POWERFACTORY

How can I setup an Under Frequency Load Shedding (UFLS) scheme?

1 Basics

This example shows a simple under frequency load shedding scheme (or UFLS for short) in the 39 Bus New England System for the loads at buses 16, 21 and 23 as shown in the figure 1.1. You should import the *PowerFactory* example "39 Bus New England System with UFLS.pfd".

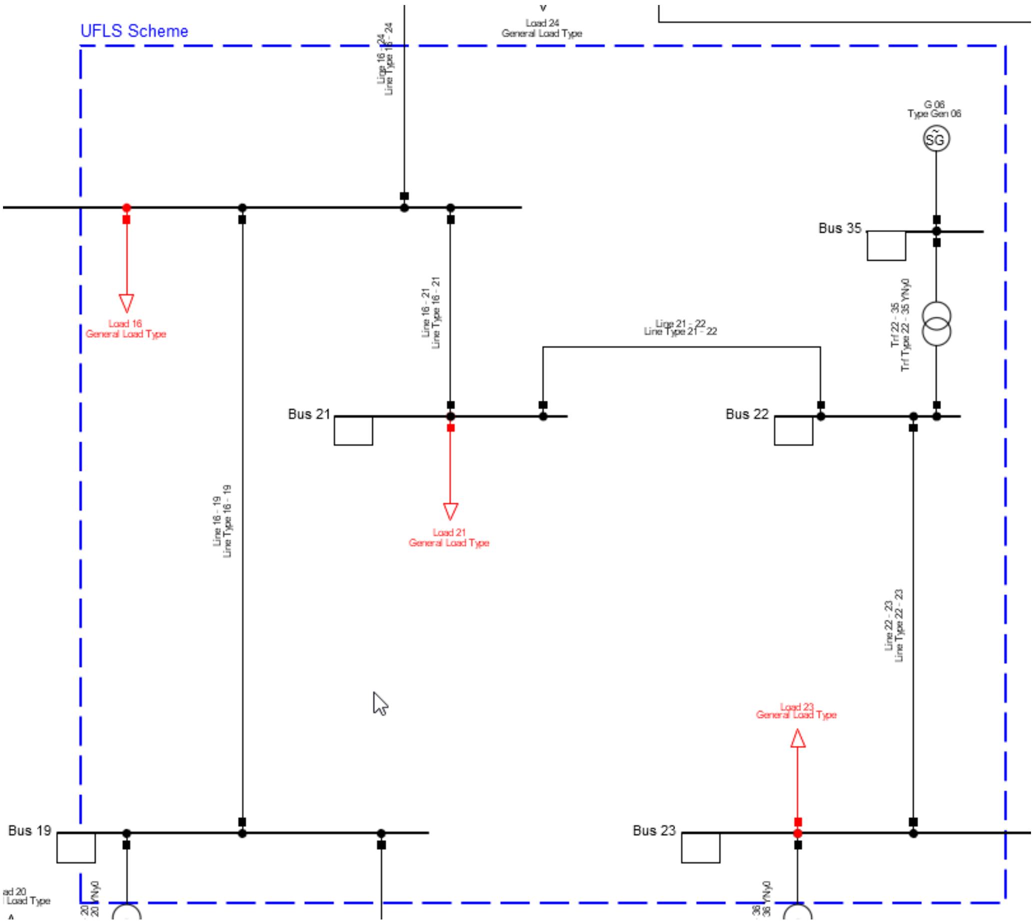

Figure 1.1: Network with UFLS Scheme

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You can access the relay by right-clicking on a load cubicle and selecting the *Edit Devices* option as illustrated in the figure 1.2.

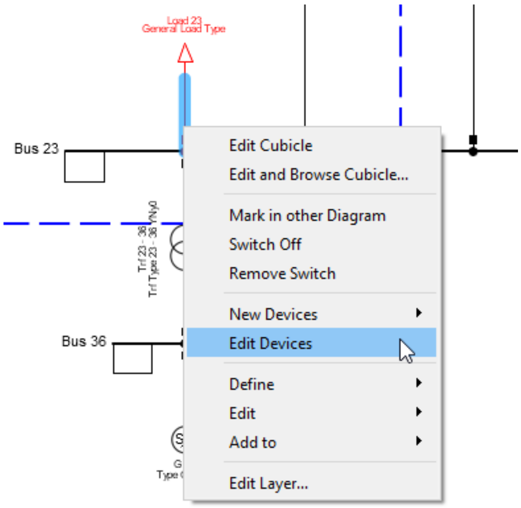

Figure 1.2: Open the devices contained in the load cubicle

Later, you can view the relay listed in the *Edit Devices* window as shown in the following figure.

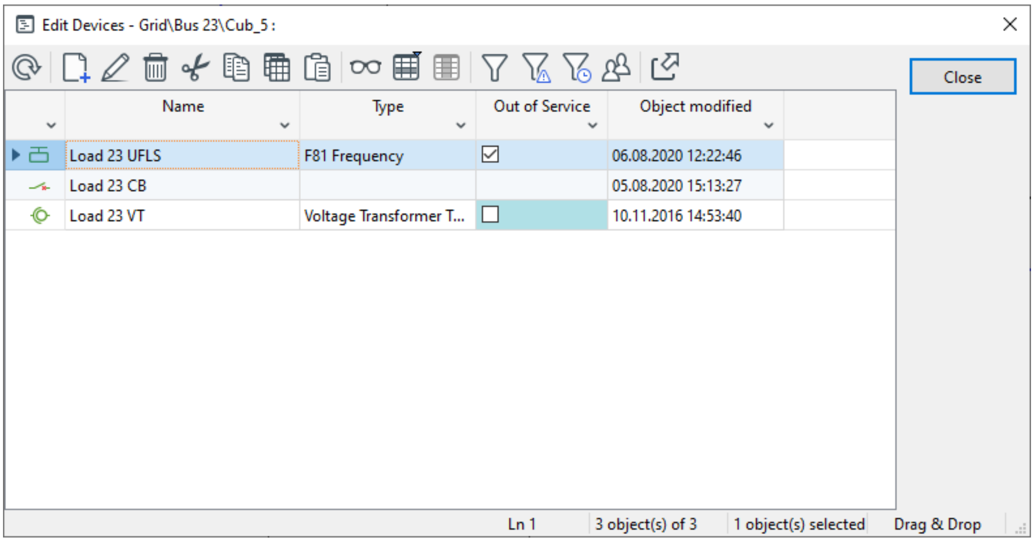

Figure 1.3: Relay Load 23 UFLS configured in the Load 23 cubicle

The edit dialog of one of the UFLS protection relay elements is presented in figure 1.4.

You can click on the f<1 function to view the stage 1 underfrequency protection element. In this case, the load is set to trip if the frequency falls below 59.8 Hz for 5 seconds or more. The underfrequency function $f < 1$ is as shown in the figure 1.5.

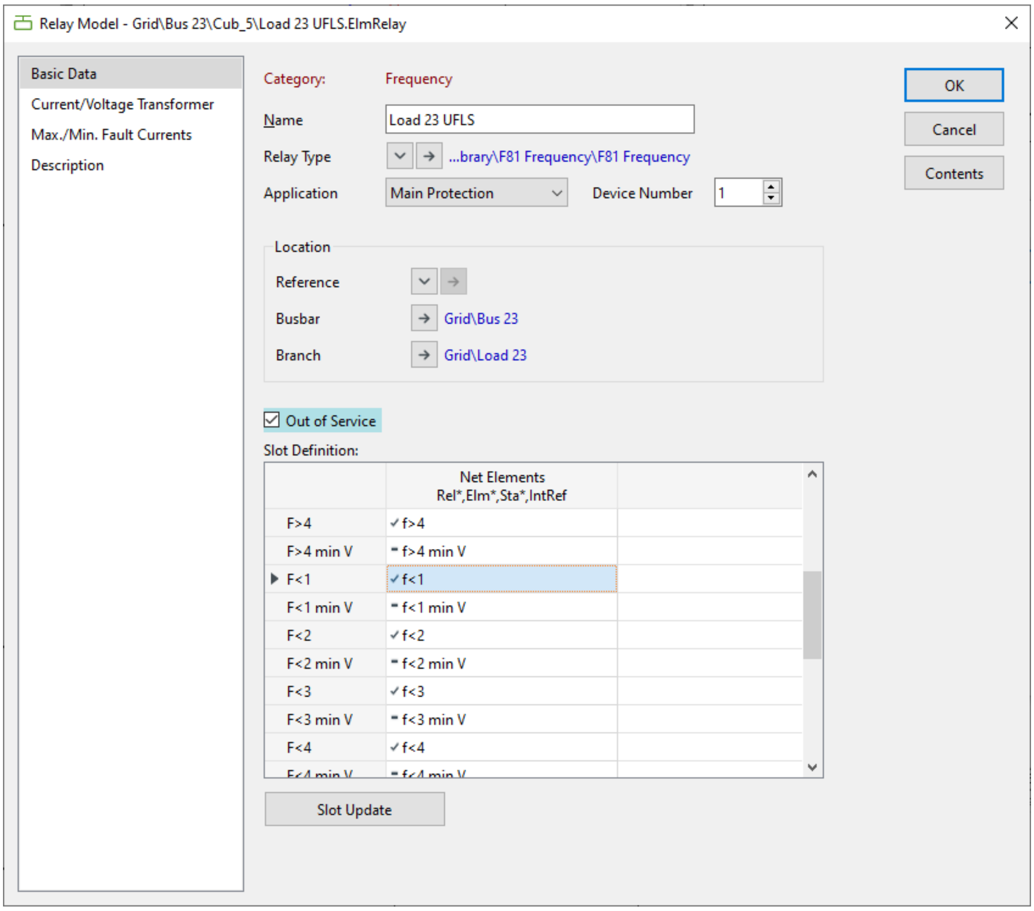

Figure 1.4: Relay Model for Load 23 UFLS

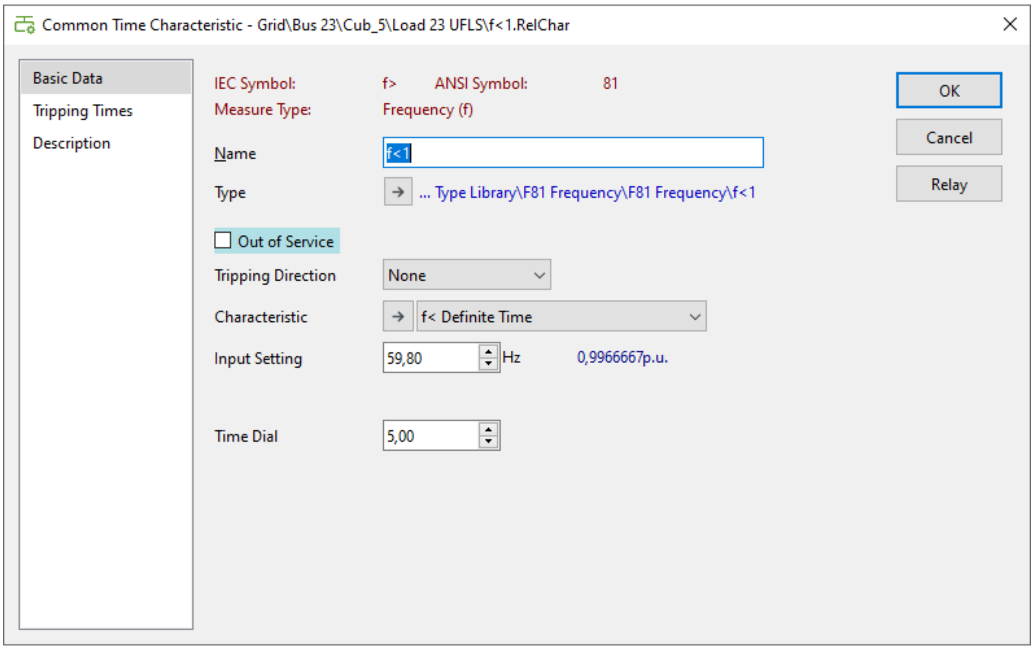

Figure 1.5: Stage 1 underfrequency element

2 Generator Trip Frequency Response

The frequency response of the system as a result of disconnecting the generator “G 06” at $t = 1s$ is analysed in this section. To achieve this, we will simulate four study as mentioned below:

- When no UFLS is in service.
- When UFLS at Load 23 in service.
- When UFLS at Load 21, 23 are in service.
- When UFLS at Load 16, 21 and 23 are in service.

Case 1: Right click on the Study Case “01_G 06 Trip without UFLS” and activate it. When no UFLS is in service, the following plot as shown in the figure 2.1 shows the frequency response of the system.

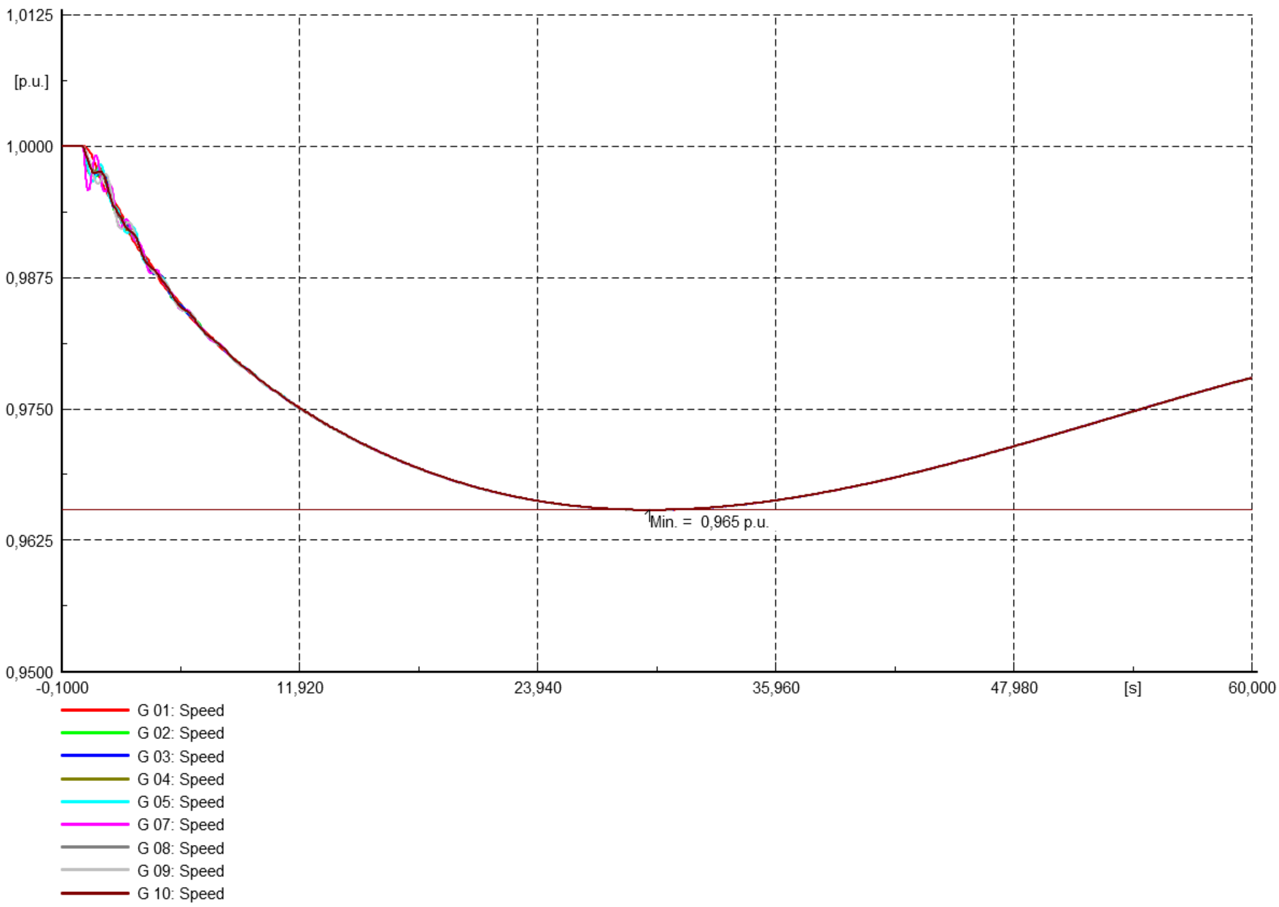

Figure 2.1: G 06 Trip without UFLS active

It can be seen that the minimum frequency dips to 0.965 p.u. (or 57.9 Hz) while the long term response shows that the frequency does not recover back to the nominal grid frequency of 60 Hz after 60 seconds. Typically, this would be addressed through means of UFLS or via secondary frequency control measures such as AGC. The primary frequency response of the generators is performed through the governors and typically there will always be a post-disturbance offset in frequency due to the governor droop setting.In this example, we will analyse the effects of UFLS protection relays at loads 16 (329 MW), 21 (274 MW) and 23 (247.5 MW). Prior to the disconnection of the generator “G 06”, it is supplying 650 MW of active power.

Case 2: Right click on the Study Case "02_G 06 Trip with UFLS 23" and activate it. When UFLS at Load 23 is in service, the following plot as shown in the figure 2.2 shows the frequency response of the system.

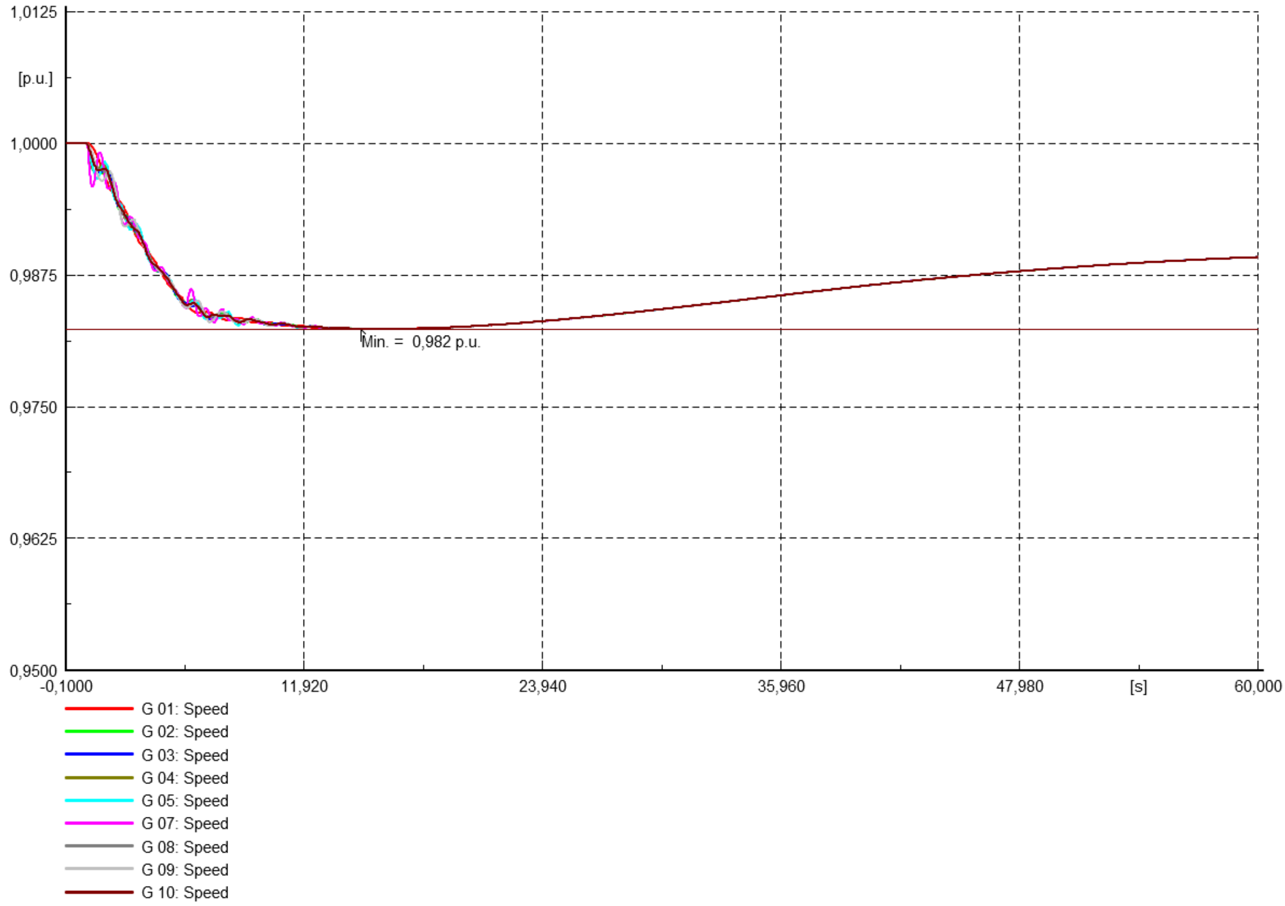

Figure 2.2: G 06 Trip with UFLS at Load 23

In this case, Load 23 is shed which represents a disconnection of 247.5 MW in response to the frequency decline resulting from the disconnection of the generator "G 06". The minimum frequency dips to 0.982 p.u. (or 58.92 Hz) but is still below 60 Hz after 60 seconds.

Case 3: Right click on the Study Case "03_G 06 Trip with UFLS23_21" and activate it. When UFLS at Loads 21 and 23 is in service, the following plot as shown in the figure 2.3 shows the frequency response of the system.

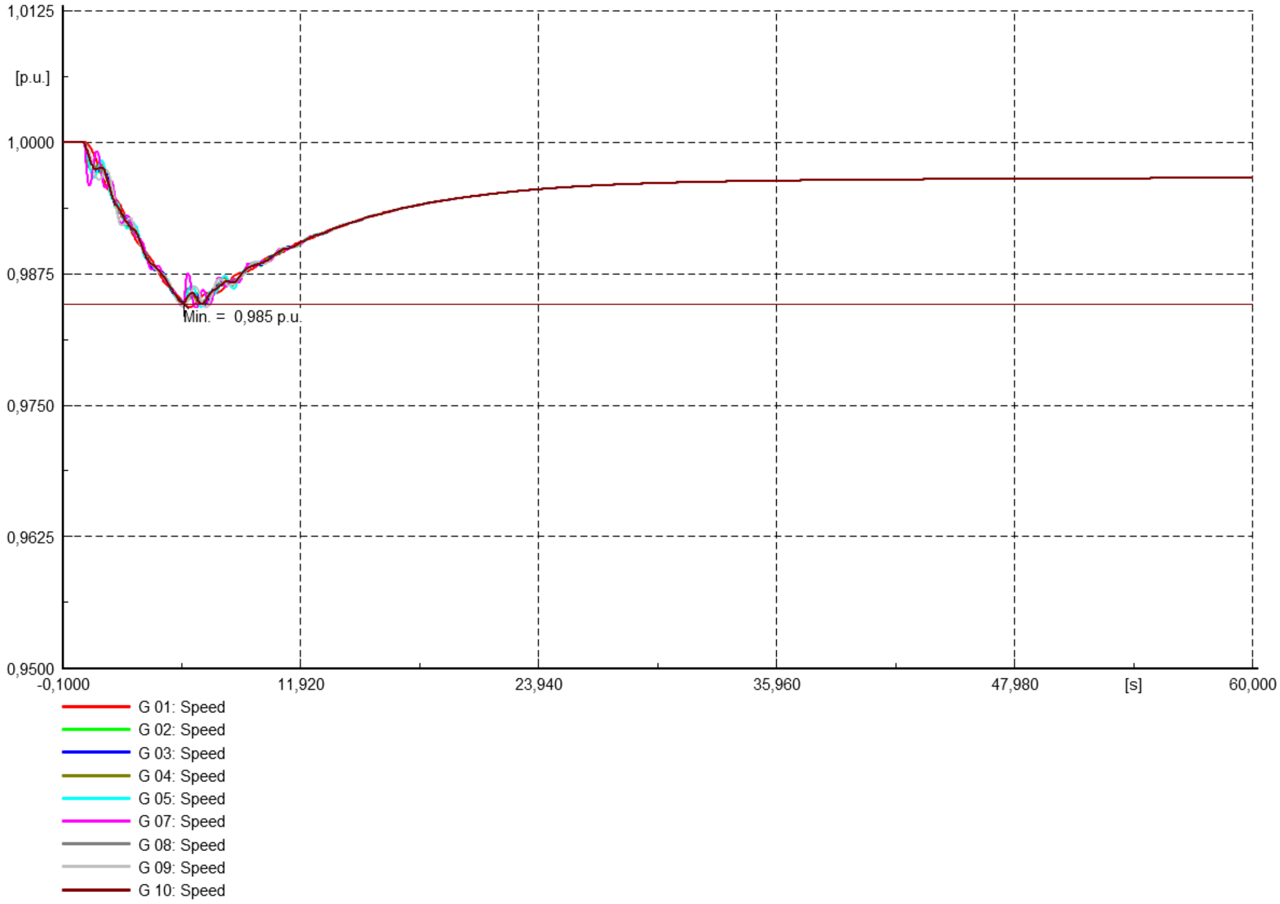

Figure 2.3: G 06 Trip with UFLS at Load 21 and 23

In this case, Loads 21 and 23 are shed which represents a disconnection of 521.5 MW in response to the frequency decline resulting from the disconnection of the generator “G 06”. The minimum frequency dips to 0.984 p.u. (or 59.04 Hz) and recovers to 0.997 p.u. (or 59.82 Hz) after 60 seconds.

Case 4: Right click on the Study Case “04_G 06 Trip with UFLS” and activate it. When UFLS at Loads 16, 21 and 23 is in service, the following plot as shown in the figure 2.4 shows the frequency response of the system.

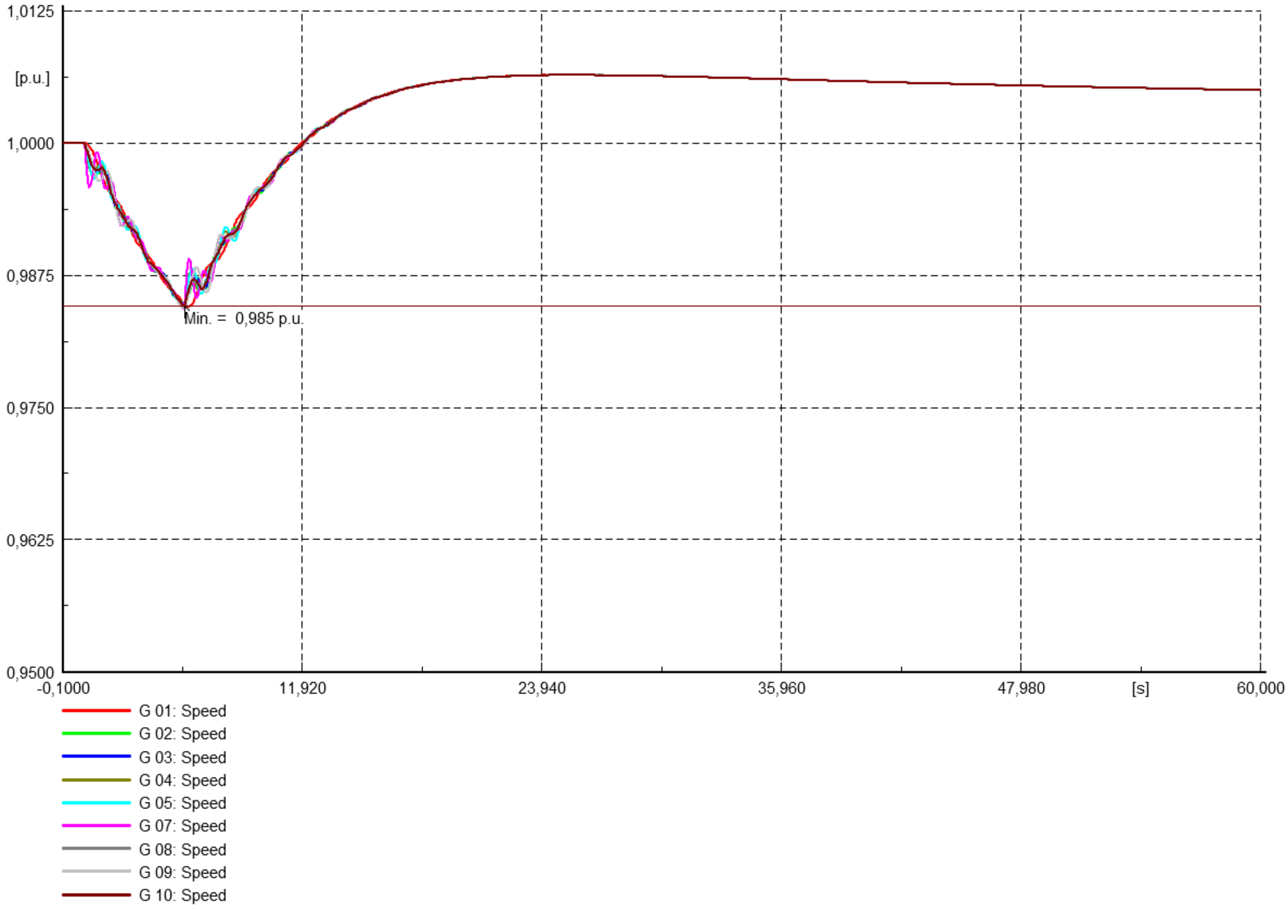

Figure 2.4: G 06 Trip with UFLS at Load 16, 21 and 23

In this case, Loads 16, 21 and 23 are shed which represents a disconnection of 850.5 MW in response to the frequency decline resulting from the disconnection of the generator “G 06”. The minimum frequency dips to 0.984 p.u. (or 59.04 Hz) and recovers to above 60 Hz after 60 seconds. In this case, shedding 850.5 MW in response to a 650 MW shortfall in generation would be considered excessive, which leads to the overfrequency condition after UFLS has taken place.

As you can see from all the four curves, generator “G 07” is having more fluctuations in frequency. Therefore, the plot shown in figure 2.5 shows the speed response of generator “G 07” in all four different scenarios.

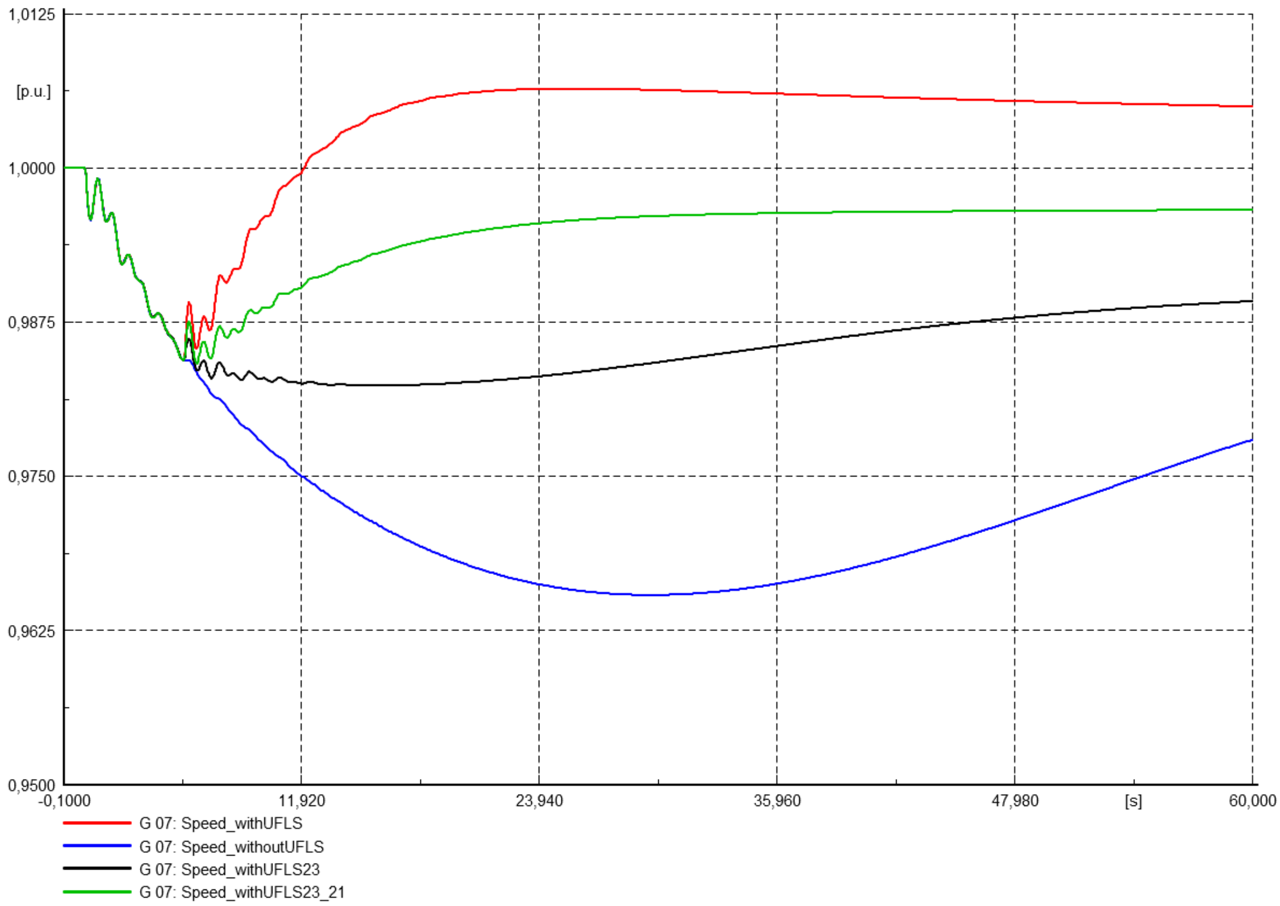

Figure 2.5: Speed Response of generator “G 07” in different scenarios

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