OMICRON

Application Note

Understanding Fault Loops for Test Universe Users

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Related OMICRON Product
CMC – Test Universe

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Basic Protection Testing

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v1.0

Abstract
As the complexity of protection and control devices increases, testing methods that use realistic test stimuli make testing more efficient and effective.

OMICRON Test Universe provides a number of simulation tools that make this straightforward.

Content

Please use this note only in combination with the related product manual which contains several important safety instructions. The user is responsible for every application that makes use of an OMICRON product.

1 Introduction

1.1 Requirements to use this application note

1.1.1 Safety Instructions

To use this application note it is very important to read and to understand the **Safety Instructions** of *Test Universe* and of the electrical equipment that is controlled by *Test Universe*. They can be found in the corresponding manuals.

DANGER – Life-hazardous voltages and currents!

- The OMICRON *Test Universe* software controls electrical equipment that can output life-hazardous voltages and currents.
- Before operating any such electrical equipment, carefully read the **Safety Instructions** section in the manual that was provided with the equipment.
- Do not use (or even turn on) any electrical equipment without understanding the information in its manual.
- Existing national safety standards for accident prevention and environmental protection may supplement the equipment's manual.
- Only trained personal should operate *RelaySimTest*.

NOTICE – Equipment damage!

- The OMICRON *Test Universe* software controls electrical equipment that can output voltages and currents which are able to damage equipment.
- Before operating any such electrical equipment, be sure that no equipment will be damaged.

1.1.2 General Requirements

To use this application note it is necessary to read the "Getting started" manual [1] of *Test Universe* before and it is necessary to have a good knowledge about the CMC test system.

1.2 What this application note covers

The application note describes basic fault behavior and the use of "Set Modes" available in QuickCMC, State Sequencer, Ramping, and Pulse Ramping test modules in Test Universe.

1.3 Basic Fault Behavior

To efficiently use the tools in Test Universe, a basic understanding of fault behavior is desirable. In the following section the basics of system fault behavior is explained.

Regardless of the fault type, when an electrical fault occurs, the affected phase voltage decreases, the affected phase current increases, and the phase angle between the faulted phase voltage and current shifts in a "current lagging" direction. The magnitude of these changes depends on several factors such as system voltage, source impedance, line impedance, fault location, and fault impedance.

When testing protection devices, three basic fault types are considered: The phase to phase fault, the phase to neutral fault, and the three-phase fault.

For the purposes of this discussion, we will assume fault impedance is zero. Of course, this is not always the case but the assumption works well while testing of most protective relay functions.

1.3.1 Phase to Phase Faults

When two conductors are electrically connected, a phase to phase fault occurs. This results in fault currents that are higher than found in phase to neutral faults. Faulted phase voltage amplitudes measured by the relay decrease and voltage angles collapse together, resulting in a decrease of faulted phase L-L voltage (Vab=Va+(-Vb)). Currents in the affected phases increase and appear 180deg out of phase. The L-L current also lags the L-L voltage. See figure 1 below.

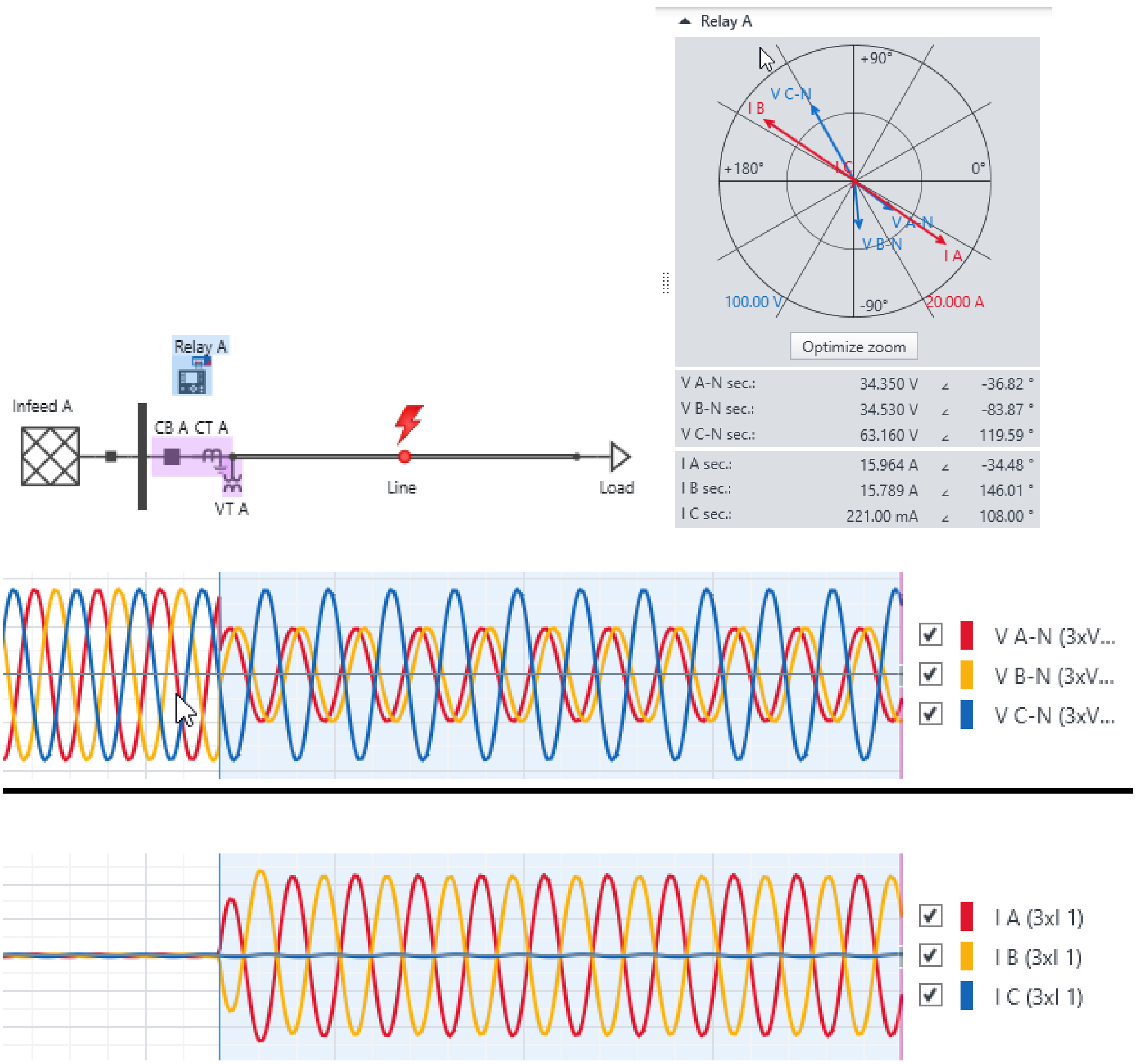

Figure 1: Depiction from OMICRON RelaySimTest software showing a phase to phase(A-B) fault at 50% pf the line.

Due to the nature of the fault, no ground current (3I0) is generated.   Therefore, ground fault protection elements will ignore this fault. This characteristic can be used to test phase overcurrent or distance elements without tripping ground elements, which are usually set more sensitively.

If the fault occurs closer to the relay, fault current is of course higher and the voltage collapse is more profound due to the reduced line impedance between the relay and the fault. This phenomenon is depicted in figure 2. Note that in this case, L-L voltage is near zero.

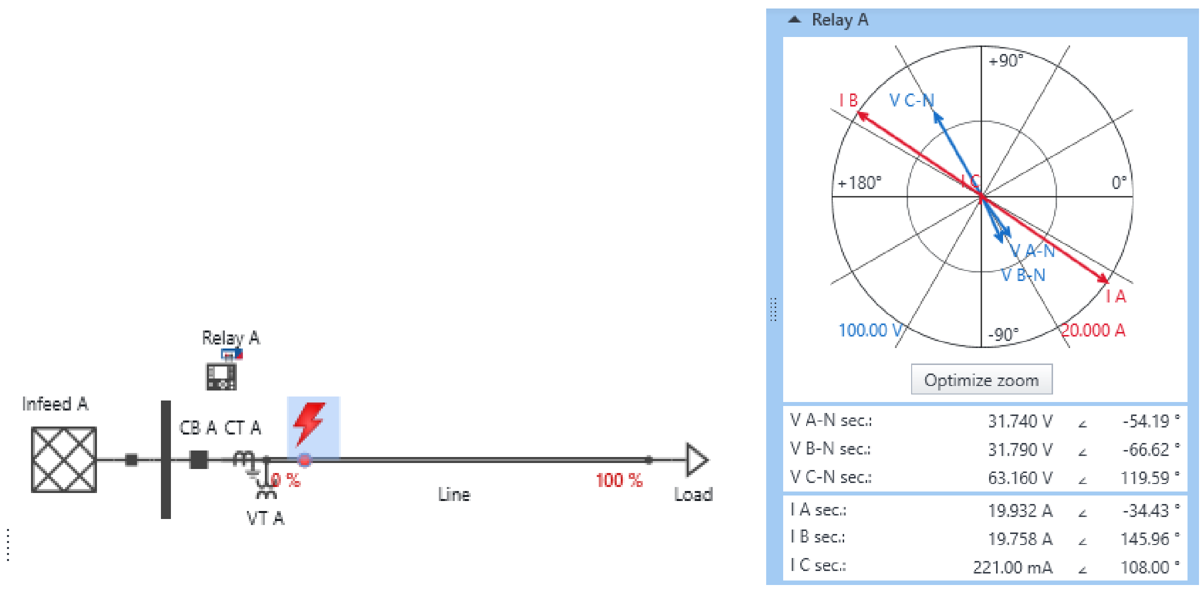

Figure 2: Phase to phase (A-B) fault at 10% of the line.

1.3.2 Phase to Neutral Faults

Phase to neutral faults are the most common type of power system fault. These faults occur when a conductor becomes grounded by contact with a grounded object or simply falling to the ground. When a phase to neutral fault occurs, faulted phase voltage amplitudes measured by the relay decrease and currents in the affected phases increase and lags the L-G voltage. See figure 3 below.

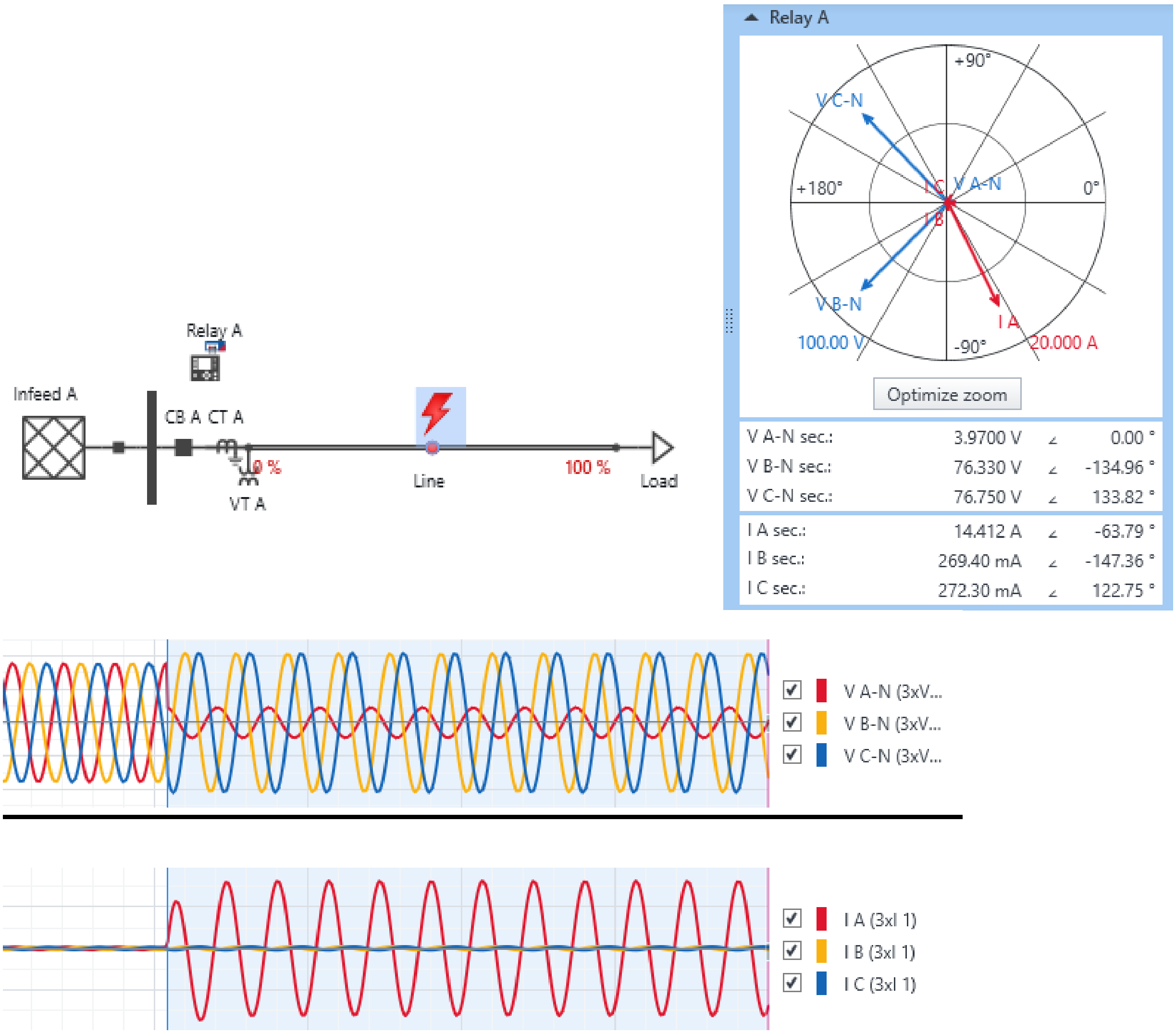

Figure 3: Phase A-N fault at 50% of the line

1.3.3 Three Phase Faults

Three Phase faults occur when all three phases are electrically connected and are characterized by symmetrical voltage and currents, as well as the highest currents of any fault type. Like the other fault types, current lags voltage.

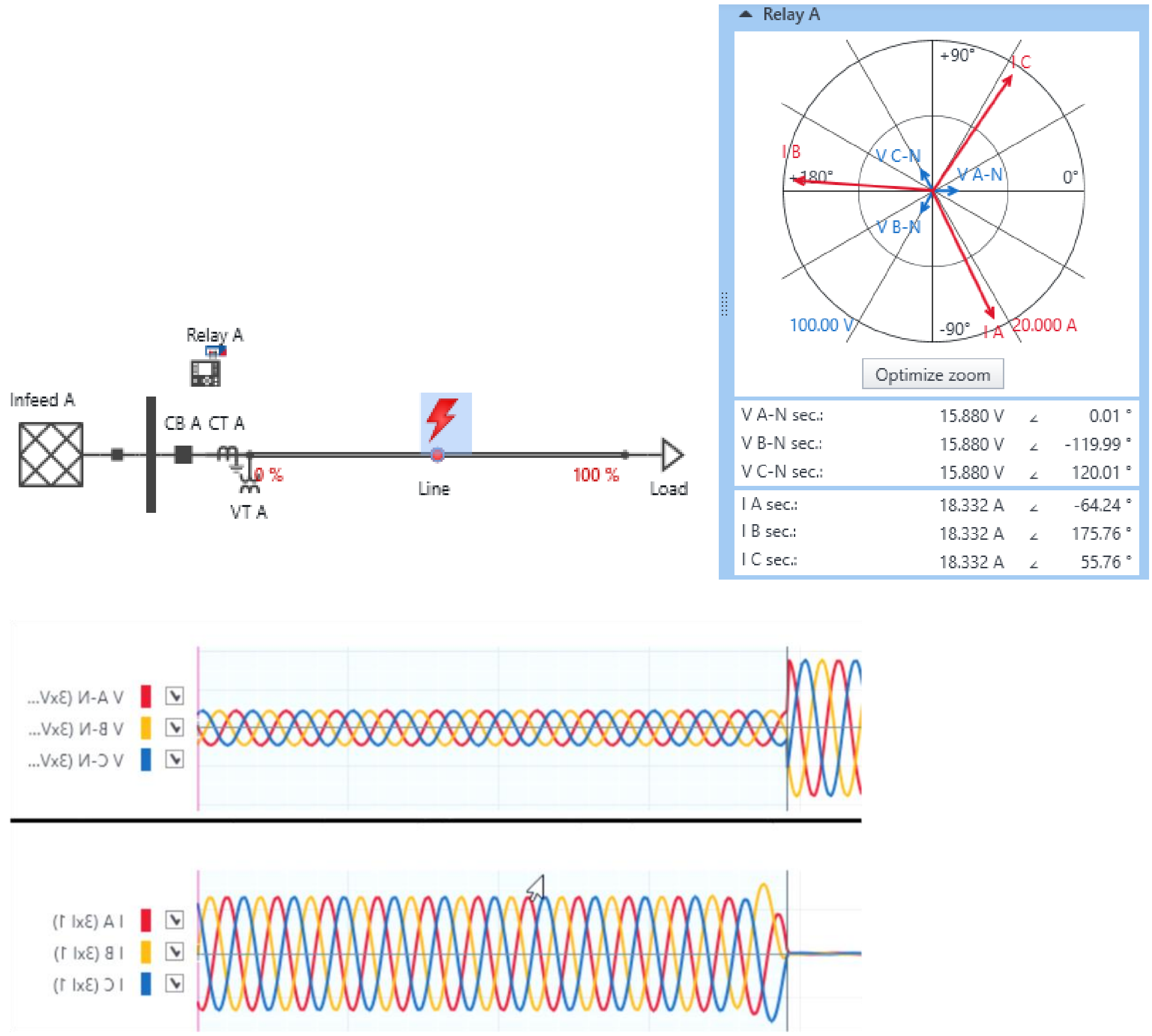

Figure 4: Three phase fault values

2 Using Fault Value Tools in Test Universe

Test Universe provides a number of tools which allow the user to quickly and efficiently simulate realistic fault conditions. Realistic fault simulations is one strategy to facilitate testing without intermediate setting changes.

Note that depending on the default phase name setting, the phase labels may not match the following screen captures. To change your selection, open the Test Universe welcome screen, select “System Settings”, then select “Phase Names”, and finally, change the selection as desired. Reboot Test Universe to apply the changes.

2.1 QuickCMC

QuickCMC provides a means to perform manual tests efficiently and easily. In QuickCMC, the fault loop tools are accessed through the “Set Mode” drop down in the Analog Outputs grid (figure 5).

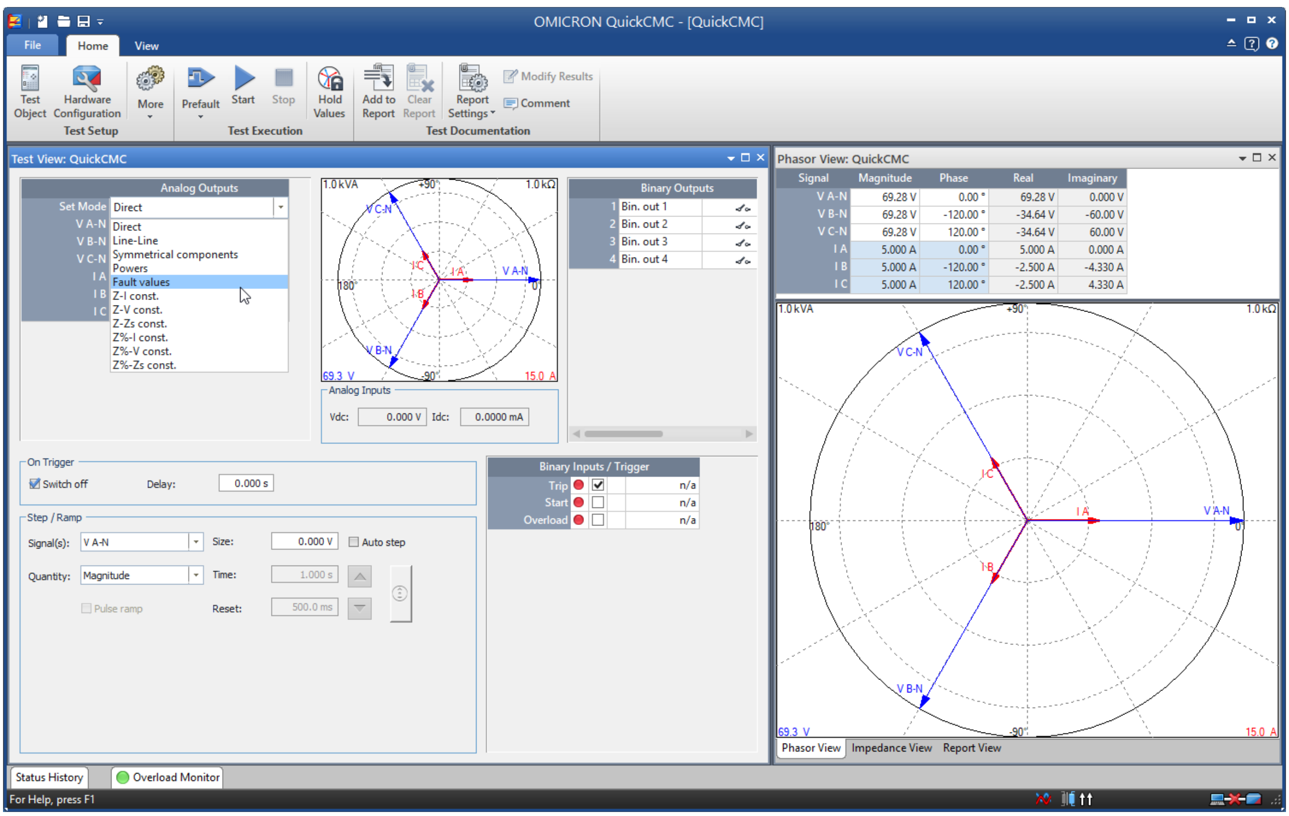

Figure 5: Selection of fault values in QuickCMC

Under fault values, instead of the usual grid of phasors, the users select the desired fault type, faulted phase voltage, faulted phase current, and angle and the individual phasors are calculated automatically (figure 6).

Analog Outputs			
Set Mode	Fault values		
Fault Type	A-B		
V Fault	10.00 V	30.00 °	60.000 Hz
I Fault	10.00 A	-50.00 °	60.000 Hz
Angle(V-I)		80.00 °	

Figure 6: Setting fault values in QuickCMC

Fault Values may be selected as follows:

- Fault Type: To simulate phase faults, select A-B, B-C, C-A, A-N, B-N, C-N, or A-B-C that corresponds to the element and phase under test. Note that the fault type can be changed at any time, allowing for efficient repetitive testing of other phases.
- Fault Current: If testing a inverse time phase overcurrent (51), select the desired multiple of pickup. If testing an instantaneous phase overcurrent (50), select a value greater than the 50 pickup by at least the current tolerance specification.
- Fault Voltage: Usually required only when testing directional overcurrent relays that are polarized by phase voltage. If testing a non-directional overcurrent, a voltage near nominal will prevent voltage elements from picking up during testing. If testing a directional over current, 30-80% of nominal will usually suffice.
- Angle (V-I): Usually required only when testing directional overcurrent relays that are polarized by phase voltage. Note that the units for this value is degrees of current lagging voltage. Typical values when simulating faults in the forward direction is 60-90 degrees.
- Fault Current Angle and Fault Voltage Angle: These values are automatically set when the Angle (V-I) is set.

2.2 State Sequencer

The State Sequencer module allows the user to automate sequences to efficiently test timing and logic functions.

In State Sequencer, Fault Values set mode is accessed in the Detail View. Select the desired state in the state sequencer, then select Fault Values under the Analog Out tab. Prefault and post fault states can be added to complete the simulation. Finally, the required assessments can be added to complete the automated test. Note that a different set mode can be set for each state.

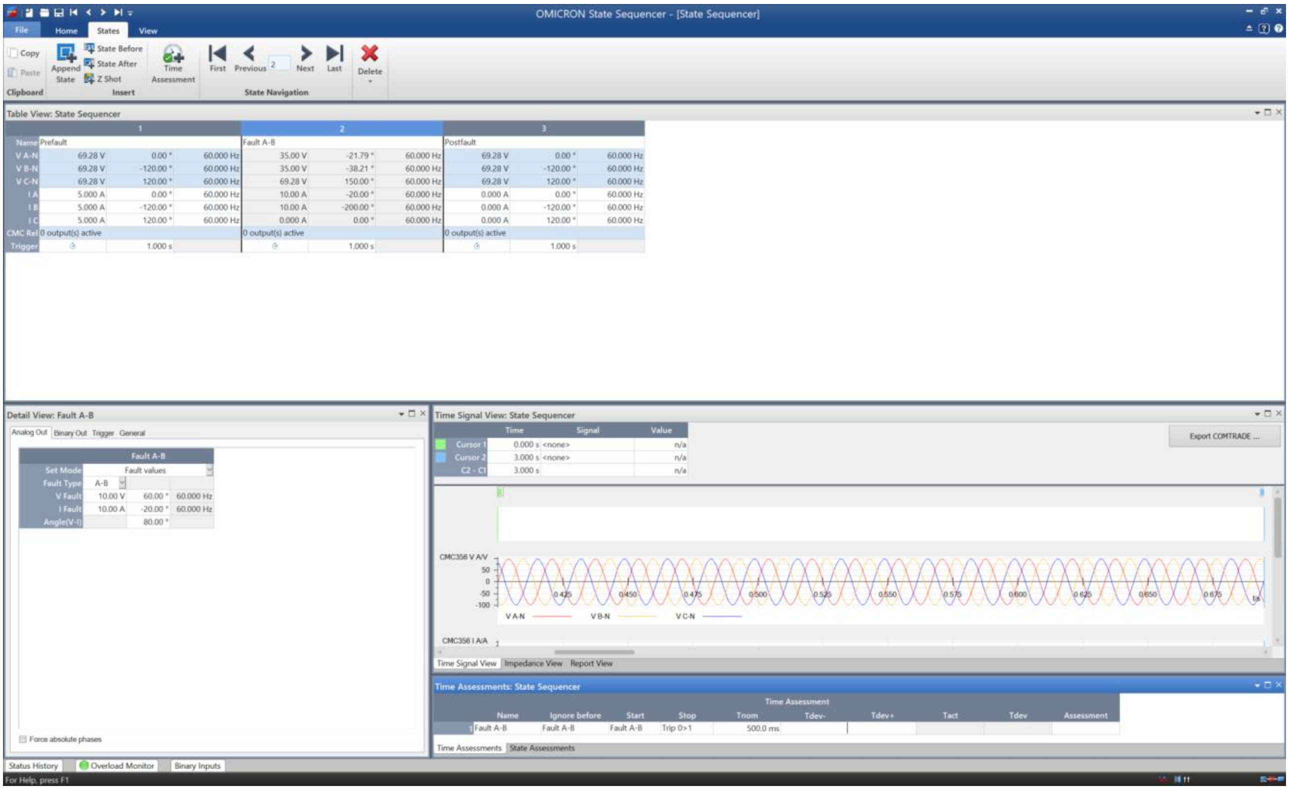

Figure 7: Selection of fault values and adding states on State Sequencer

Of course, more complex sequences are possible bay adding test states and assessments. To do this efficiently, in the Table View, highlighting a state and selecting Append State creates an identical state at the end of the sequence. In this way, additional tests can be rapidly created. The user needs only to change the fault loop and add assesments as desired.

2.3 Pulse Ramping

Pulse Ramping allows the user to test conflicting elements by applying a series of steps. The Fault Values drop down is accessed in the fault state details.

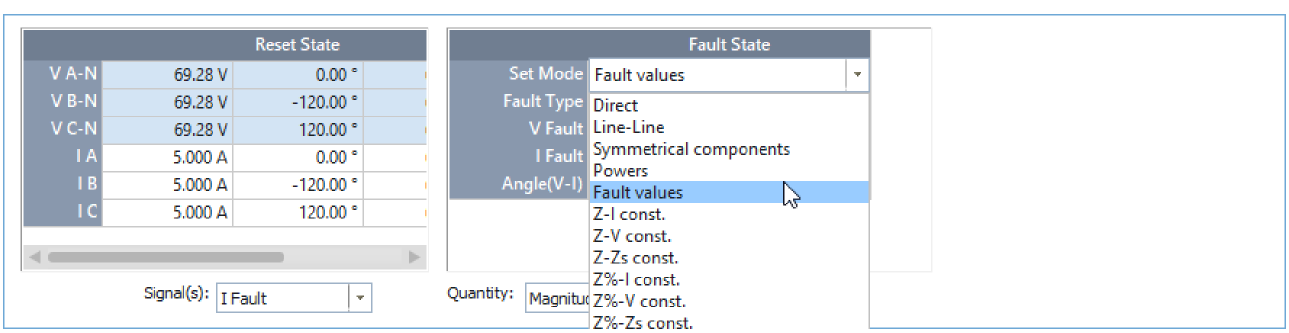

Figure 8: Selection of fault values in Pulse Ramping

Like State Sequencer and QuickCMC, once Fault Values is selected, the familiar Fault Values grid appears.

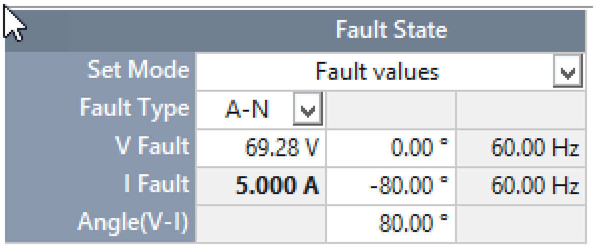

Figure 9: Selection of fault values in Pulse Ramping

The desired ramping signal is then selected with the Signal(s) control.

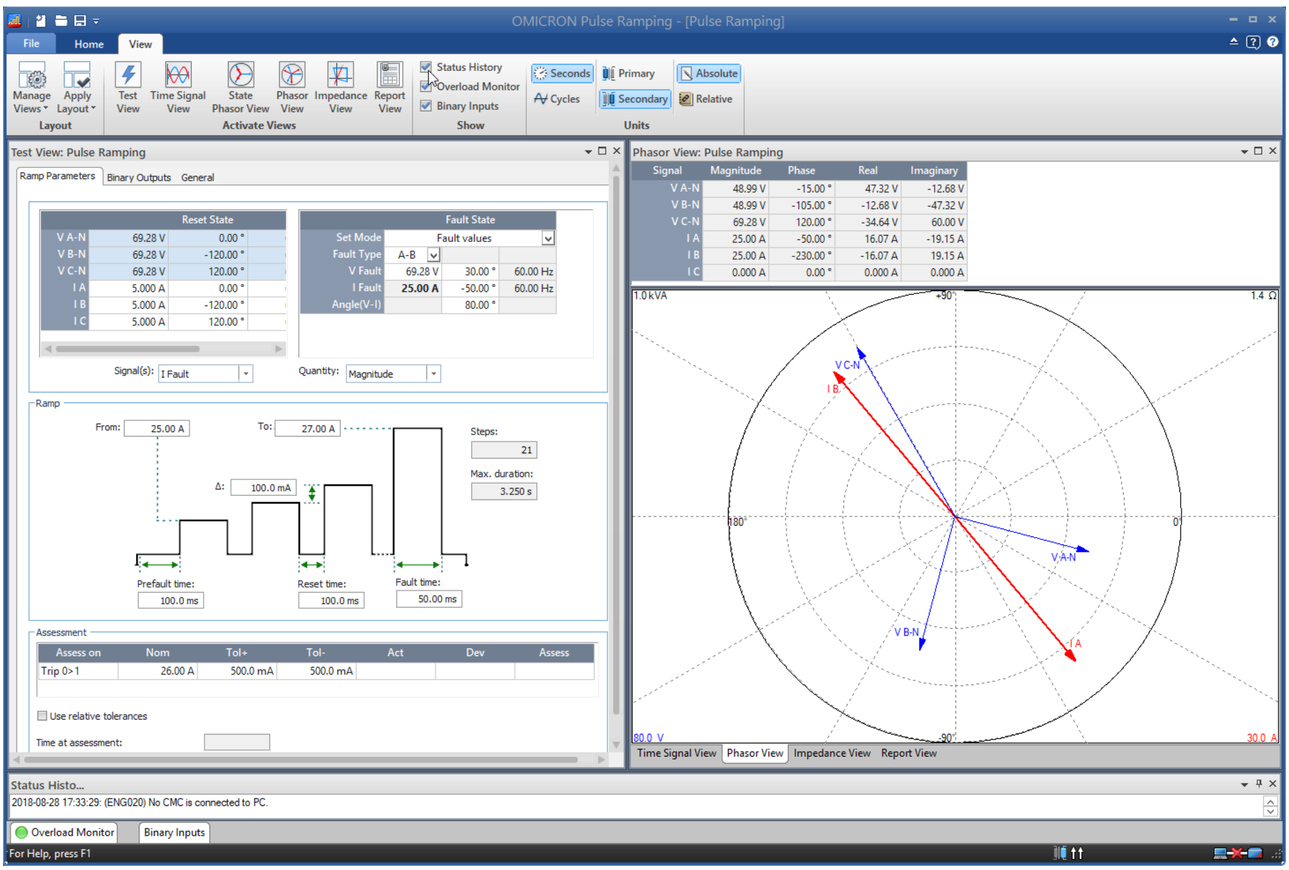

Figure 10: Programming the ramp states in Pulse Ramping

The best strategy is to set the Fault Time to a value slightly greater than the trip time of element under test and slightly less than the expected trip time of conflicting elements which may otherwise operate more quickly than the element under test. For example, if the relay under test has a phase instantaneous over current set to 26A with a trip time of 25msec, and a phase time overcurrent set to pick up at 6A.

2.4 Ramping

Like QuickCMC, State Sequencer,and Pulse Ramping, the Ramping module supports the use of fault values. Fault Values are acessed by adjusting the set mode in similar fashion.

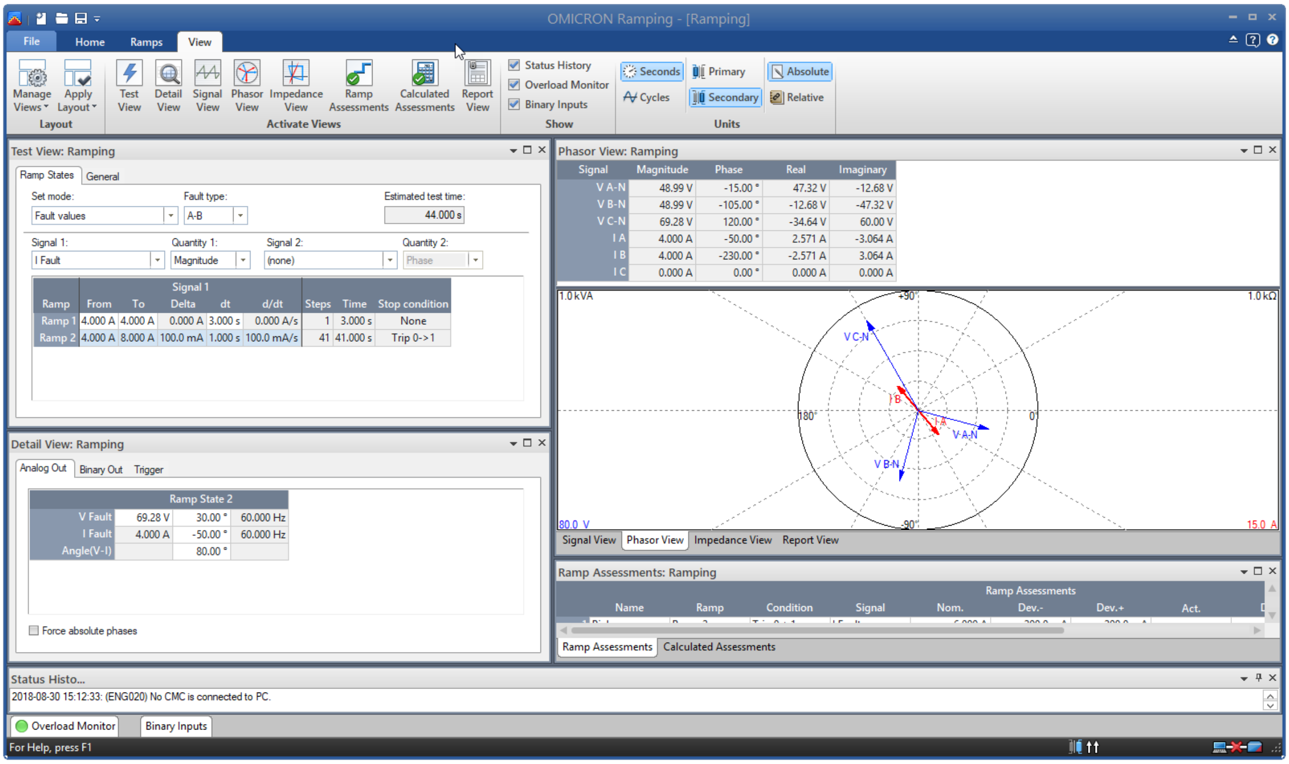

Figure 11: Fault Values in the Ramping module

OMICRON is an international company serving the electrical power industry with innovative testing and diagnostic solutions. The application of OMICRON products provides users with the highest level of confidence in the condition assessment of primary and secondary equipment on their systems. Services offered in the area of consulting, commissioning, testing, diagnosis, and training make the product range complete.

Customers in more than 140 countries rely on the company's ability to supply leading edge technology of excellent quality. Broad application knowledge and extraordinary customer support provided by offices in North America, Europe, South and East Asia, and the Middle East, together with a worldwide network of distributors and representatives, make the company a market leader in its sector.

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