

ETAP TIP – No. 010

Transient Stability – Relay Controlled Actions

Applicable ETAP Versions: 5.5.0, 5.5.5, 5.5.6

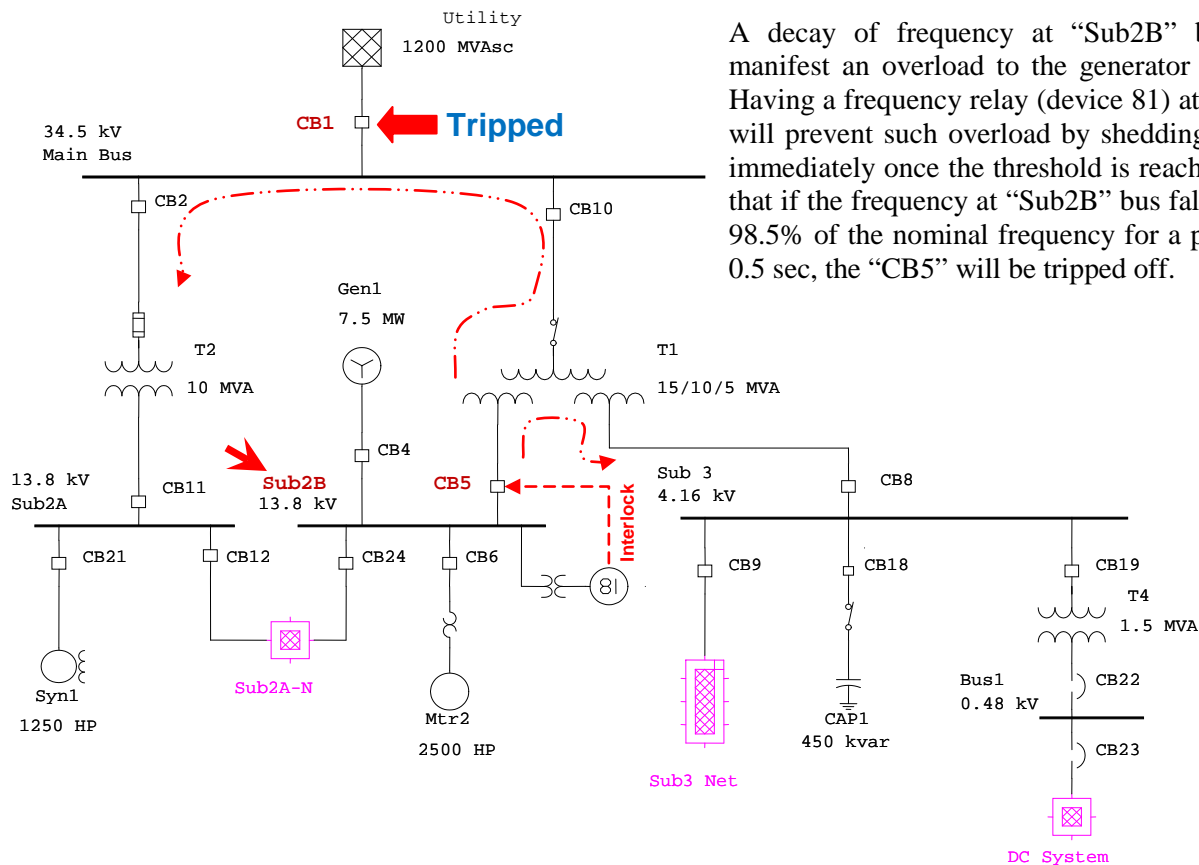
(For lower versions, some of the descriptions and procedures below may differ in some ways)

As illustrated in ETAP TIP – No. 009, the “Events and Actions” method requires pre-determine action times.

In power systems, many actions occur without any pre-acknowledgment, instead, they are controlled by sensors and relays. For instance, a current relay (50/51) will trip off circuit breakers once the measured current by relay exceeds a pre-set value. In another case, a voltage relay (27/59) can be used to open or close circuit breakers based on its monitored voltage and comparison with an upper and a lower setting. These types of actions do not have a definite time of happening and are solely dependent on the system dynamic responses and relay settings. In ETAP, the actions of relays can be integrated in the transient stability to resemble the true power system real operating conditions.


Illustration:

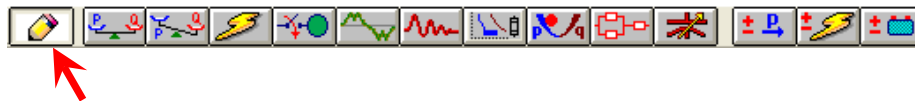
Using the “Example-ANSI.oti” sample project, suppose that Utility “CB1” tripped off. After this event, generator “Gen1” will be islanded and will supply the balance power.



A decay of frequency at “Sub2B” bus will manifest an overload to the generator “Gen1”. Having a frequency relay (device 81) at this bus will prevent such overload by shedding load(s) immediately once the threshold is reached. Say that if the frequency at “Sub2B” bus falls below 98.5% of the nominal frequency for a period of 0.5 sec, the “CB5” will be tripped off.

Procedure:

1. To incorporate the action of 81 relay in Transient stability simulation, it should be modeled first.
2. Activate the “Study View” one line diagram presentation by clicking its window (or you can go to “project view” and double click “Study View” folder)
3. Switch to “Edit” mode by clicking the “Pencil” icon  on the mode toolbar.



4. Model the Potential Transformer.
See Fig. 1

- a. On the “AC Instrumentation” toolbar, click the “Potential Transformer” (PT) icon.
- b. Move the mouse under “Sub2B” bus
- c. Connect the left terminal of the “PT” to bus “Sub2B” by dragging the square handle of the former towards the latter.

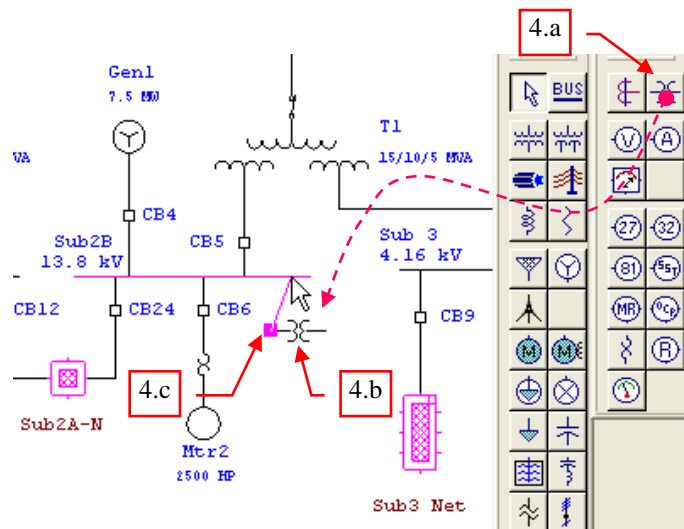


Fig. 1

5. Model the Frequency Relay (Device 81).
See Fig. 2

- a. On the “AC Instrumentation” toolbar, click the frequency relay “81” icon.
- b. Move the mouse on the right side of the PT.
- c. Connect the device 81 relay to the right terminal of the “PT” by drag and drop.

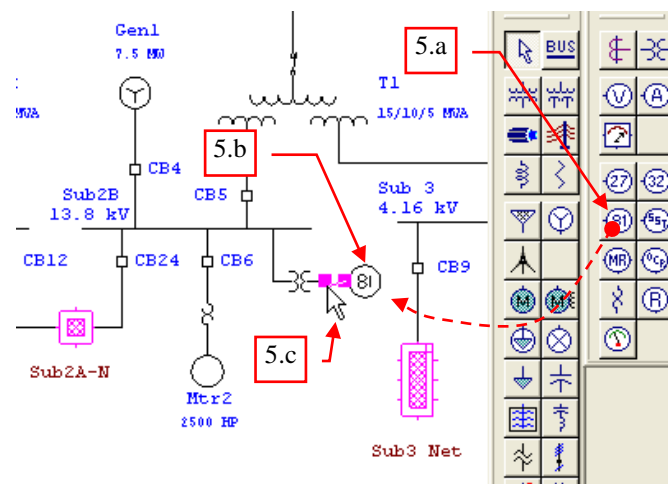


Fig. 2

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6. Define the setting of the “81” relay. See Fig. 3.

a. Double-click the “81” relay symbol on the One Line Diagram. The “Frequency Relay Editor” dialog box will be displayed.

b. Click on the “Setting” tab of the “Frequency Relay Editor” dialog box.

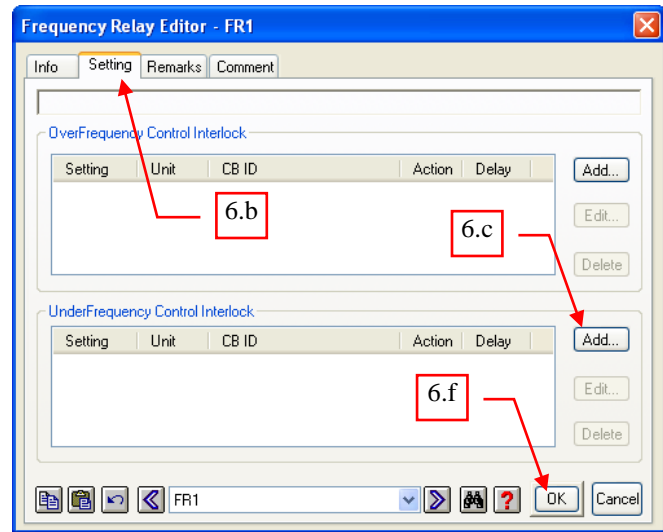
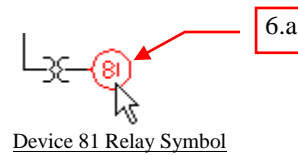
c. On the “UnderFrequency Control Interlock” frame, click on “Add...” button. The “Frequency Relay Control Interlock Editor” will be displayed.

d. On the “Frequency Relay Control Interlock Editor”, enter the following:

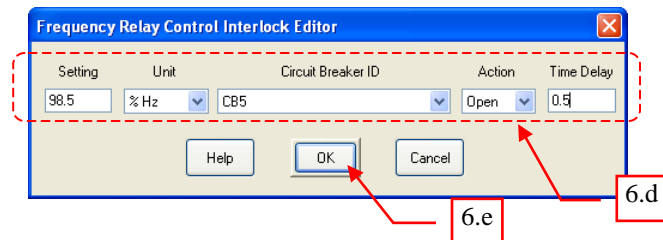
Setting : 98.5%
Unit : %Hz
Circuit Breaker ID : CB5
Action : Open
Time Delay : 0.5 sec

e. Click the “OK” button on the “Frequency Relay Control Interlock Editor” dialog box.

f. Click the “OK” button on the “Frequency Relay Editor” dialog box.




Frequency Relay Editor




Frequency Relay Control Interlock Editor

Fig. 3

7. Switch to Transient Stability Analysis Mode by clicking the icon  on the “Mode” toolbar.



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8. Create a new study case (by copying an existing one) by clicking the icon  on the “Study Case” toolbar



9. The “Duplicate Study Case” dialog box will be displayed as shown in Fig. 4.

- a. Select the existing study case to be copied i.e. “TS”.
- b. Enter a unique name for the new study case. For example, “Relay-Action”
- c. Click “Ok” button

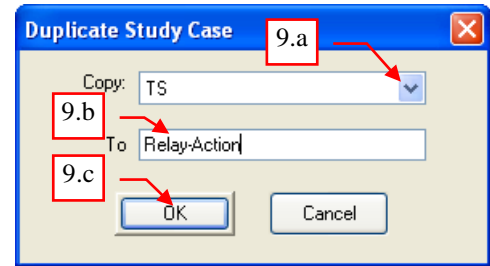



Fig. 4

10. Edit the study case “Relay-Action”. See Fig. 5

- a. Select the study case “Relay-Action”.
- b. Click “Edit Study Case” button 

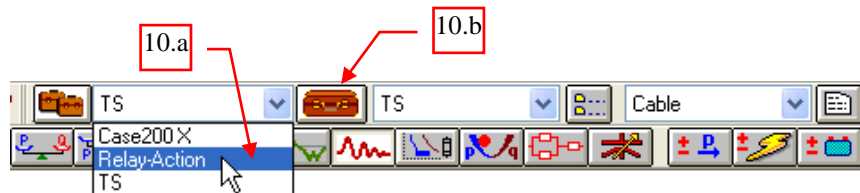


Fig. 5

11. The “Transient Stability Study Case” dialog box will be displayed as shown in Fig. 6. Click the “Events” Tab.

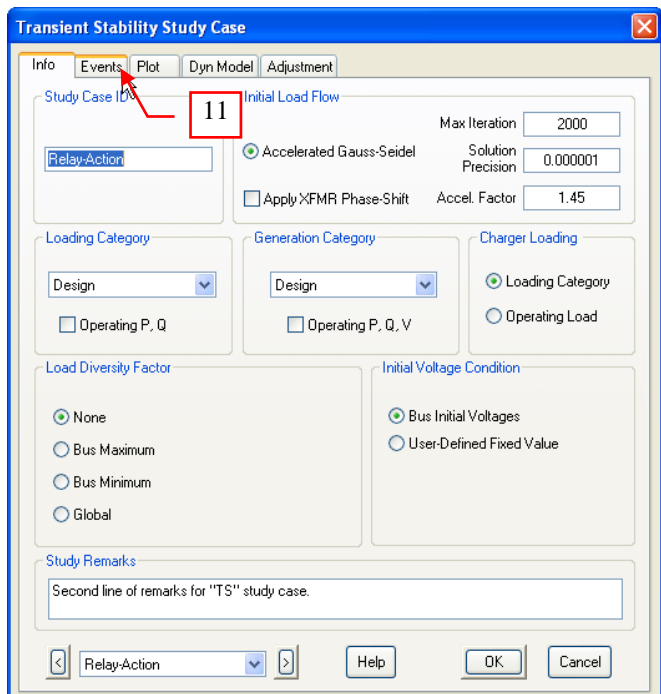


Fig. 6

12. In the “Events” tab, existing events and actions will be seen that were inherited from the “TS” study case copied in Step 9 (See Fig. 7). Delete these and create a new event and action, i.e. trip “CB1”.

- Select “Even1” ID
- Click “Delete” button
- Do similar actions to delete “Event2”
- Click “Add..” button. The “Event Editor” dialog box will be displayed.

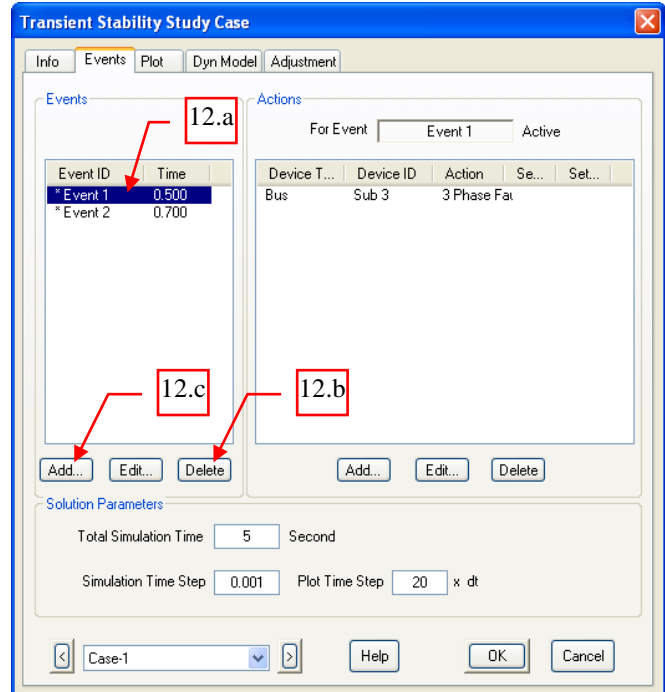


Fig. 7

13. In the “Event Editor” dialog box shown in Fig. 8, do the following:

- Type “E1” on the “Event ID” text box
 - Type “0.5” on the “Time” text box
- Note: 0.5 is the time in second at which the event occurs.
- Click the “OK” button

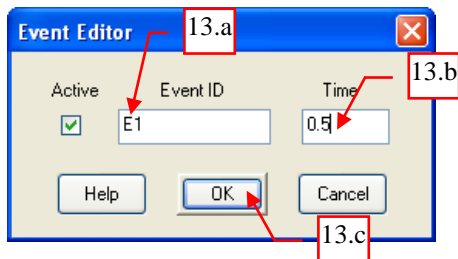


Fig. 8

14. With the Event ID “E1” active (selected) in the “Events” Frame of the “Events” dialog box, click the “Add” button at the “Actions” frame (See Fig. 9). The “Action Editor” dialog box will be displayed.

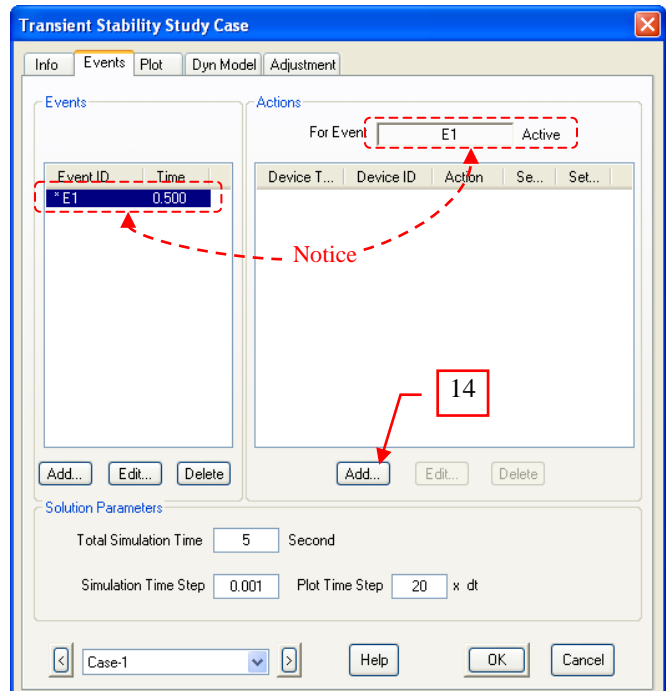


Fig. 9

15. Do the following in the “Action Editor” dialog box shown in Fig. 10:

- Select “Circuit Breaker” on the “Device Type”.
- Select “CB1” on the “Device ID”.
- Select “Open” on the “Action”.
- Click the “OK” button.

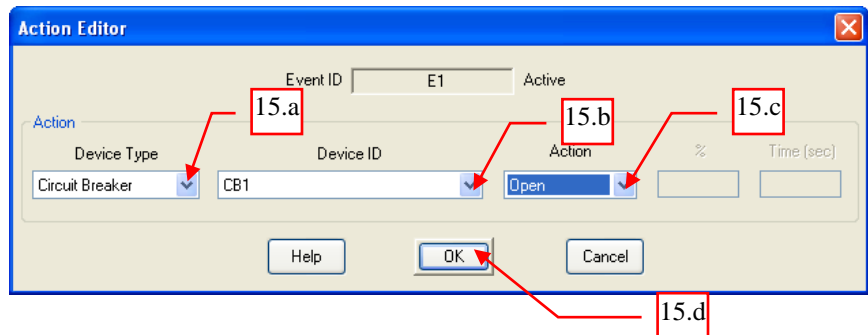


Fig. 10

16. For this particular exercise, maintain the existing setting on the “Solution Parameters” frame.

17. Since the concern is to verify frequency at bus “Sub2B” when “CB1” opens, instruct the program to create plot profiles for the said bus. See Fig. 11.

- Click the “Plot” tab.
- On the “Device Type”, select “Buses”.
- On the “Plot Options” select “Sub2B”.
- Click the “Plot & Tabulate” check box to leave a check mark, or just click directly at the “Plot/Tabulate” column adjacent to “Sub2B”. Note: “X” mark means plots will be created.
- Click the “OK” button to close the study case.

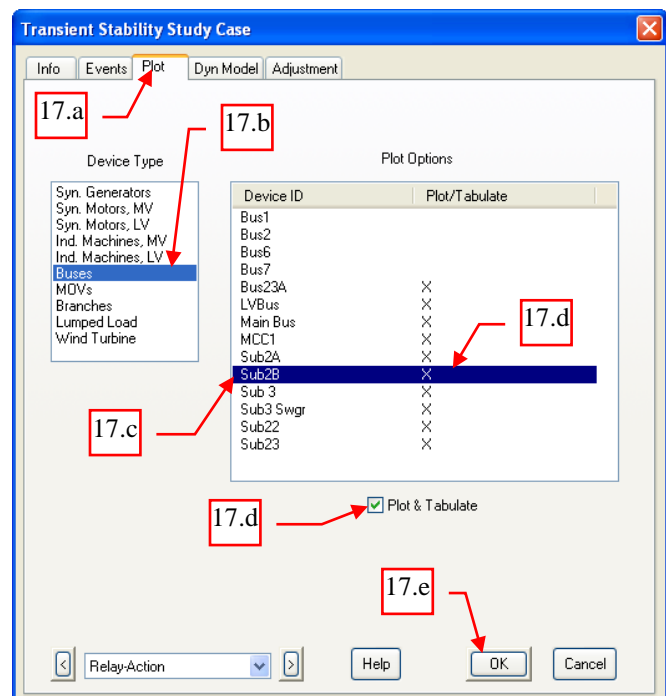


Fig. 11

18. Now, run the simulation. On the “Study Case” toolbar, select “Prompt” from the “Output Report” pull down box. The program will prompt for a filename of the output report for the study case “Relay-Action” when the simulation is ran. See Fig. 12.

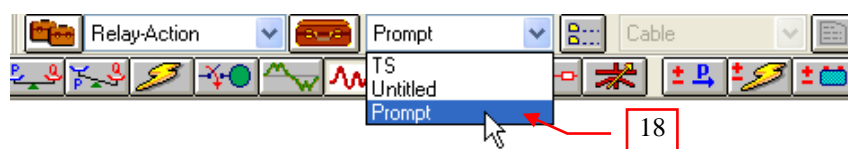
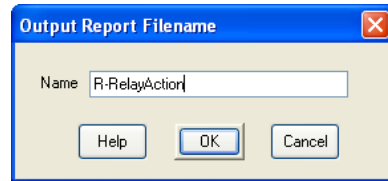


Fig. 12

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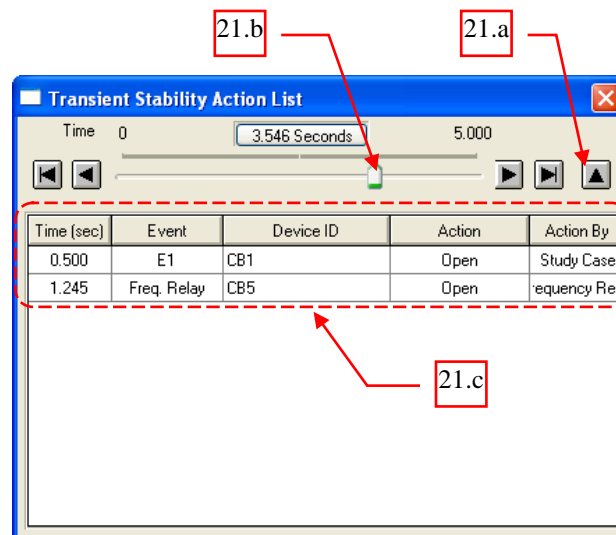
19. On the “Transient Stability” toolbar, click “Run Transient Stability” button, see Fig. 13.

20. The “Output Report Filename” dialog box will be displayed (due to Step 18) as shown below. Type “R-RelayAction” and click the “OK” button. The program will proceed with the calculation.



21. When the calculation is complete, the “Transient Stability Time-Slider” dialog box will be displayed. This slider allows for animation of the result of simulation at different points in time. See Fig. 14.

- a. Click the “Toggle Action List” button to show the “Action List”
- b. Click and drag the “Slide Pointer” towards right.
- c. Notice the “Action List” is populated with the events, associated devices, and the corresponding actions in chronological order.



Notes for the Events:

- i. Event “E1” is the Event specified on the Study Case with pre-determine action time. See Step 13
- ii. Event “Freq Relay” is the event triggered by the relay 81 action where the action time was determined by the system dynamic response and relay settings

22. To view the “Sub2B” bus profile, on the “Transient Stability” toolbar, click the “Transient Stability Plots” button. See Fig. 15.



Fig. 13



Fig. 15

23. On the “Transient Stability Plot Selection” dialog box, do the following (See Fig. 16):

- a. On the “Device Type”, select “Buses”
- b. On the “Device ID”, select “Sub2B”.
- c. There are 6 plots available for the Bus device. But in this exercise, view only the “Frequency”. Click the “Uncheck All” button.
- d. Check “Frequency”
- e. Click the “OK” button.

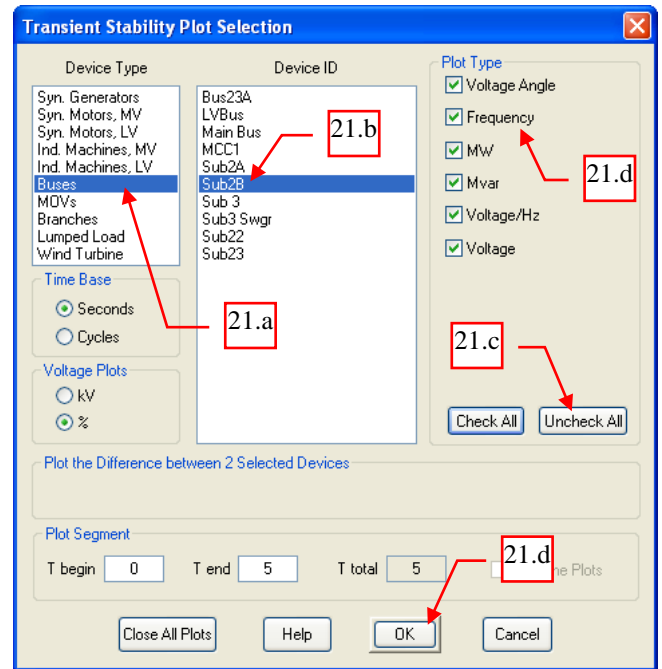
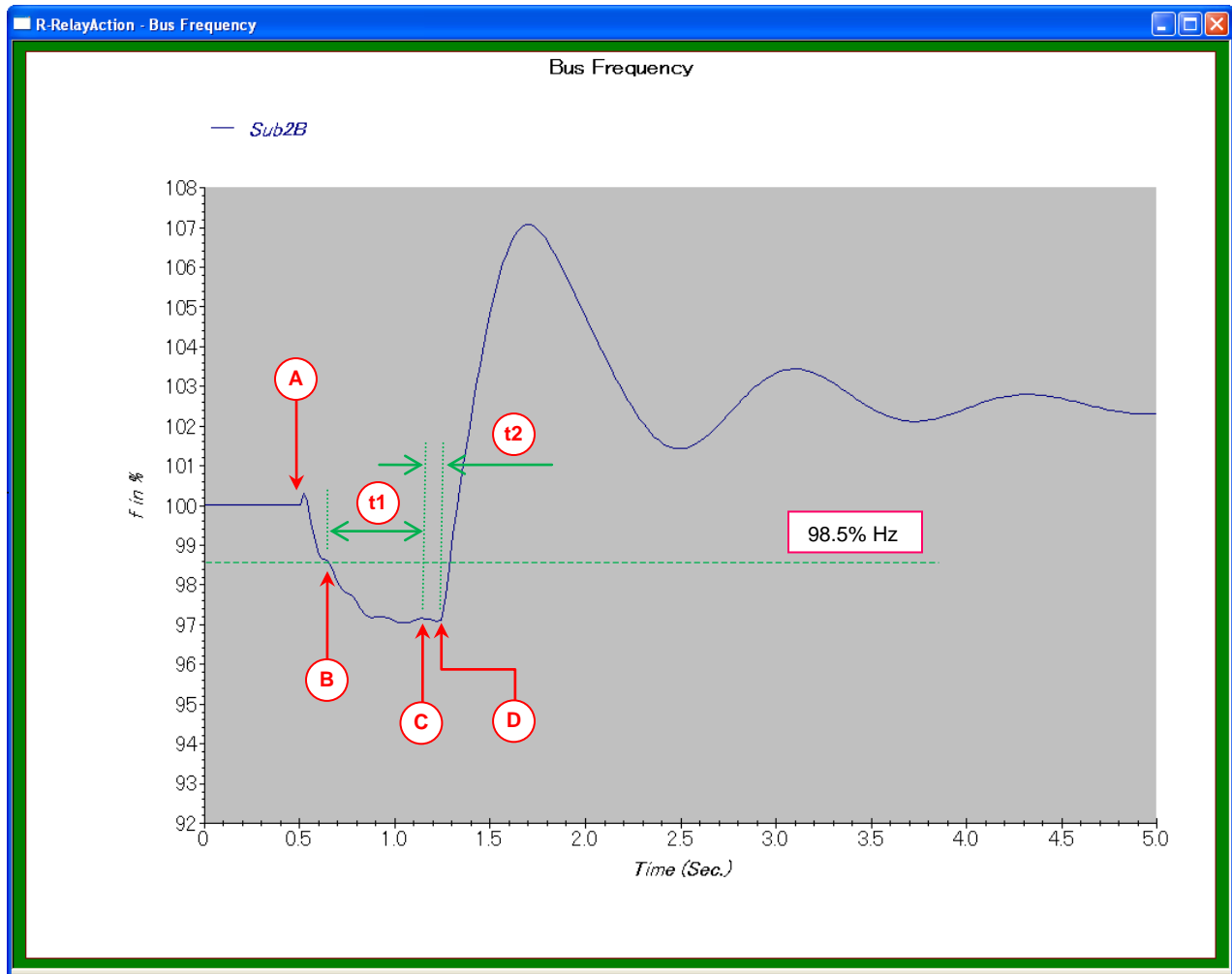


Fig. 16

24. The output plot is displayed in Fig. 17. When “CB1” tripped off, “Gen1” sustained overload as manifested by the decay in frequency at bus “Sub2B”. When the decay reached the device 81 relay threshold, it picked-up and after the time delay setting timed-out, it triggered “CB5”. “CB5” tripped at 1.245 sec. Afterwards, the frequency increased.



- A - CB1 (Utility CB) tripped at 0.5 sec
- B - Device 81 Relay picked-up at 0.662 sec (98.49% Hz)
- C - Device 81 Relay timed-out at 1.162 sec (0.662 + 0.5 sec)
- D - CB5 tripped at 1.245 sec (0.662 + 0.5 + 0.083 sec)

- t1 - 0.5 sec, time delay setting of Device 81 Relay
- t2 - CB5 speed, 5 cycles or 0.083 sec at 60Hz

Fig. 17