. Enter your project details in the *Project Information* window.
3. Click **OK** when you are finished.

4.5.2. Loading an Existing/Previous Simulation

To load an existing simulation:

1. Select **Project > Load** in the top menu.
2. Locate a previously saved project in your system directory.
3. Click **Open** when you are finished.

4.5.3. Saving a Simulation

To save your simulation:

1. Select **Project > Save** in the top menu.
2. Name the project and choose a system directory to save the file.
3. Click **Save** when you are finished.

4.5.4. Saving a Screen Capture

To save a screen capture of the *main screen*:

1. Select **File > Save Screen** in the top menu.
2. Choose the image type and name the file.
3. Choose a system directory to save the file.
4. Click **Save** when you are finished.

4.6. Printing SOLV™ Information

The following section will instruct you in printing the results and reports that SOLV™ generates.

4.6.1. Printing Reports

To print one or more of the reports generated in your SOLV™ simulation:

1. Select **Print Reports** in the top menu.
2. Choose from the following options in the **Select Reports** window:
    - **Oneline Diagram Report**
    - **IEEE Std 519 Compliance Report**
    - **Harmonic Current Distortion IEEE Std 519 Compliance Table**

- **Harmonic Distortion Report**
- **PCC #1 Current and Voltage waveforms and harmonic spectrums**
- **PCC #2 Current and Voltage waveforms and harmonic spectrums**
- **PCC #1 Current and Voltage waveforms and harmonic spectrums—IEEE Std 519 Compliance Report**
- **PCC #2 Current and Voltage waveforms and harmonic spectrums—IEEE Std 519 Compliance Report**
- **Telephone Interference Report: I*T Product and TIF Calculations**

3. Select the check-box next to the desired reports
4. Choose printing options in the *Print Setup* window.
5. Click **OK** when you are finished.

4.6.2. Printing the Screen

To print the current screen:

1. Select **File > Print Screen** in the top menu
2. Choose printing options in the *Print Setup* window.
3. Click **OK** when you are finished.

5. Glossary

AWG: Symbol for American wire gauge.

Eddy Current Loss %: In magnetic devices, this includes eddy-current losses in the core, windings, case, and associated hardware. This value is in % of total transformer losses.

Efficiency %: The ratio of the useful power output to the total power input.

Ft: Symbol for foot. An imperial unit of length equal to 12 inches.

Harmonics #: Harmonics as voltages or currents at frequencies that are a multiple of the fundamental frequency.

Hz: Symbol for hertz. A unit of frequency referring to the number of cycles per second.

Isc, kA: An overcurrent resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions.

kVA: Symbol for kilovolt-ampere. A unit of electrical load.

Kvar: Symbol for kilovolt-amperes reactive. A unit of reactive power.

kW: Symbol for kilowatt. A unit of energy equal to one thousand watts.

Line Voltage Imbalance, %: The maximum percent deviation from the average of three-phase voltages.

MCM: Symbol for circular mils. A unit of area, one MCM is equal to 1000 circular mils.

MVA: Symbol for apparent power. A unit of power.

Power Factor: In an AC power system, the ratio of the real power over the apparent power flowing to the load in a circuit.

Subtransient reactance, Xd %: The apparent reactance of a generator at the instant a short circuit occurs, per unit value.

Tuned harmonic # with reactor, fo: Combined resonance frequency of the inductor and capacitors in the circuit, relative to the fundamental frequency.

V: Symbol for volt. A unit of electric potential, electric potential difference, and electromotive force.

Z%: Symbol for percentage impedance.

MIRUS International Inc.
31 Sun Pac Blvd.
Brampton, Ontario
Canada L6S 5P6

1 - 888 - TO – MIRUS (1 - 888 - 866 – 4787)

Tel: (905) 494-1120

Fax: (905) 494-1140

E-Mail: mirus@mirusinternational.com

Website: www.mirusinternational.com