Works 2013

Optimization (sphere function)

WHITEPAPER

TECHNO logismiki
Advanced Technical Software

5 Imitou str, 15561, Cholargos, Athens, Greece
tel: ++30 210 65 64 147 - fax: ++30 210 65 48 461
www.technologismiki.com - info@technologismiki.com

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Chapter

1 About the whitepaper

1.1 Purpose

The purpose of this whitepaper is the optimization (minimization) of a simple problem represented by the well-known sphere function.

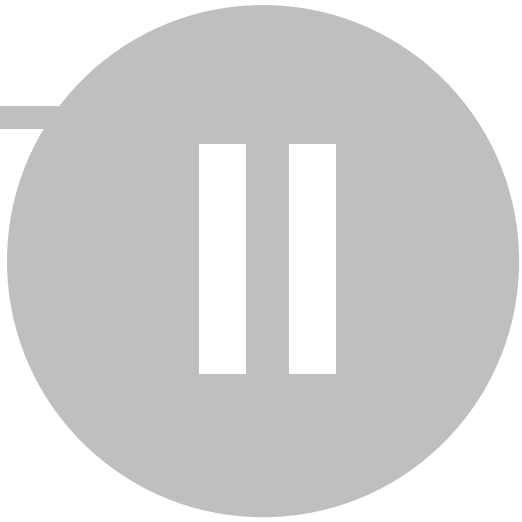
1.2 Software

In order to complete the example successfully, the following software is required:

- xlOptimizer v2.0.
- Microsoft Excel (version 2003 or newer).

Later versions of the aforementioned software may be incompatible with the structure of the example as it is presented herein.

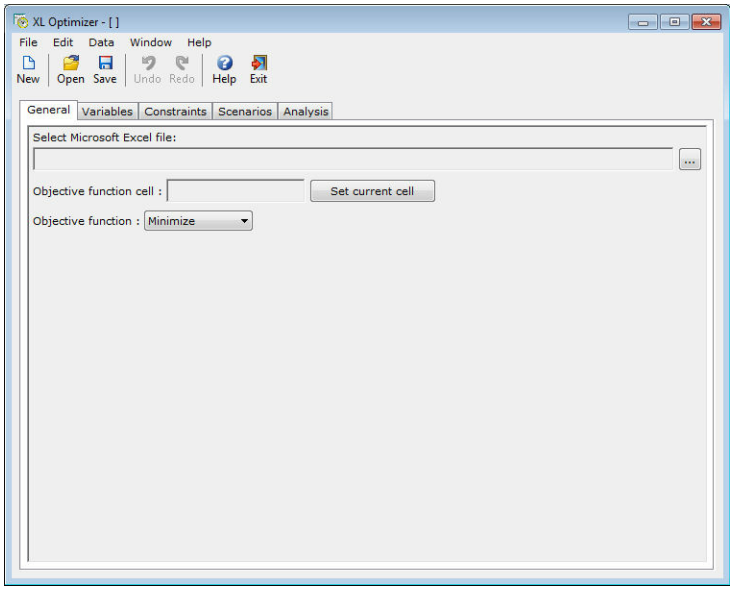
Chapter



2 Steps

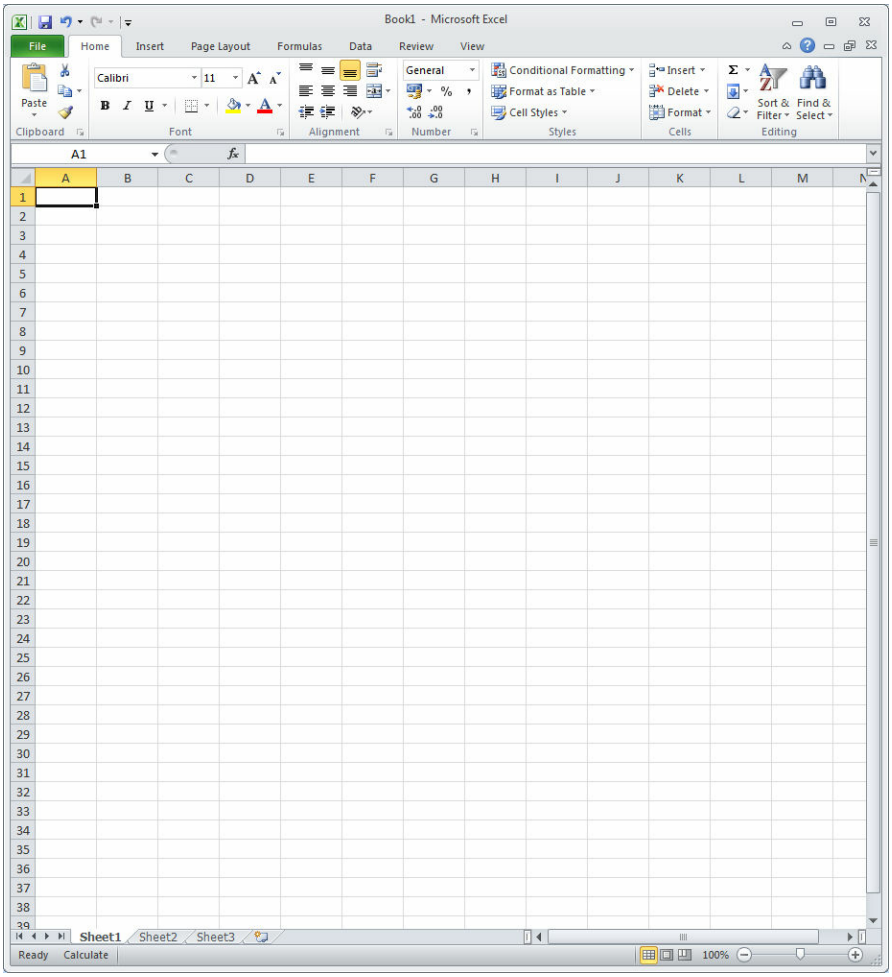
2.1 Step 01: New project

Select **New Project** from the **File** menu. The program will remove any data from memory and prepare to start a new project:



2.2 Step 02: Setting up the spreadsheet

We proceed to create the spreadsheet. Open Microsoft Excel (in the following images, version 2010 of Microsoft Excel is shown; the process is precisely the same with older versions):



Select a filename, e.g. Sample 1.xls and save it somewhere in your hard drive. It is very convenient to save both the project file (.m82) and the Microsoft Excel file (.xls or .xlsx) in the same path (although this is not mandatory).

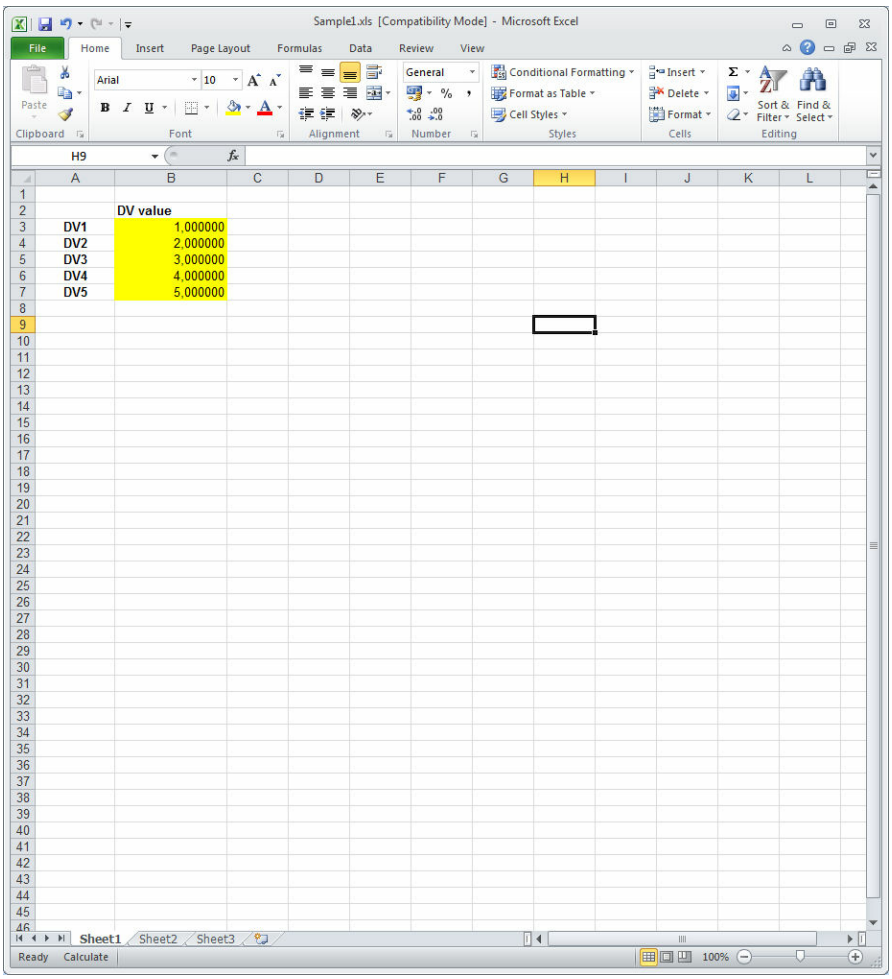
For optimization, it is important to define a suitable **objective function**. This objective function takes as arguments the values of the design variables and produces an output (a number) which is decisive as to if the proposed solution is "good" or "bad". A simple mathematical expression, which can be used as toy-problem, is the well known sphere function:

$$f\left(x_1, x_2, x_3, \ldots, x_n\right) = x_1^{\ 2} + x_2^{\ 2} + x_3^{\ 2} + \ldots + x_n^{\ 2} = \sum_{i=1}^{n} x_i^{\ 2}$$

We assume that our problem has 5 variables, i.e. n=5, and each of them takes values in the range -10 to 10. We wish to minimize this expression. Due to the simple mathematical representation, we know a priori that the global optimum is zero, and occurs when all variables are equal to zero.

In Microsoft Excel, leave a line for the title, and create a column with the names of the design variables, e.g. DV1, DV2, ..., DV5. In the column on the right, enter their values (initial values are set equal to 1, 2, ..., 5 in the following image). Note that the

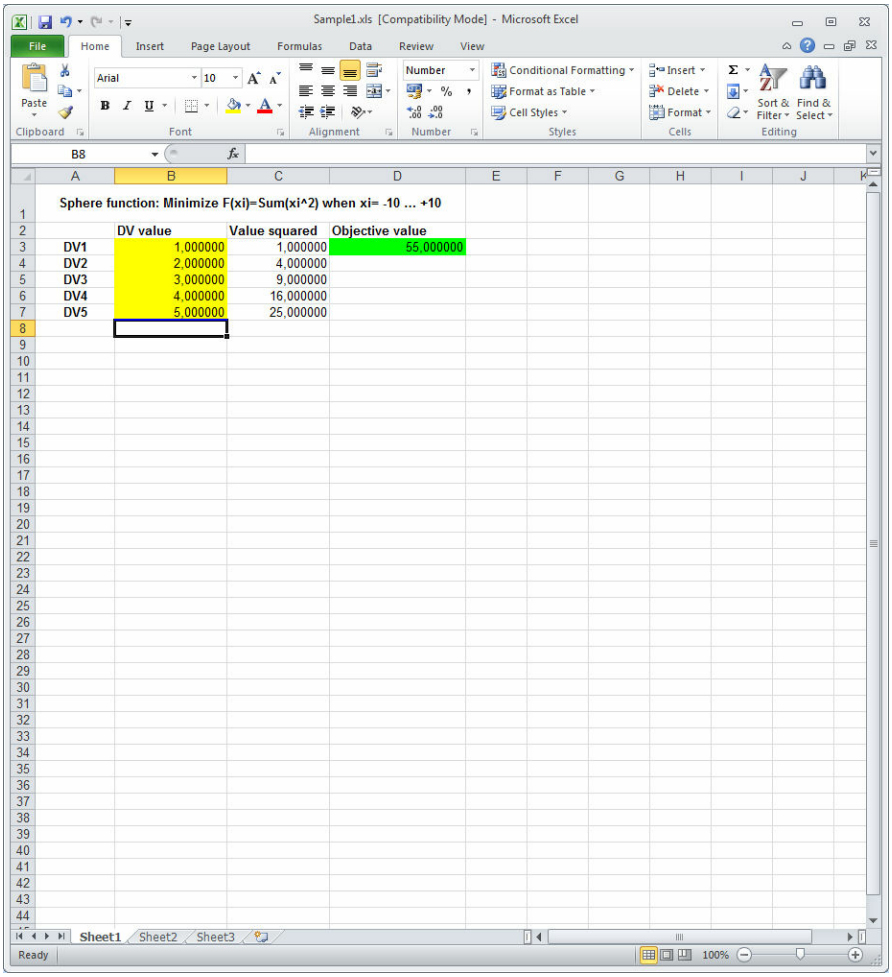
background of the cells is set to bright yellow to avoid confusion.



In the next column, enter a function which returns the square of the cell on the left, i. e. in cell C3, enter '=B3^2'. Extend this function to the other cells below.

Evaluate the sum of the squares in cell D3, by entering the expression '=SUM(C3:C7)'.

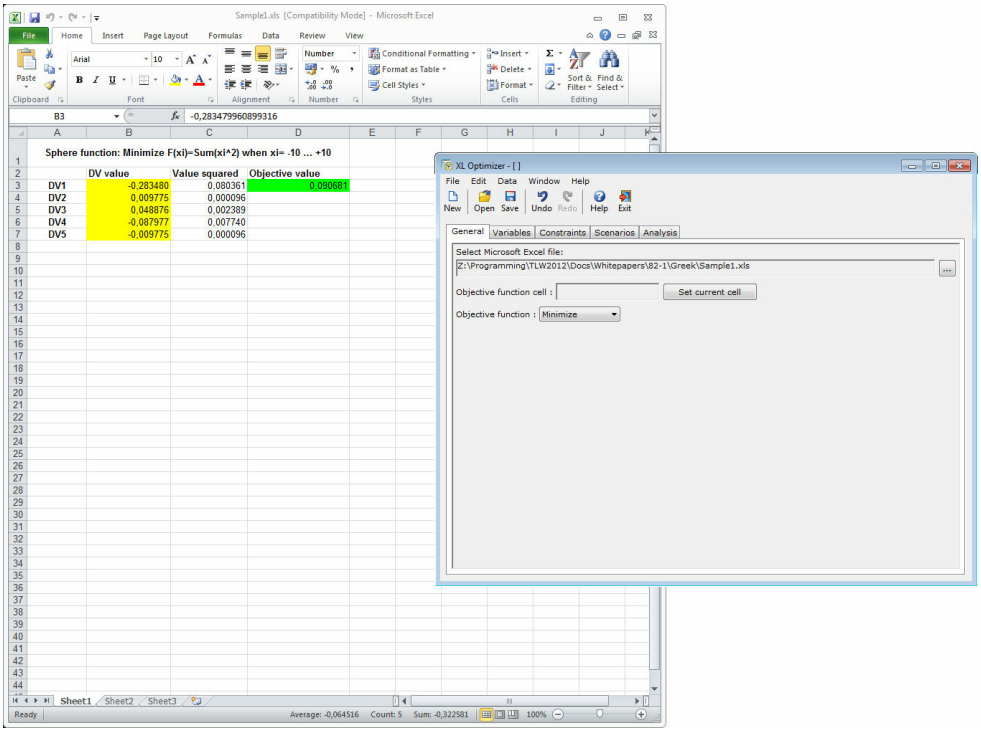
Add the titles, and set the background of cell D3 (the objective function) to green. The final image of the spreadsheet is as follows:



The spreadsheet is ready. Save the file and **close Microsoft Excel**.

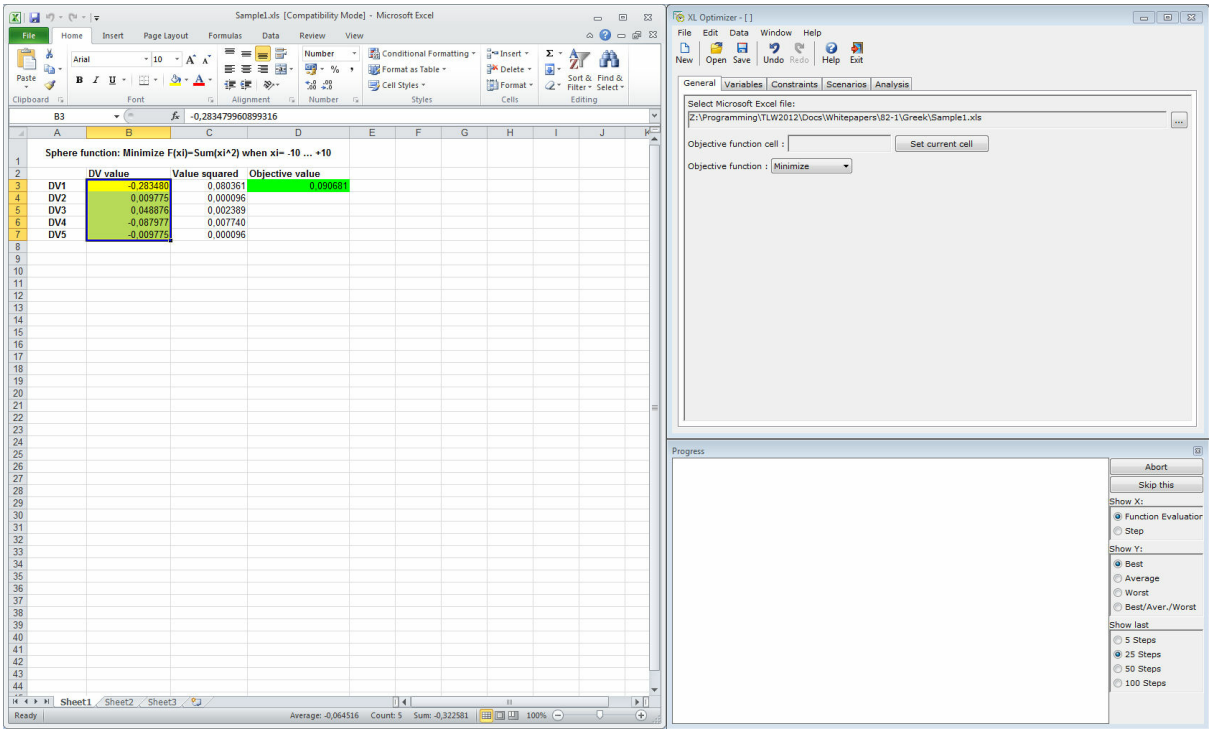
2.3 Step 03: Data input

We return to xlOptimizer. Select the **General** tab. Click the button with the ellipses "..." in the **Select Microsoft Excel file:.** Select the spreadsheet file that you have created in the previous step. Press Ok and Microsoft Excel is loaded:



In xlOptimizer, select **Window > Status/Progress window** to view the status/progress window (if not already visible).

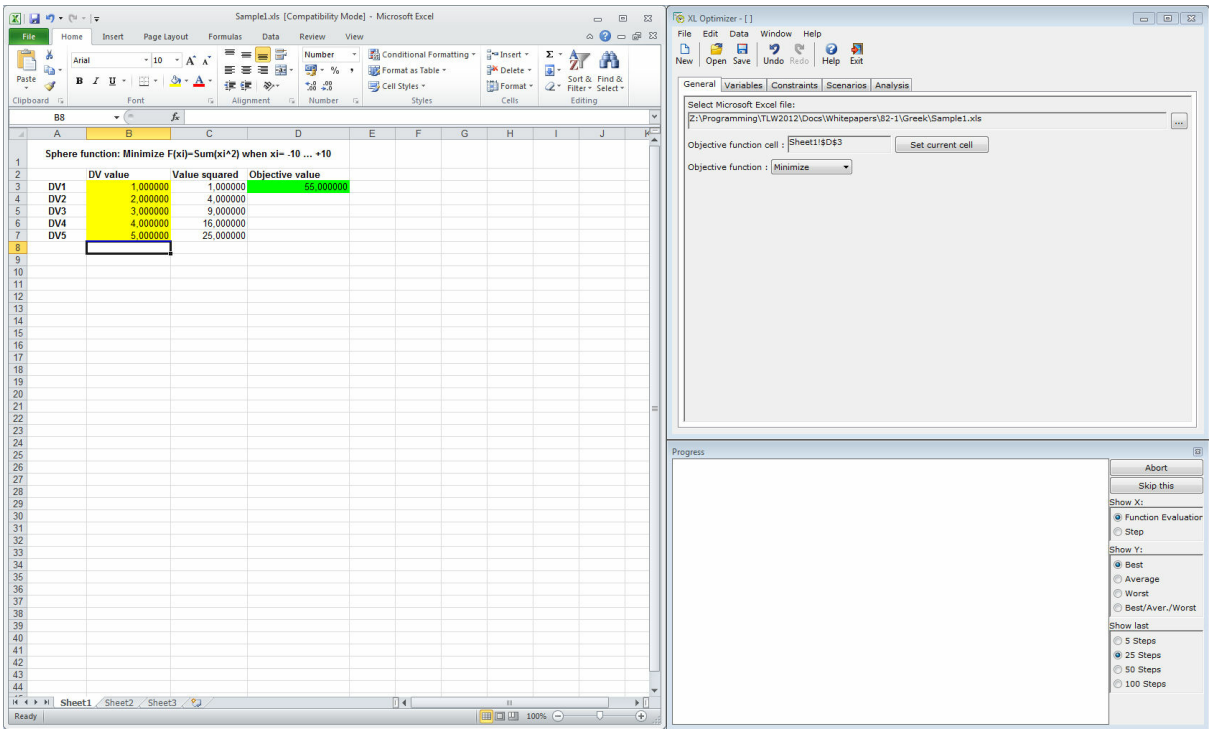
Also, select **Window > Auto-arrange** to arrange the windows automatically. The screen now looks like this:



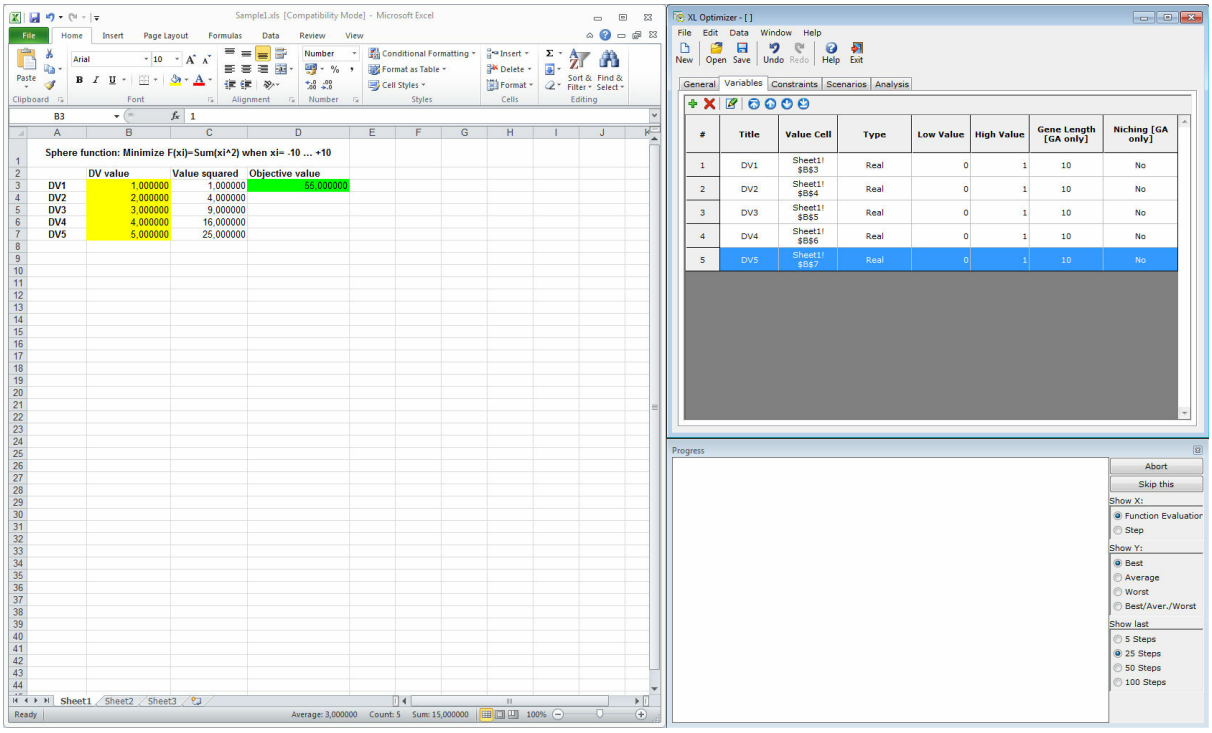
We need to enter the cell that contains the objective function. In **Microsoft Excel, select cell D3 (only)**. Next, in xlOptimizer click **Set current cell button.** As a result, the corresponding field is updated. When the mouse pointer is over the button, the background of the currently selected cell in Microsoft Excel is temporarily set to red (to avoid confusion).

In the **objective function** field, make sure that **minimize** is selected.

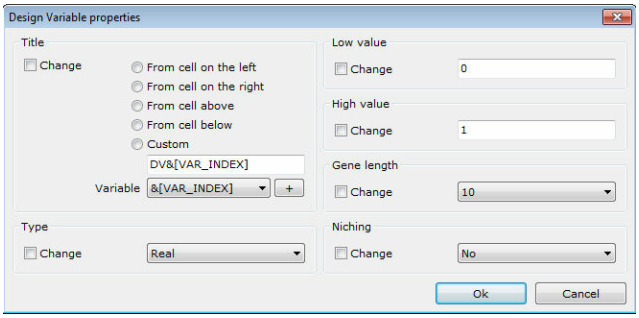
The screen now looks like this:



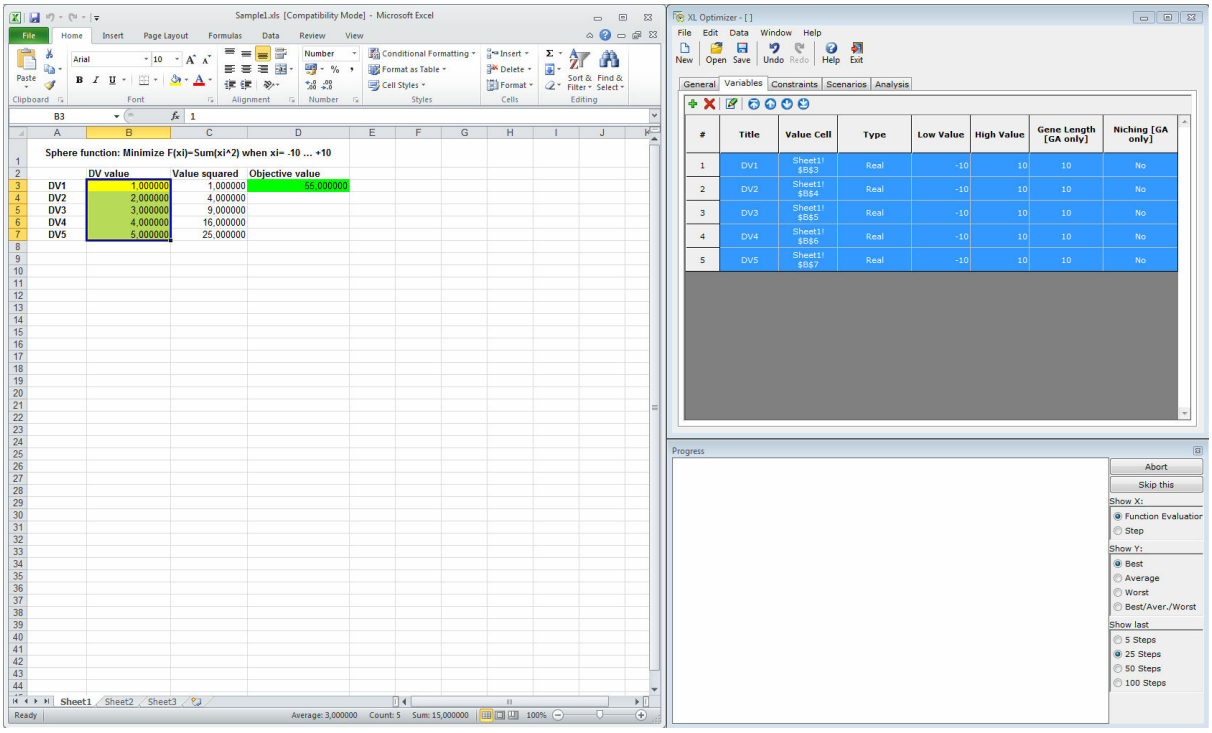
In xlOptimizer, select the **Variables** tab. In Microsoft Excel, select cells B3 to B7 (with the yellow background). In xlOptimizer select **Data > Variables > Add**. The variables are added to the list:



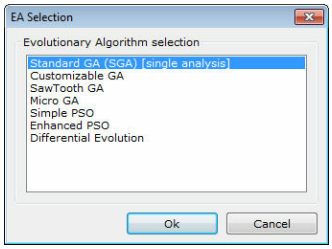
We need to change the lower and upper boundaries of the variables. In xlOptimizer, select all rows (for all variables) and next select **Data > Variables > Properties**:



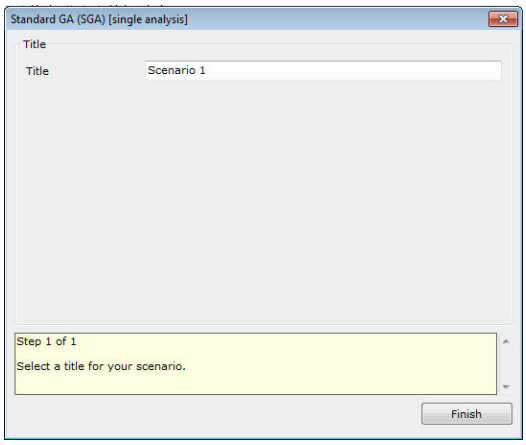
In the **Low value** field, change zero to -10. Make sure that the **Change** field is checked, so that the changes are actually applied to the variables. Also, change the **High value** from 1 to 10. Press **Ok** to close the form and apply the changes. The boundaries are now changed:



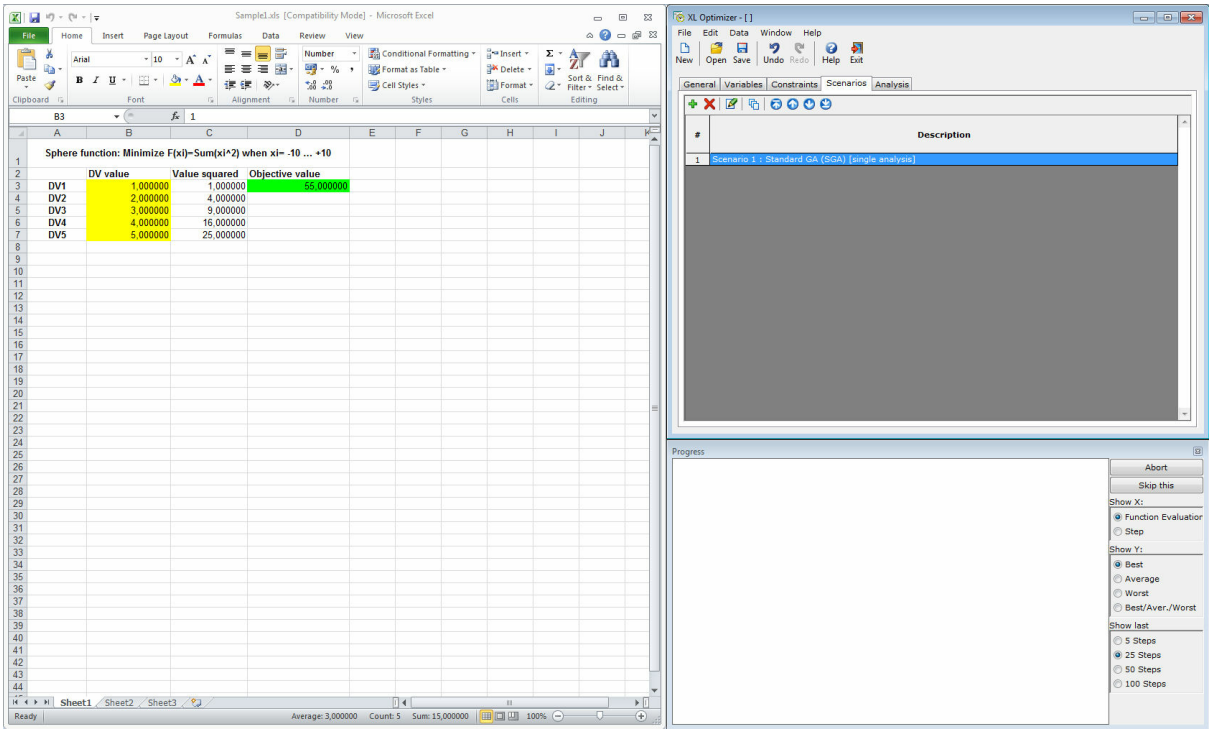
Finally, we will create a analysis scenario. In xlOptimizer, select the **Scenarios** tab. From the menu, select Scenarios > Add. The Evolutionary Algorithm selection form appears:



Select the first option, Standard GA [single analysis], and press **Ok**. The corresponding wizard appears:



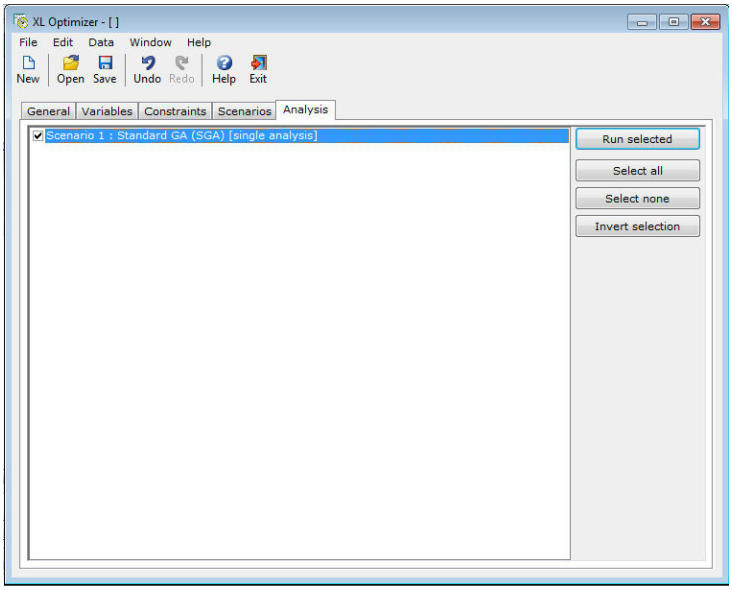
Leave the **Scenario 1** as the title of the scenario and press **Finish**. All other parameters are set automatically. The scenario is added to the list. The screen now looks like this:



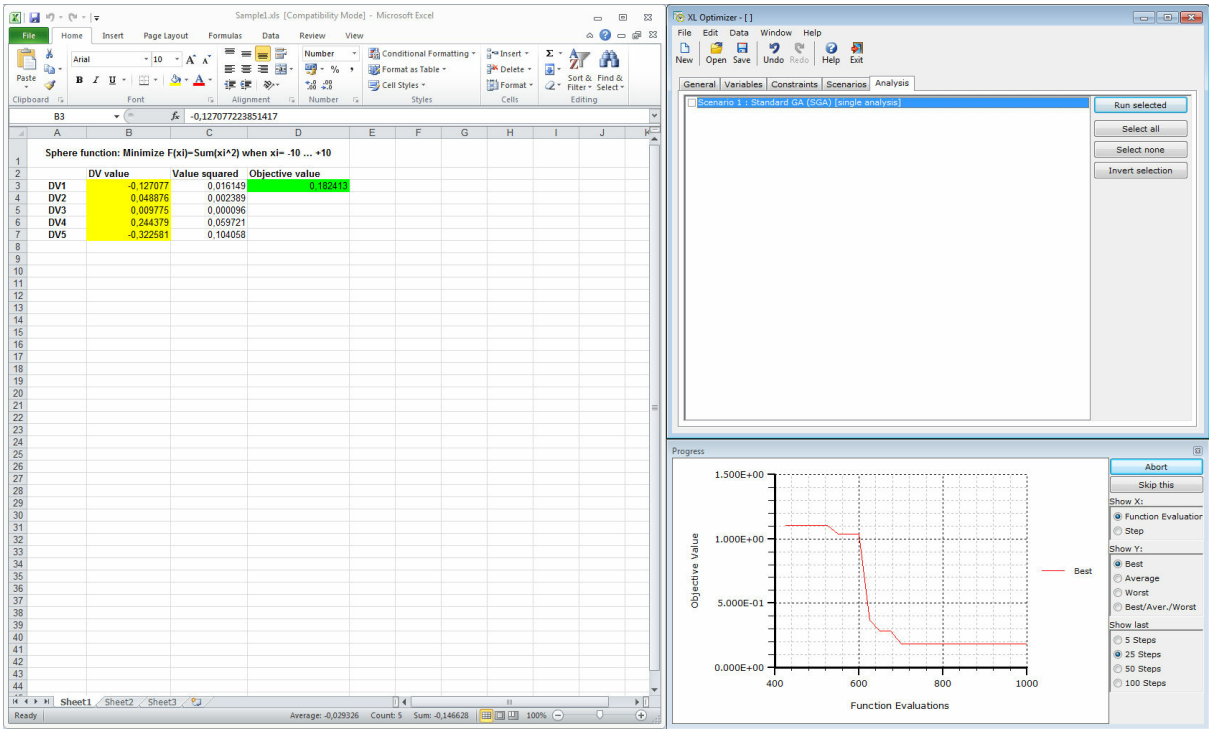
The data input is now complete. From the menu, select **File > Save project as** and save the file, e.g. Sample1.m82 in the same path as Sample1.xls. We are now ready to proceed with optimization.

2.4 Step 04: Calculations

In this step, we will proceed with the optimization. In xlOptimizer, select the **Analysis** tab. Check the only scenario in the list**:**



Click the **Run selected** button. Optimization begins. In order to improve performance, the Microsoft Excel window is hided. The status/progress window shows information on the progress. The analysis concludes after 20000 function evaluations or if you press the **Abort** button. In any case, Microsoft Excel window pops-up with the best solution that was found.



Chapter

3 Help

3.1 Technical support

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- FAX: ++30-210-654-8461
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