

USING GENOPT WITH TRNSYS 16 AND TYPE 56

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Quick instructions to run the example (if you are an advanced user or just in a hurry)

- Unzip GenOpt and copy the contents of go_prog into "C:\Program Files\GenOpt". This means that the full path to the "WinGenOpt.class" should read as "C:\Program Files\GenOpt\genopt\WinGenOpt.class"
- Add the path to GenOpt to your CLASSPATH environment variable as explained in section 2.2.1. **Do not skip this step!**
- Unzip the example into "C:\Program Files\Trnsys16\Examples". It should create the "Genopt-Type56" folder, i.e. the full path to the project file, "Genopt-Type56.tpf", should read "C:\Program Files\Trnsys16\Examples\Genopt-Type56\Genopt-Type56.tpf".
 - You can open the project and look at the starting point in the Simulation Studio. If you want to know what the example is doing, please read Section 3.
- To perform an optimisation study, browse to "C:\Program Files\Trnsys16\Examples\Genopt-Type56" in Windows Explorer and launch "StartOptimisation.bat". This should start the GenOpt interface. In the interface, click on the green arrow (or go to File/Start). Select the GenOpt.ini file and click "Open". This should launch the TRNSYS simulations. If it does not, make sure you are opening the "Genopt.ini" file that is located in "C:\Program Files\Trnsys16\Examples\Genopt-Type56".

If this does not work, you might have to actually read this document (and check the "troubleshooting" section)

1. Introduction

1.1. About this document

This document assumes that you are reasonably comfortable with the TRNSYS jargon, such as what is the TRNSYS input file (deck, or .DCK) and what is the building description file (Building file, or .BUI, created by TRNBuild). Please refer to the TRNSYS Manual [1] for more details.

This document briefly describes how to use GenOpt [2] with TRNSYS, including some features that are currently not available from the dedicated TRNSYS interface for GenOpt, TRNOPT [3].

The document comes with a working example. In order to run the example "out of the box", you will have to install the different programs and the example itself in the directories listed below. This is necessary because absolute paths are hard-coded in some of the configuration files provided with the example.

1.2. About GenOpt

GenOpt [2] is an optimisation program for the minimization of a cost function that is evaluated by an external simulation program. It can be used with any simulation program that reads inputs from and write outputs to text files. GenOpt and its user manual can be downloaded free of charge (after registration) from the Lawrence Berkeley National Lab website, <http://gundog.lbl.gov/GO>.

1.3. About TRNOPT

TRNOPT is a dedicated TRNSYS interface for GenOpt. It has been created by TESS (<http://www.tess-inc.com>) in order to streamline the optimisation process and it is being distributed as part of the TESS libraries Version 2. With TRNOPT, the entire process of optimizing the results from a TRNSYS simulation

reduces to choosing the TRNSYS input file, choosing the variables which will be varied to optimize the results, and choosing the simulation result to be optimized. In this respect TRNOPT is highly recommended to any TRNSYS user wishing to experiment with GenOpt.

This document is intended to demonstrate the use of some GenOpt features that are currently not available from within TRNOPT: equations implementing relationships between optimisation variables, and direct modification of building parameters located within the BUI file (created by TRNBuild) and not in the DCK file.

1.4. Program versions

This document relies on settings, default directories, etc., which were tested for the following program versions:

- TRNSYS
 - Tested with TRNSYS 16.01.0002
 - TRNSYS 16 is required (TRNSYS 15 will not work), TRNSYS 16.01.0000 or above is strongly recommended
- GenOpt
 - Tested with GenOpt 2.0.0
 - Any subsequent version of GenOpt 2 (if any) should work, GenOpt 1 will not work
- Java
 - Tested with Java 2 Runtime Environment, Standard Edition, Version 1.5.0 Update 11
 - Any Java 2 version compatible with GenOpt should work, i.e. Java 2 Runtime Environment Version 1.4.2 or higher.

2. Setting up the programs

2.1. TRNSYS 16

This document assumes that you have installed TRNSYS 16 in the default directory (C:\Program Files\Trnsys16). If you have installed it in a different directory, you will need to make the appropriate changes in pathnames that appear in the configuration files for the example (see below).

2.2. GenOpt

This document assumes that you have unzipped the downloaded version of GenOpt into its own directory and moved that directory into "C:\Program Files\GenOpt".

In other words, the full path to the main program, "WinGenOpt.class" should read as "C:\Program Files\GenOpt\genopt\WinGenOpt.class". You will have to create the directory "C:\Program Files\GenOpt" and move there the content of the "go_prog" directory created when unzipping the downloaded version of GenOpt. If you wish to install GenOpt in a different directory, you will need to make the appropriate changes in pathnames that appear in the configuration files for the example (see below).

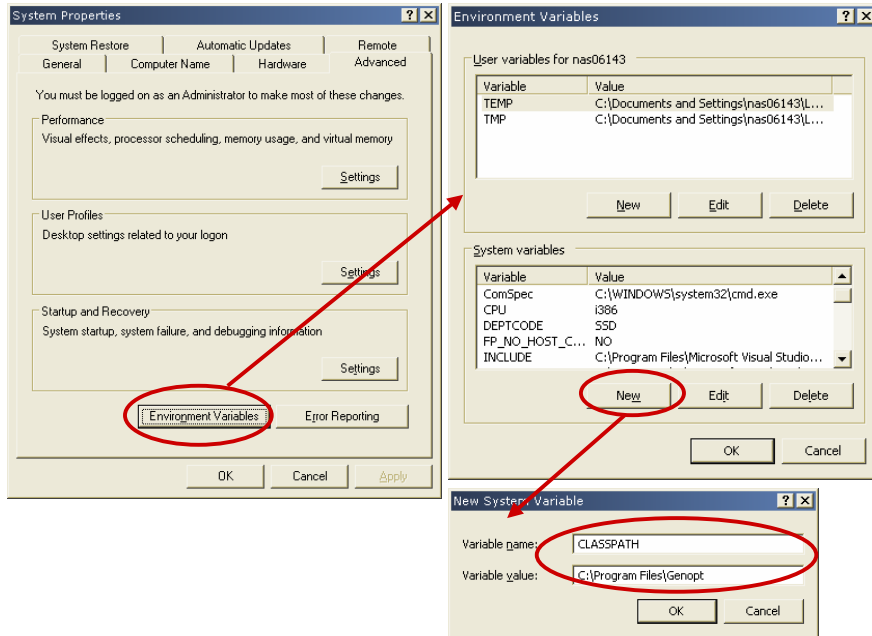
2.2.1. Setting CLASSPATH in the environment variables (IMPORTANT STEP!)

You **must** add the path to GenOpt to the CLASSPATH environment variable. Failing to do so will result in a java error in if you attempt to run the example as it is.

In order to do so:

- Right-click on "My Computer" and select "Properties" (or go to Start/Settings/Control Panel/System)
- Go to the "Advanced" tab
- Click on "Environment variables" (see screenshot below)
- If you can see a CLASSPATH variable, select it, click on "Edit" and add ";C:\Program Files\GenOpt" (without the quotes) to the variable value. It is important to type the string **without surrounding quotes!**

- If you cannot see a CLASSPATH variable, click on "New" under "System variables" (see screenshot below). Enter "CLASSPATH" (without the quotes) for the variable name and "C:\Program Files\GenOpt" (without the quotes) for the variable value. It is important to type both strings **without surrounding quotes!**

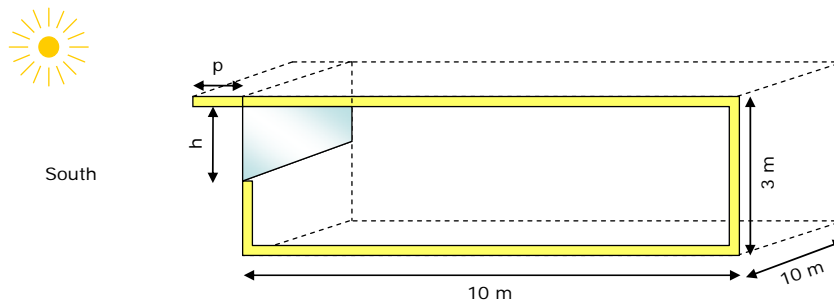


2.3. Java

You should install a Java version that is compatible with GenOpt. If you want to test your Java installation, open a command prompt and type "java -version". You should get a message with the java version installed on your machine. If you don't then chances are GenOpt will not work and you should reinstall a recent version of the Java Runtime Environment which you can download from <http://www.java.com>.

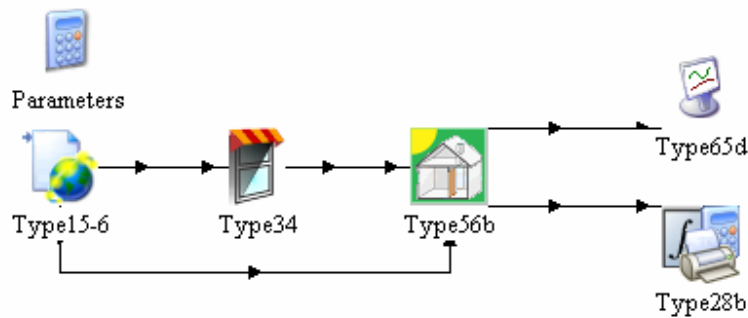
3. The example

The example models a very simple square building (10 x 10 m, 3 m height). It only has one window, oriented due south. The two optimized variables are the window height (h , measured from the top) and the overhang projection, p .



A Studio screenshot is given here below. The total heating and cooling load is calculated by Type 28 and written to an external file (*.sum where *** is the project name, i.e. GenOpt-Type56 here).

In order for GenOpt to find the cost function to minimize, it is important to leave QTot as the first printed variable in Type 28. It would also possible to use an integrator (Type 24) and a printer (Type 25), as long as you make sure you tell GenOpt where and how to find the cost function.



The project will create the GenOpt-Type56.dck TRNSYS input file (DCK file, or deck file). The building description is located in "Building.bui". Those two files will be used to generate templates for GenOpt (see below).

One particularity of the project is that the two optimisation variables, the overhang projection and the window height, have been defined in an equation block ("Parameters"). This is not strictly necessary but it makes your life easier when creating the GenOpt templates.

A list of all files used in the example is provided for reference at the end of this document (section 9)

with "GenOptRun.bui". This is not strictly necessary but it will ensure that your original BUI file is left as it is during the optimisation. This filename (GenOptRun.bui) must be provided to GenOpt in the project initialization file (see below).

```
*-----*
* Zone ROOM / Airnode ROOM
*-----*
ZONE ROOM
AIRNODE ROOM
WINDOW=DOUBLE : SURF= 1 : AREA= %aWindow% : EXTERNAL : ORI=SOUTHSHADED : FSKY=0.5
WALL =BST_H_EXT : SURF= 2 : AREA= %aWall% : EXTERNAL : ORI=SOUTH : FSKY=0.5
WALL =BST_H_EXT : SURF= 3 : AREA= 30 : EXTERNAL : ORI=NORTH : FSKY=0.5
WALL =BST_H_EXT : SURF= 4 : AREA= 30 : EXTERNAL : ORI=EAST : FSKY=0.5
```

5. Creating the project files for GenOpt

5.1. GenOpt configuration file for TRNSYS 16 (GenOpt-Trnsys16.cfg)

This file includes settings that should be used by GenOpt for all TRNSYS optimisation projects. For that reason, it should be located in the main GenOpt directory or in a directory within the TRNSYS 16 installation. However, for this example, we will use a local copy located in the project directory (C:\Program Files\Trnsys16\Examples\GenOpt-Type56).

Please check the file itself and comments inside the file for more information. Two items are worth noting: special characters and TRNExe switches.

5.1.1. Special characters

Any special character passed to the GenOpt string interpreter must be preceded by a backslash (\). Two special characters that are often used are the backslash itself (in pathnames) and the quotes. So the path TRNSYS 16 looks like:

```
C:\Program Files\Trnsys16\Exe\TRNExe.exe
```

And the input file name sent to TRNSYS (deck filename, which must be enclosed between quotes in case there are spaces in it) looks like:

```
\">%Simulation.Files.Input.Path1%\%Simulation.Files.Input.File1%
```

5.1.2. TRNExe switches

TRNExe must be called with special switches so that it does not stop at the end of the simulation and wait for a user action. Please check the "Running TRNSYS in batch mode" section in the TRNSYS Manual [1] for more details. The "/h" switch is used here, which means that TRNExe should run completely hidden in the background if there is no active online plotter in the simulation. At the time of writing, TRNBuild does not comply with this behaviour and you will still see its window popping up at each optimisation run, but the TRNSYS progress bar will not be displayed. Change to "/n" if you want to display the progress bar.

5.2. GenOpt project initialization file (GenOpt.ini)

This file is typically located in the project directory. It tells GenOpt where to find the files to run for the current optimisation project. Please check the file itself and comments inside the file for more information.

The warning about special characters in the GenOpt configuration file also applies here. In particular, any "\" in pathnames must be converted to "\\".

A few other points are worth noting:

5.2.1. Project path

If all input and output files are in the same directory, you only need to specify it once, at the first occurrence of "Path1". You can then refer to the previously defined path, by having instructions such as:

```
Path2 = Simulation.Files.Template.Path1;
```

includes settings that should be used by GenOpt for all TRNSYS optimisation projects. For that

5.2.2. Templates

Templates must be provided to GenOpt for the optimisation. You should provide the filenames for the two template files (DCK and BUI) described in section 4.

5.2.3. Input files

The "input" section provides filenames for the files created by GenOpt at each optimisation run, "GenOptRun.dck" and "GenoptRun.bui". You should remember that the template for the DCK file should refer to the correct BUI file, as explained in section 4.1.

5.2.4. Finding the value of the objective function

GenOpt must know in which file to look for the numerical value of the cost function after each run and how to find that numerical value.

The output filename and path are provided in the Simulation.Files.Output section:

```
Output {
  File1 = "GenOptRun.sum";
  Path1 = Simulation.Files.Template.Path1;
}
```

The place where to find the cost function is defined in the Simulation.ObjectiveFunctionLocation section:

```
ObjectiveFunctionLocation {
  Name1 = "QTot";
  Delimiter1 = "Sum 0.8760000000000000E+0004" ;
}
```

GenOpt always proceeds by looking for the **last occurrence of a delimiter string** and reading the numerical value **after that string**. What this section says is that the cost function named "QTot" should be read after the last occurrence of "Sum 0.8760000000000000E+0004". This is adapted to the output of Type 28 in mode "2", which is used in the example (note that mode 2 is **not** the default for Type 28), assuming that the cost function is the first output variable of Type 28 (the first column):

```
SUMMARY FOR UNIT 7
Simulation Summary in intervals of 1.000000 month
-----
Month Time QTot QHeat QCool
Jan 0.7440000000000000E+0003 0.7323671099231E+0003 0.7323671099231890E+0003 0.0000000000000000E+0000
Feb 0.1416000000000000E+0004 0.4932822976986E+0003 0.4928614184750621E+0003 0.4208792235762E+0000
...
(Edited for clarity. Note that the actual Type28 output also has more significant digits)
...
Nov 0.8016000000000000E+0004 0.3654354259556E+0003 0.3653657006425123E+0003 0.6972531304370E-0001
Dec 0.8760000000000000E+0004 0.7735996173125E+0003 0.7735996173502123E+0003 0.0000000000000000E+0000
Sum 0.8760000000000000E+0004 0.5114417241175E+0004 0.2959722064493123E+0004 0.2154695177090E+0004
```

(The value of the cost function, which is the yearly sum of QTot, is shown in bold).

5.3. GenOpt optimisation commands (GenOpt-OptimizationCommands.txt)

This file tells GenOpt what parameters to optimise and what algorithm to use.

Continuous parameters are defined by specifying a name, min/max/initial values and a step size for the first iterations (see [2] for more details and for information on how to define discrete variables).

```
Parameter {
  Name = h;
  Min = 0.01;
  Ini = 2.00;
  Max = 2.99;
  Step = 0.50;
  Type = CONTINUOUS;
}
```


7. Troubleshooting

7.1. GenOpt does not start

Launch a command prompt window, change the directory to "C:\Program Files\Trnsys16\Examples\Genopt-Type56" and type in the following command:

```
java -version
```

You should get something like this:

```
java version "1.5.0_11"  
Java(TM) 2 Runtime Environment, Standard Edition (build 1.5.0_11-b03)  
Java HotSpot(TM) Client VM (build 1.5.0_11-b03, mixed mode)
```

If not, reinstall the java runtime environment (see section 2)

If java seems to be working properly, type in the following command:

```
java genopt.WinGenOpt GenOpt.ini
```

This should open the main GenOpt window. If it does not, you are likely getting the following error:

```
Exception in thread "main" java.lang.NoClassDefFoundError: genopt/WinGenOpt
```

Did you set the CLASSPATH environment variable correctly? Repeat the steps in section 2.2.1. As a quick fix, you may try to type in the following instructions:

```
set CLASSPATH=%CLASSPATH%;C:\Program Files\GenOpt  
java genopt.WinGenOpt GenOpt.ini
```

Note that you will have to type in those instructions each time you run the program unless you set the environment variables correctly and save them as explained in section 2.2.1.

Another possible cause of that problem is that you did not install GenOpt correctly or that you installed it in a different directory. Check that the file "C:\Program Files\GenOpt\genopt\WinGenOpt.class" exists. It is easy to get confused with the GenOpt directory structure and to have a go_prog directory somewhere in the way. Just move your directories around until you get the following structure:

```
C:\Program Files\GenOpt  
  
  cfg  
  example  
  genopt  
  jdoc  
  
  readme.html  
  
C:\Program Files\GenOpt\genopt  
  
  algorithm  
  db  
  gui  
  img  
  io  
  lang  
  simulation  
  util  
  
  GenOpt.class  
  WinGenOpt$1.class  
  WinGenOpt$2.class  
  WinGenOpt$3.class  
  WinGenOpt$4.class  
  WinGenOpt.class
```

7.2. GenOpt is launched correctly but the optimisation does not start

Are you opening the correct initialisation file after pressing the green arrow? You should open the GenOpt.ini file that is in the current directory (C:\Program Files\Trnsys16\Examples\Genopt-Type56\GenOpt.ini).

If you are getting an error message similar to the following:

```
Error message:
*****
genopt.simulation.SimulationInputException:
Variable was not found in any simulation input template file,
or in any function objects:
  Searching for String: '%overhangProjection%'. Cannot find string.
  '%overhangProjection%' must occur in at least one simulation
  input template file, or in at least one function object.

GenOpt terminated with error.
```

You may have forgotten to edit the template files (DCK and BUI) and replace numerical values with their variable names, or you may have typos in the variable names. It is a good idea to start with only one variable and then refine the project.

8. References

- [1] Klein et al., 2004. TRNSYS 16 – A TRAnsient SYstem Simulation program, User manual. Volume 1: Getting Started. Solar Energy Laboratory, University of Wisconsin-Madison. More information on TRNSYS at <http://sel.me.wisc.edu> or <http://www.trnsys.com>
- [2] Wetter M. GenOpt, generic optimisation program, user manual, version 2.0.0. Technical report LBNL-54199, Lawrence Berkeley National Laboratory; 2004. Manual and program downloadable free of charge from <http://gundog.lbl.gov/GO>
- [3] TESS, 2004. TRNOPT v16 Installation, Run-Time Instructions, and License Agreement. Thermal Energy Systems Specialists, Madison, WI. <http://www.tess-inc.com>

9. Overview of example files (for reference)

File name	Role
Original TRNSYS project file (starting point)	
GenOpt-Type56.tpf	TRNSYS Studio project used as a starting point. It creates the TRNSYS input file (DCK) and several output files (LST, LOG, SUM) with the same name. In the project, Type 56 reads the building data from Building.bui
GenOpt-Type56.dck	TRNSYS input file (DCK, or deck) created by the project
GenOpt-Type56.log	TRNSYS LOG file created by the project
GenOpt-Type56.lst	TRNSYS LST file created by the project
GenOpt-Type56.sum	Output file created by Type 28. It includes QTot, the objective function (Total heating+cooling load)
GenOpt-Type56.pti	TRNSYS file with online plotter options (background color, etc.)
Original Building files (starting point)	
Building.bui	Building description file created with TRNBuild and used in the Studio project
Building.blb	Building data file automatically created by TRNBuild (from information in the BUI)
Building.trn	Building transfer function file automatically created by TRNBuild (from information in the BUI)
Building.inf	Building information file automatically created by TRNBuild (from information in the BUI)
Summary.bal	Output file automatically created by Type 56 (not used)
GenOpt configuration files	
GenOpt-TRNSYS16.cfg	GenOpt configuration file for TRNSYS 16
GenOpt.ini	GenOpt initialisation file for this optimisation project
GenOpt-OptimizationCommands.txt	GenOpt optimisation commands for this project
StartOptimization.bat	Batch file used to start the optimization project (optional)
GenOpt template files	
GenOpt-DeckTemplate.dck	GenOpt Template for the TRNSYS input (DCK) file
GenOpt-BuildingTemplate.bui	GenOpt Template for the building (BUI) file
Files created by GenOpt and TRNSYS at each optimisation run	
GenOptRun.dck	TRNSYS input file (DCK) for current run
GenOptRun.bui	TRNSYS building file (BUI) for current run. Note that the DCK file must refer to the correct BUI file!
GenOpt.log	TRNSYS LOG file for the current run
GenOpt.lst	TRNSYS LST file for the current run
GenOpt.sum	TRNSYS output file (with the objective function) for the current run
Files created by GenOpt during the optimisation process	
GenOpt.log	GenOpt log file with optimisation start / end time, error messages etc.
OutputListingMain.txt	Short version of the GenOpt output file (Main iterations only)
OutputListingAll.txt	Long version of the GenOpt output file