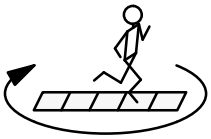
8 ADVANCED RUN FEATURES

8.1 MULTIPLE RUNS



It is often useful to repeat a case several times using a different value for a particular parameter. For instance, varying the time that a fault is applied to obtain the response of the system as a function of the fault's "point on wave" time. Sometimes, only the best case or the worst case of a particular situation is required.

The PSCAD software provides an automated method to vary one or two parameters over successive runs. The parameters may be varied sequentially or randomly over a specified range. The "signal to optimize" selects a quantity of interest to minimize or maximize over the successive runs. When varying two parameters, a contour plot of the "signal to optimize" is shown.

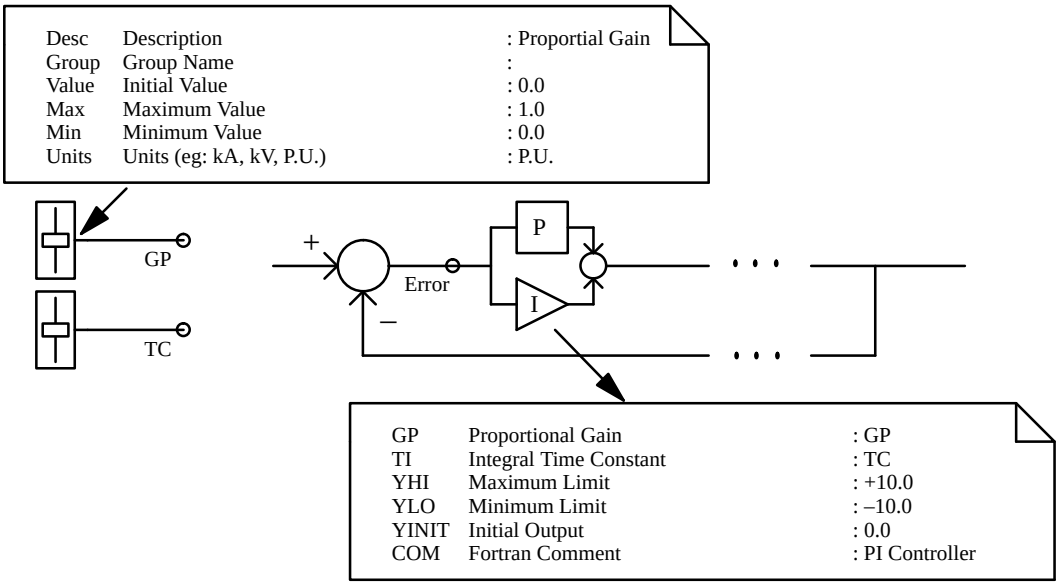
The examples in the chapter are extracted from the "`PI.dft`" example circuit in the "`MultiRun`" case of the "`Tutorial`" project.

8.1.1 Creating Variable Parameters

The parameters for a run are set through "slider" inputs. The value of the slider is set at the start of each run, and should remain constant throughout the run. The slider output may be attached directly to a control block, or given a wire label and that label used in a parameter in a control block.

For example, if the gains of a PI controller in a control system are to be varied, the circuit drawing in DRAFT may contain the following:

Although "slider" components are used in DRAFT, the corresponding sliders will not be created in RUNTIME. The multiple run component controls these values directly.



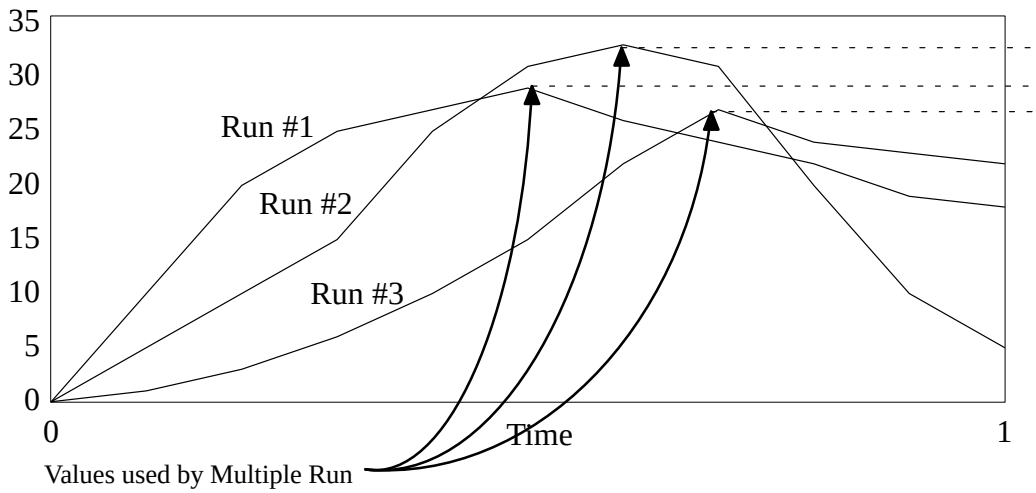
8.1.2 Creating a Goal Signal

The Multiple Run feature requires a signal which is to be maximized or minimized. Any signal which is available for plotting in RUNTIME may be selected.

The signal to be maximized or minimized is *the largest magnitude the specified channel obtains through the course of the run*. If the value at the end of the run is required, this value should have the largest magnitude due to the nature of the signal, or be sampled only at the end of the run.

Best case or worst case is dependant on whether the search is to find the best result, or to find how bad the worst result is.

For example, in the following, if the "signal to optimize" was *maximized*, then Run #2 would be indicated as the best (worst) run. If the "signal to optimize" was instead *minimized*, then Run #3 would be indicated as the best (worst) run. In other words, Run #2 has the *largest maximum*, and Run #3 has the *smallest maximum*.

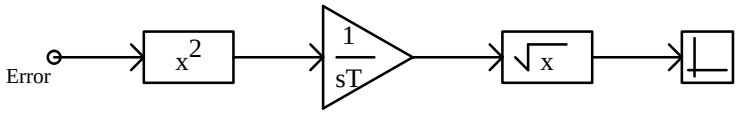


The square root is not necessary for optimization. Removing it will speed up the run. However, for nicer looking contour plots, including it is desirable.

For a PI controller in a control loop, finding the best gain might correspond with determining which gains produce the smallest root mean squared (RMS) error at the end of the run. This function

$$\sqrt{\frac{1}{T}\int_0^t \text{Error}^2 \, dt}$$

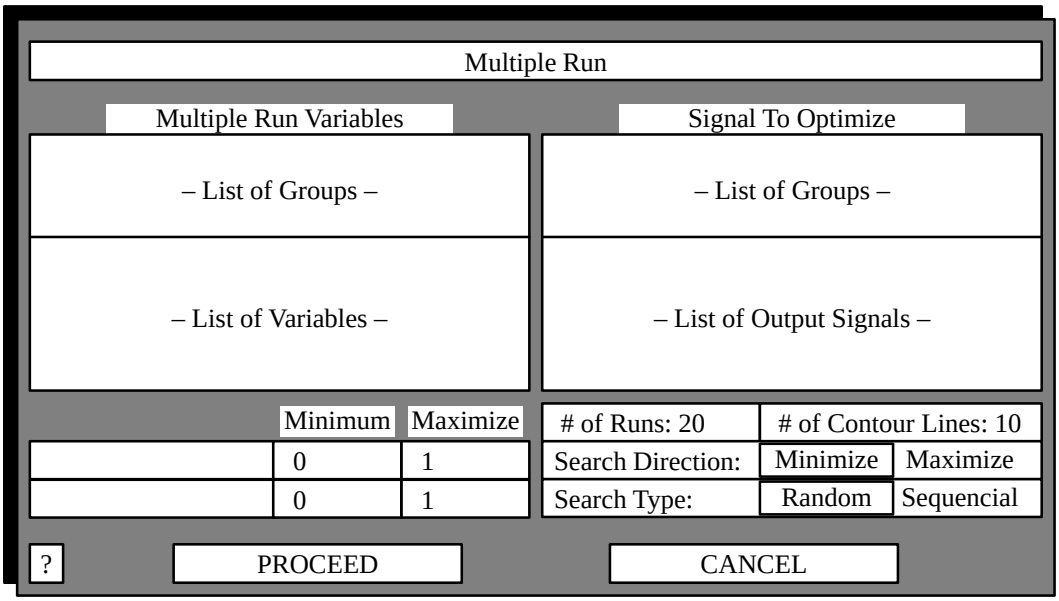
is monotonically increasing, and hence obtains its maximum magnitude at the end of the run.



8.1.3 Performing a Multiple Run

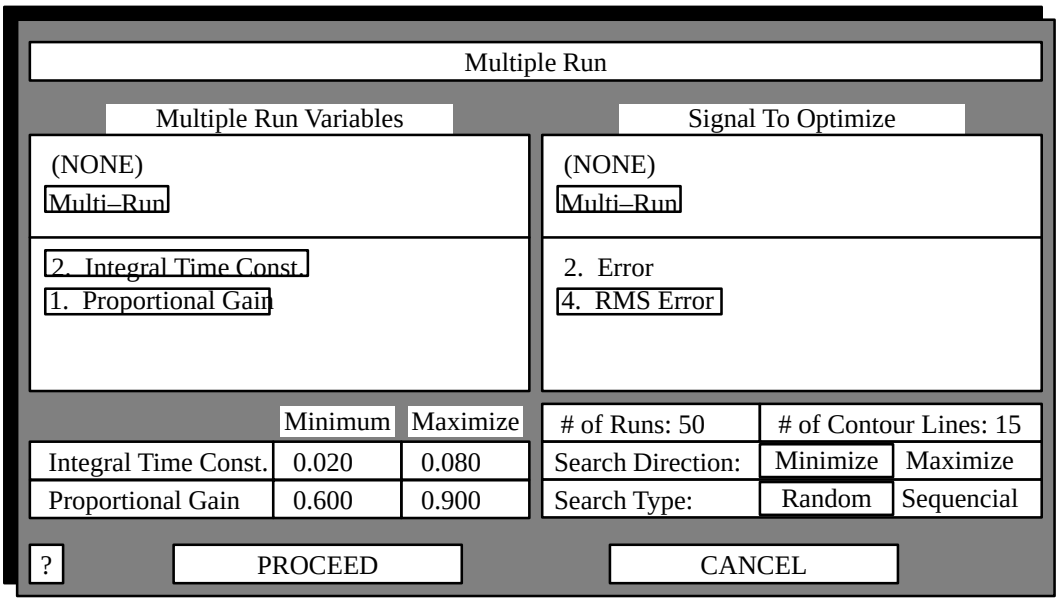
From the RUNTIME OPERATOR'S CONSOLE, sliders can be created. The user might then set the slider value(s), start a run, and examine the results. The slider values would then be changed and the case re–run until the desired results are obtained.

Instead of creating the slider interface object components, setting their values and running the case many times, a *Multiple Run* component can be created. From the OPERATOR'S CONSOLE, select MULTIPLE RUN from the CREATE menu.



In the case of the optimization of the PI controller's gain and time constants to obtain the smallest RMS error, the form may be filled in as follows. Here, it is assumed the best results (smallest RMS error) will occur for a gain inside the range 0.600 to 0.900 and a time constant inside the range 0.020 to 0.080.

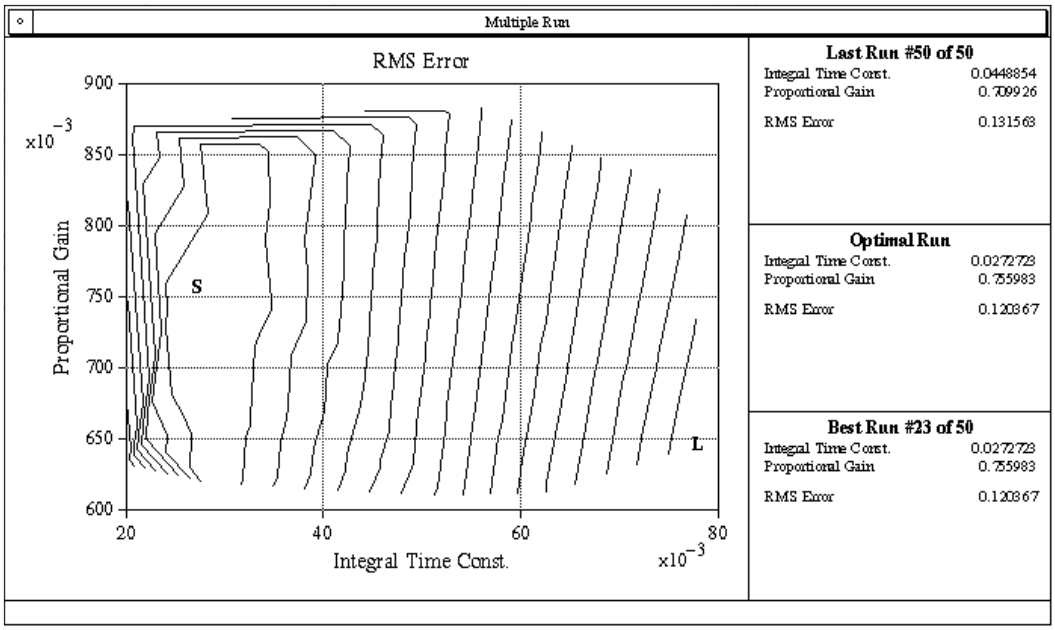
To allow repeatable results, the seed number used in the random search is the number of runs.



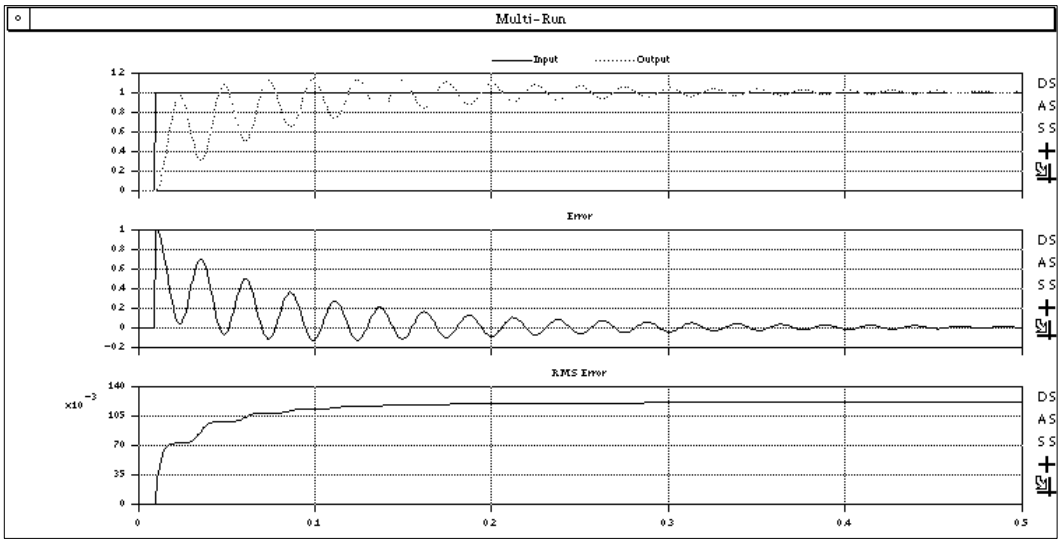
When the PROCEED button is selected, a *Multiple–Run* component will appear in the OPERATOR'S CONSOLE. Anytime the start (▶) button is selected when a multiple–run component exists, a multiple run is started.

For the gain and time–constant optimization of a PI controller in a control loop with a low pass filter, with an input unit step, the following contour plot in the multiple run component is generated.

Note: This image was produced by taking a "snapshot" of the screen image.

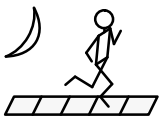


The output of the run which produced the best case is shown below.



Do not create sliders to control variables which are being controlled by the multiple run. Also, to prevent erroneous results, do not change the value of any other sliders, switches, dials, etc., during the course of a multiple run.

8.2 BACKGROUND RUNS

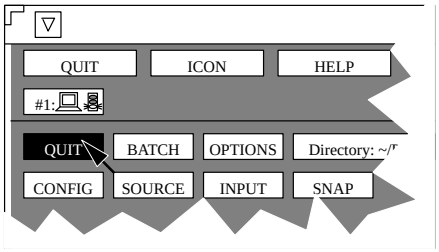


8.2.1 Placing a Run in the Background

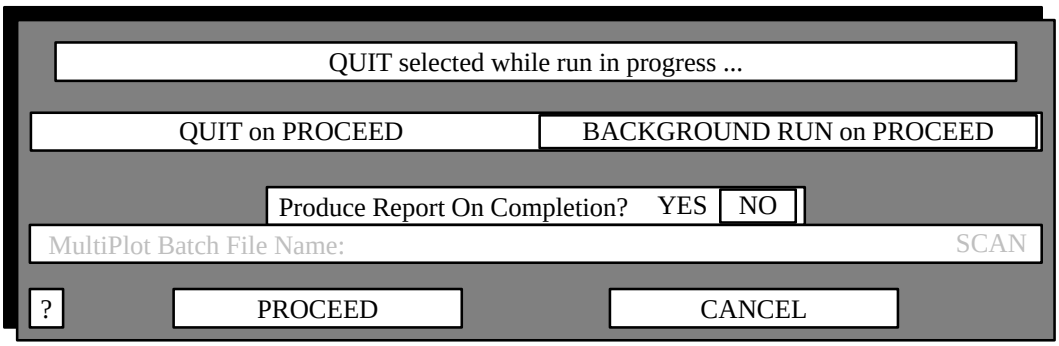
Many non–interactive simulations, especially multiple run simulations, may take a long time to finish. In these cases, it is often useful to place the run "in the background", where it continues to run, even if the user logs out and goes home for the night.

Since the run is not visible once placed in the background, no interactions may occur with the run. The "Copy Back" form will not appear at the end of the run. Instead, all of the output files produced by the run are automatically copied back.

To place a run in the background, start the run as normal, and at any point during the run select QUIT from the OPERATOR'S CONSOLE.



The run will pause, and the following form will appear.



Select BACKGROUND RUN on PROCEED and then select PROCEED to place the run in the background.

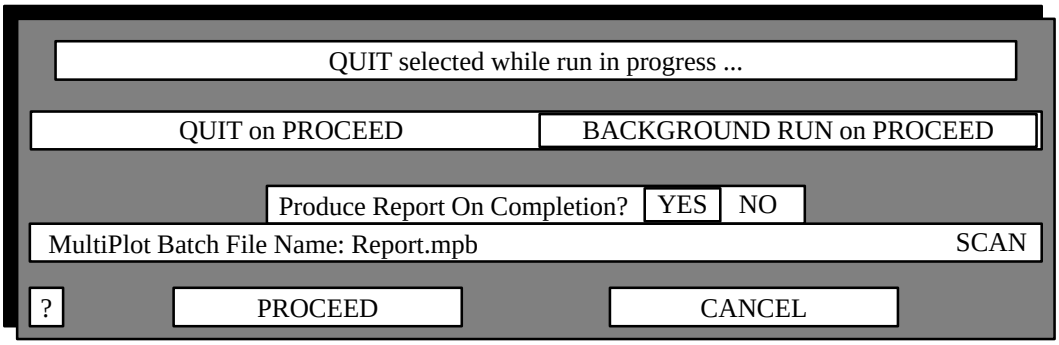
Once a run has been placed in the background, the only way to stop the run is to send a SIGTERM signal to the "`runemtdc`" process on the machine where the run was started.

Eg)

```
machine% ps xc | grep runemtdc
10817 co IW    0:03 runemtdc
machine% kill –TERM 10817
machine%
```

8.2.2 Producing Reports from Background Runs

When a background run ends, a report containing the graphs which were produced can be automatically sent to the printer. This is accomplished by specifying the name of the MULTIPLOT batch file (`*.mpb`) to be used to generate the report in the background run form.



To create the MULTIPLOT batch file, the information file (`*.inf`) and output files (`*.out-*`) must already exist. If these do not exist, run the case for a <u>short</u> period of time, writing output files, and copy the output files back. The MULTIPLOT file can then be created with the desired graphs and text, and then the multiple run started.

The MULTIPLOT batch file must not contain any graphs which are based on the output of “Calculator” or “Fourier Analysis”.