ASEA RELAYS

POWER SYSTEM SIMULATOR

for realistic testing of protective relays

ASEA

The Asea Relays power system simulator can provide you with many years of operating experience - in just a couple of weeks!

You can now obtain a quick check on how the protective relays in your power network will behave when disturbances occur in the system. By connecting the protective relays to the advanced Asea Relays power system simulator - in which a complete power network can be simulated to suit your own specifications - you can obtain information on how your power system will react when faults arise. You can then take the necessary measures, at the least possible investment cost, to eliminate the risk of serious power failure.

A copy of your own power network!

The Asea Relays power system simulator offers unique opportunities for predicting how your protective relays will operate in the actual network, under varying operating conditions.

The simulator consists of electronic circuits which accurately simulate the power network. A computer system controls the simulator and collects and processes the data.

All the significant units that may form part of a full-scale power network are represented in the simulator by electronic models.

For example, there are generators, power lines, surge arresters, circuit breakers, series and shunt capacitors and reactors. The simulator also includes models to simulate the possible causes of faults. All the models are very authentic and it is possible to simulate the complex and rapid development of the fault situations that can arise in an actual power network.

The protective relay under test is fed from the simulator through powerful amplifiers, at the normal operating voltage and the current levels that will occur in practice. The voltage is usually 110 V and the current transients can be as high as 280 A. Consequently, the protective relay connected to the simulator "sees" a network which behaves in precisely the same way as a genuine network

The simulator can represent networks at voltages between 100 and 1500 kV, with short-circuit loads of up to 50000 MVA

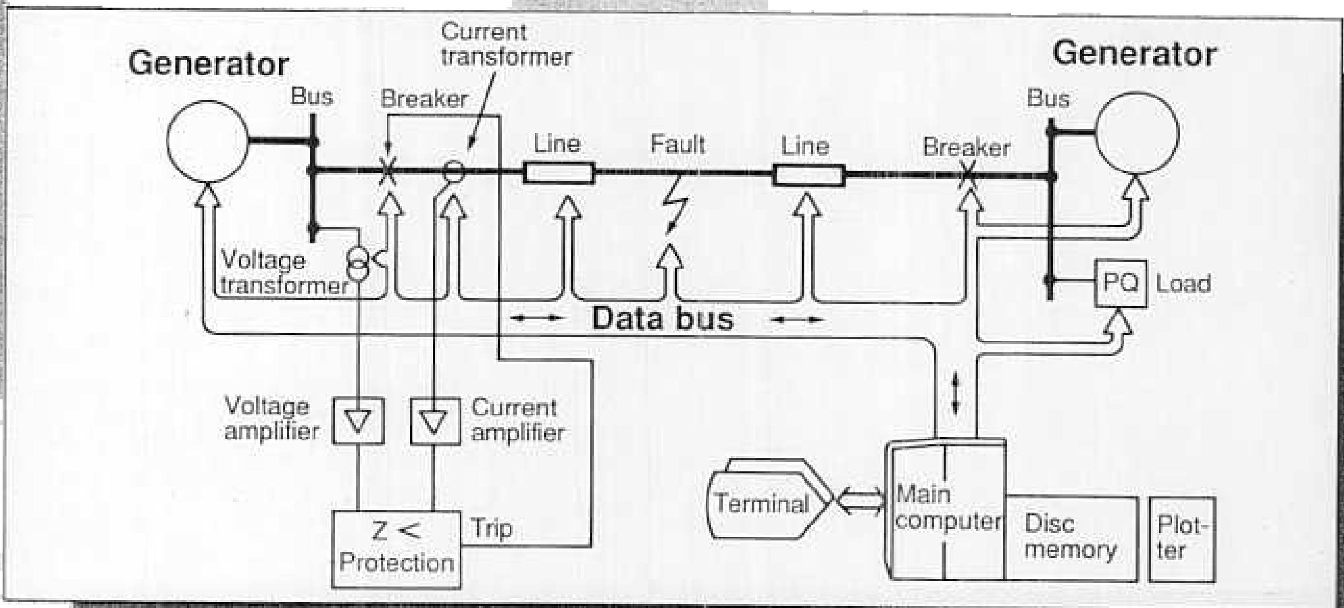
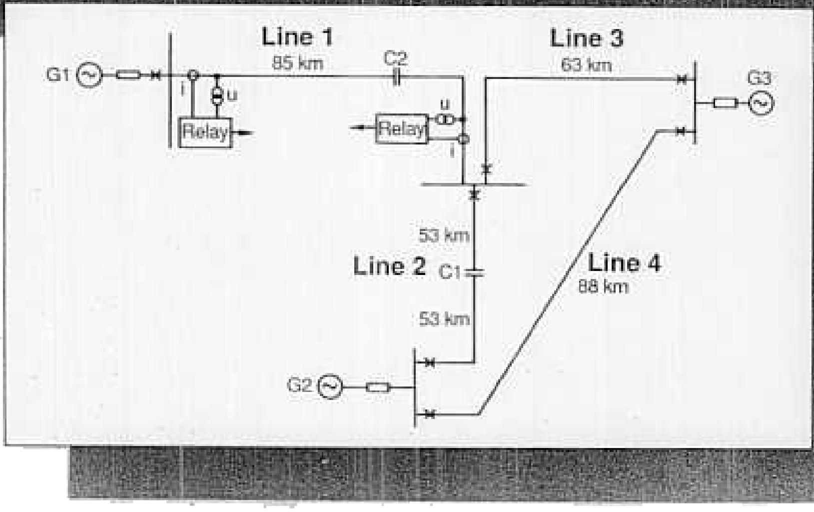


Diagram showing the simulator configuration in principle



The simulator can handle complex network layouts. Here is an example of a three-source 275 kV series-compensated transmission network.

The first few milliseconds are of outmost importance!

The course of events during the first milliseconds of a fault are decisive to the manner in which the protective relays perform. Each breaker operation triggered by the protective relay has an effect on the current and voltage throughout the network. This, in its turn, can activate other protective relays. And all this occurs extremely quickly. To obtain a true picture of what can happen in a network, simulation must be carried out in real time using extremely fast analog circuits. Direct digital simulation would be altogether too slow to provide correct test results.

Some of the line protection systems are based on the wave detector principle. Instead of measuring the reduction in impedance or rise in current, these protective systems have start units which sense the wave front passing through the lines when a fault occurs. These protection systems act very rapidly and require authentic simulation, if their function is to be properly tested.

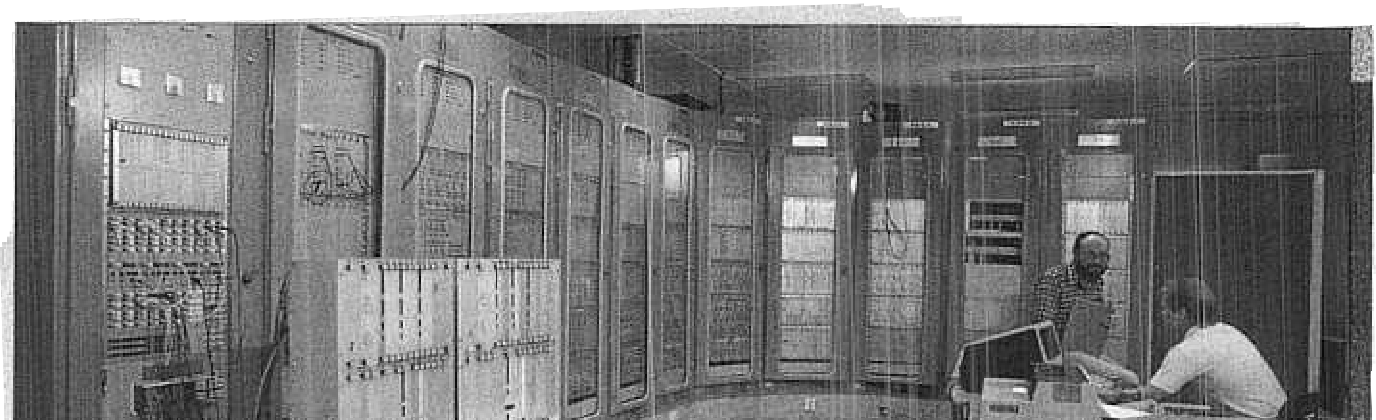
Simulator controlled by five computers and four operators!

The measuring system is based on five Hewlett-Packard computers, of which one operates as central unit and the other four as slaves. The peripheral equipment consists of graphics terminals, disk memory, flexible disk drives, magnetic tape units, printer and colour plotter.

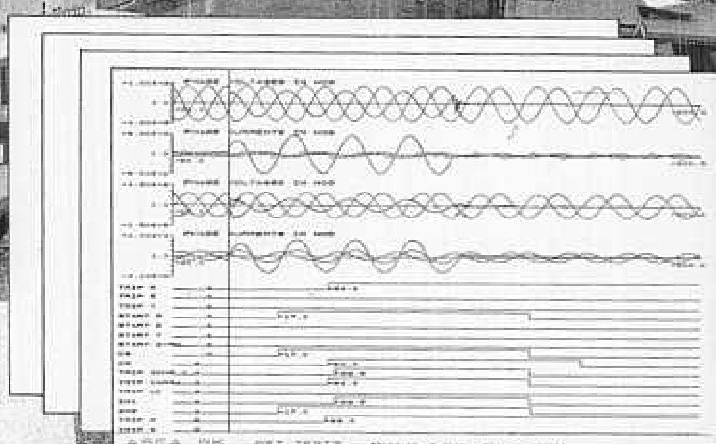
The data collection system can handle 24 analog and 64 digital signals simultaneously at a sampling frequency of up to 25 kHz. A maximum of 18 000 measurements per signal can be stored in the memories.

The simulation equipment is handled by four operators, each a specialist in his own field.

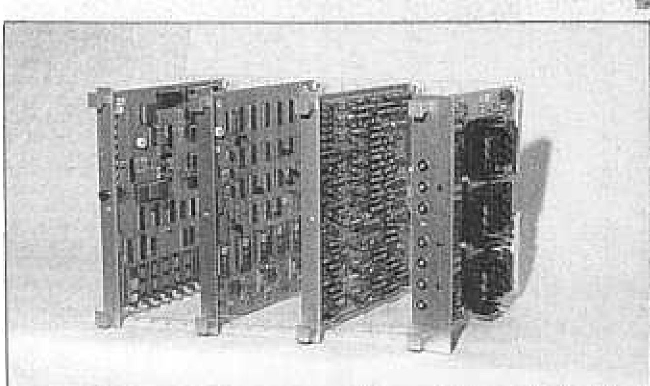
The parameters that are used in setting up a simulated network are stored on a file and can easily be brought out on a later occasion. This makes it a simple matter to repeat a test under precisely reproducible conditions. The results of tests are presented in the form of computer lists and also, for greater clarity, in the form of plotted diagrams.



The simulator room while a test is in progress. The protective relay under test can be seen on the left of the picture.



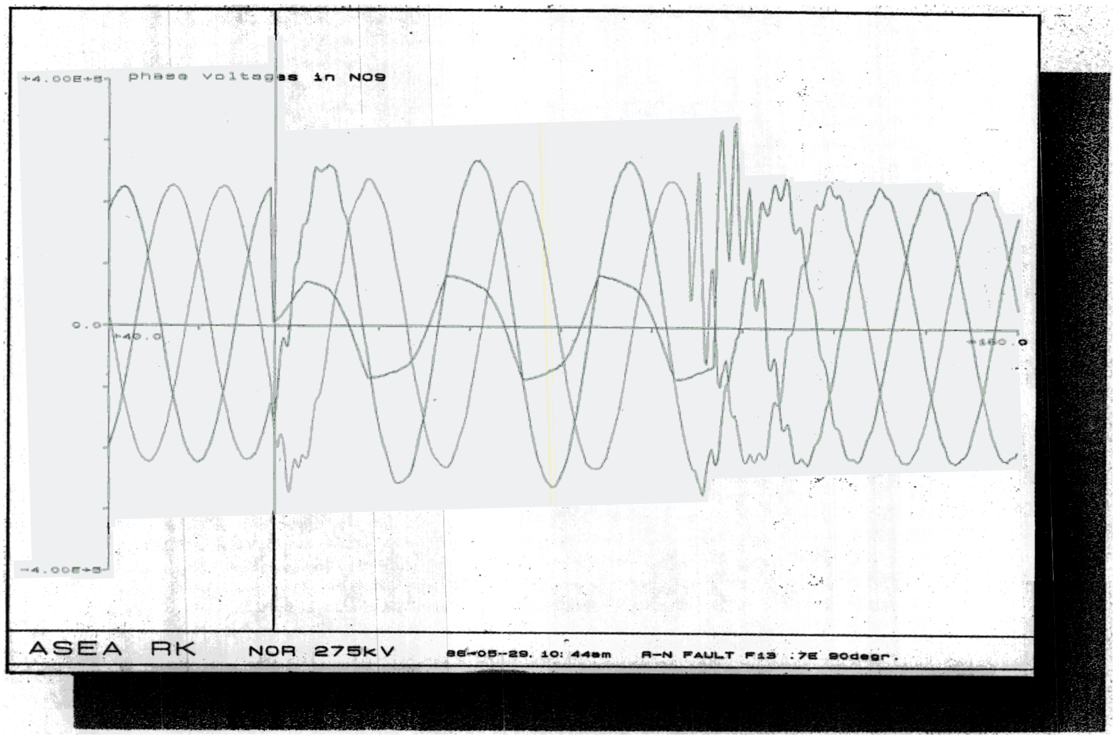
The results from a test can be shown in the form of a diagram.



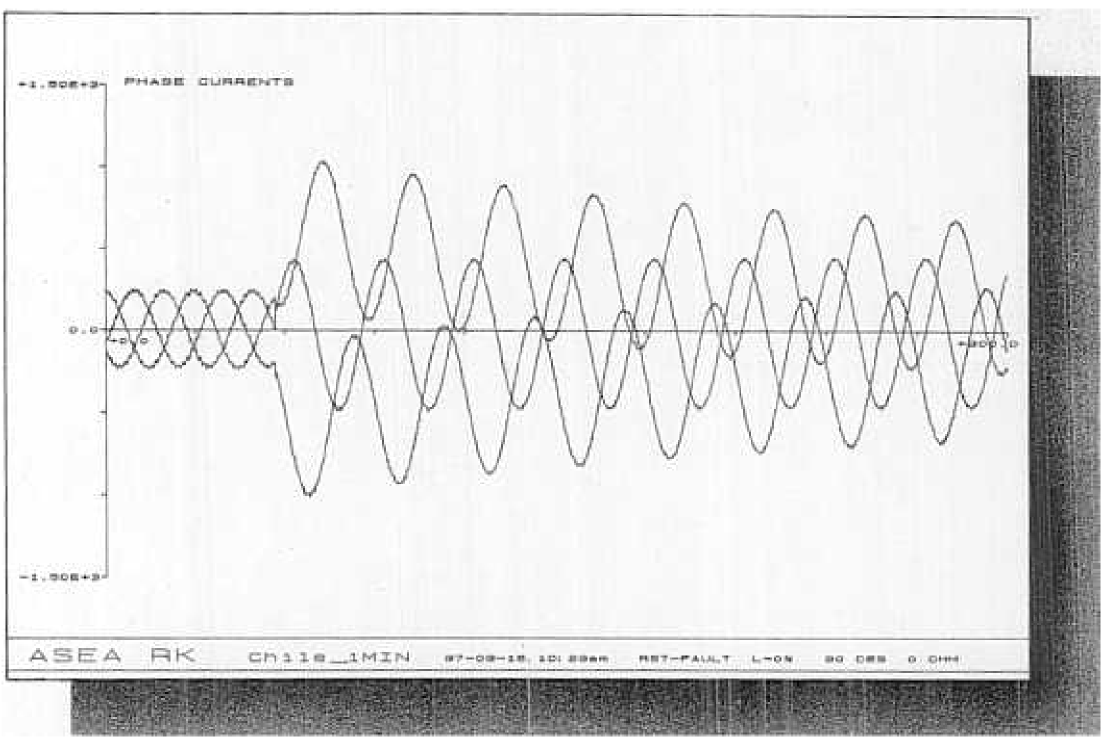
The simulator is entirely analog, with computer-controlled configuration, setting and data collection. These are some of the electronic models.

Wave-forms in a power transmission network

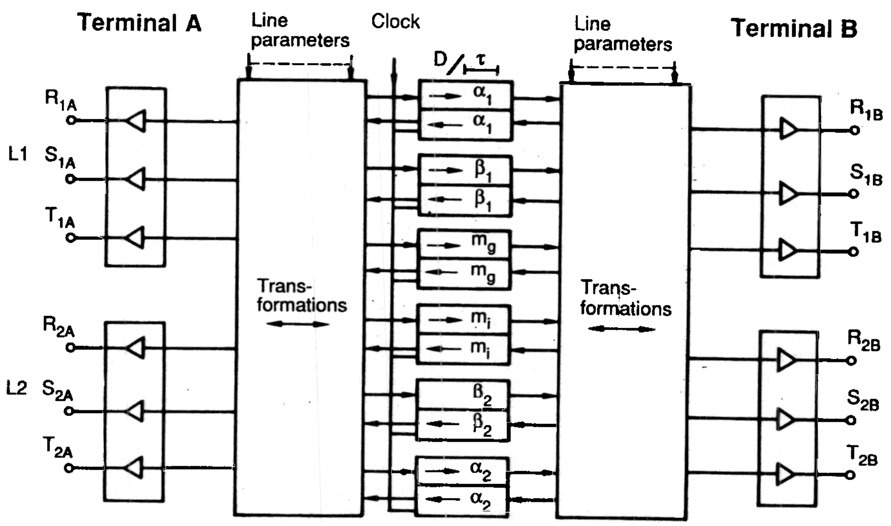
When a fault occurs in a power system, non-sinusoidal wave-forms arise. These are caused partly by non-linear elements in the system and partly by the energy stored in capacitive and reactive elements.



This oscillogram shows the voltage in a series-compensated network, where the series capacitors are fitted with zinc oxide varistors.



This oscillogram shows the current when a three-phase close-up fault occurs on a line with shunt reactors on the bus-bar behind the relay together with a weak end infeed.



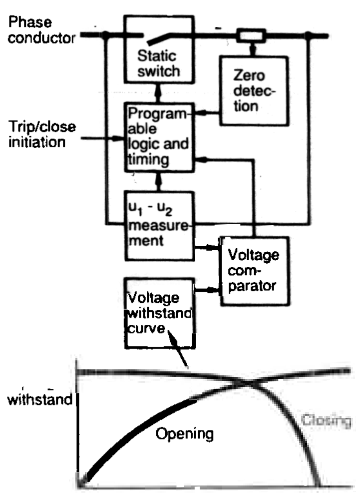
The performance of a power system simulator depends, to a great extent, on how accurately the electronic line model represents the transmission lines of the actual network. The model that is used is based on the telegraph equation, which gives the voltage and current at a point (x) on a single phase line, at time (t), as follows:

$$u(t,x)=e^{-(\frac{r}{l})t}\,(u_1(x-vt)+u_2(x+vt))$$

$$i(t,x)=\frac{1}{z}e^{-(\frac{r}{l})t}\,(u_1(x-vt)+u_2(x+vt))$$

where, u_1 = forward voltage wave
u_2 = backward voltage wave
z = surge impedance of line
v = wave propagation velocity
r = line resistance per km
l = line inductance per km

In a multi-phase system - provided some degree of symmetry exists - a transformation can be used which converts the system into a number of independent single-phase systems. In the line model shown, a Clarke transformation is used to create 0-, α- and β- systems. In order to handle parallel lines with mutual coupling, the model also includes a component which is dependent upon the coupling between the lines. This is the m-component shown in the diagram.



This shows the simulator circuit breaker model in a single-phase functional diagram. The control computer sets individual parameters for each phase, so that non-simultaneous breaking can be simulated. An opening and/or closing resistor might also be included in the model, but are not shown in the diagram.

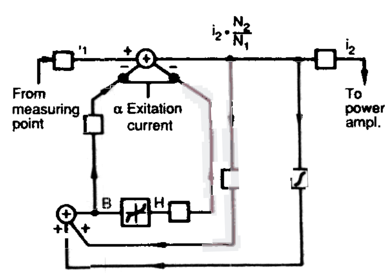
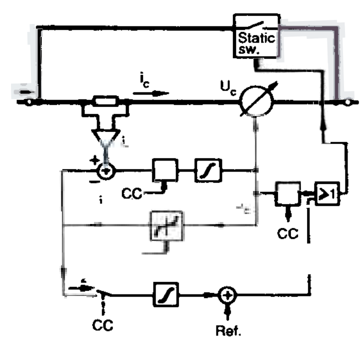
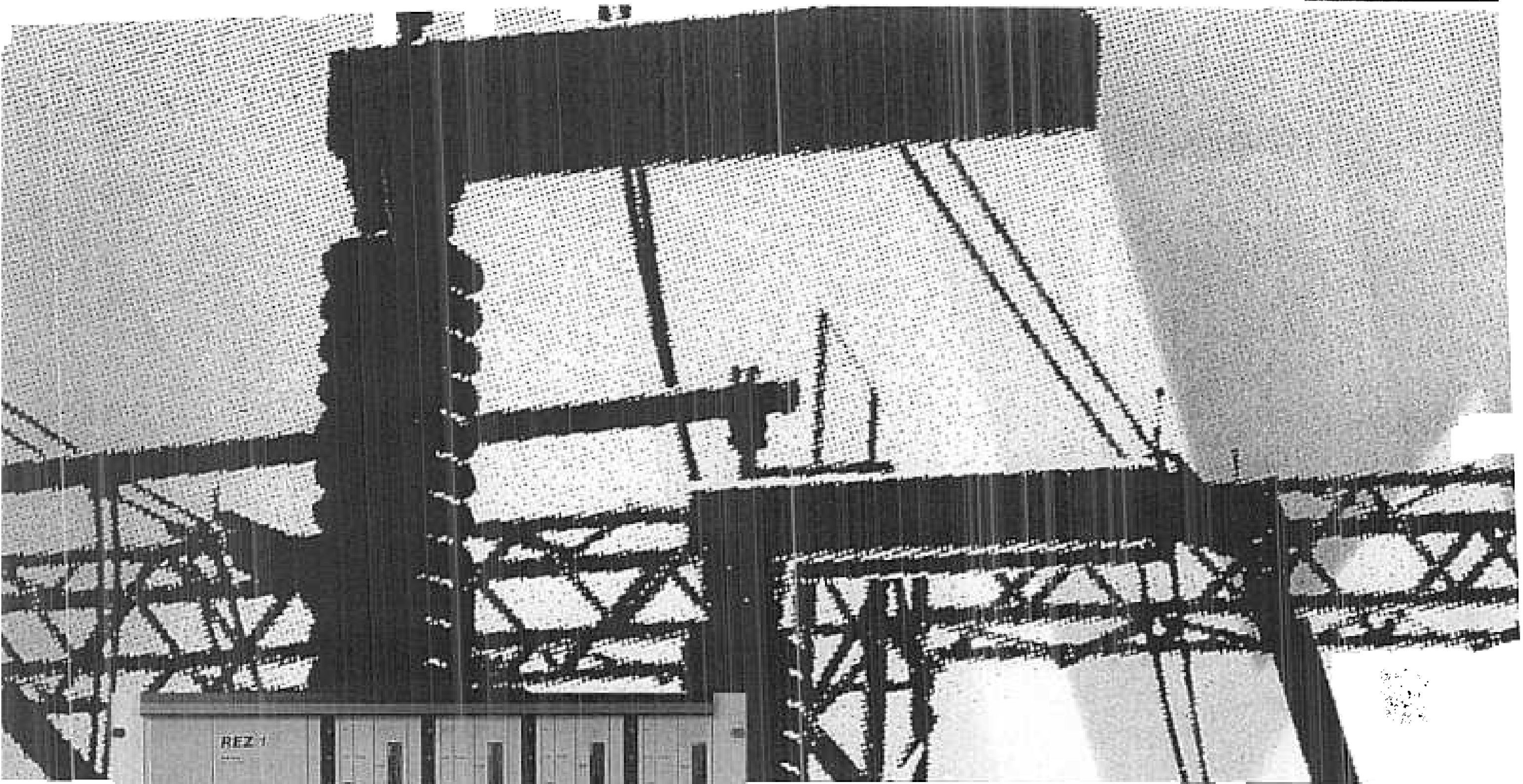
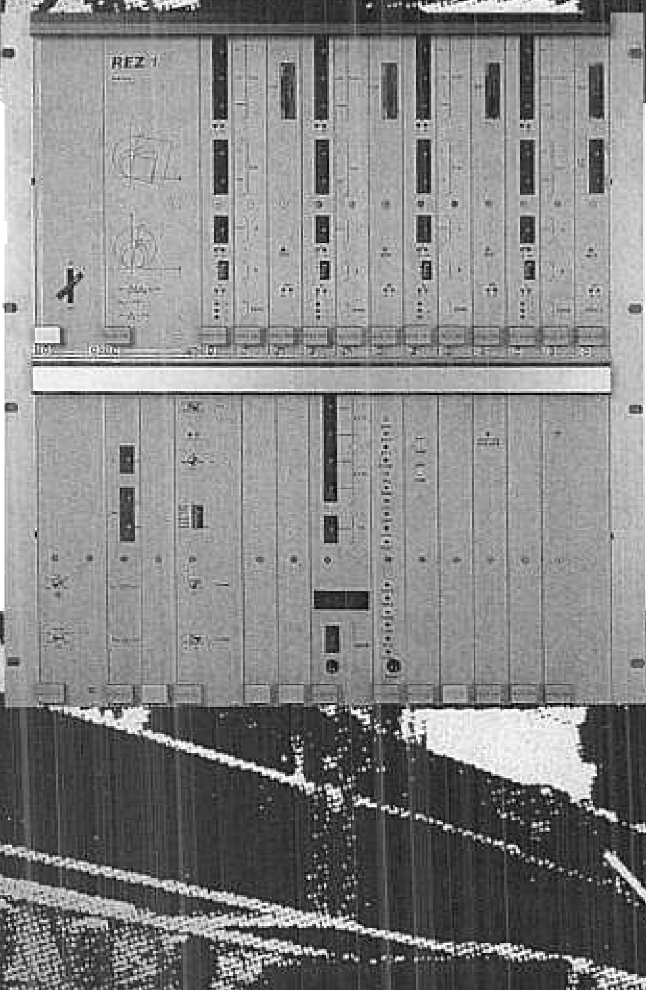


Diagram of current transformer model. The control computer sets seven parameters to characterize the current transformer to be used. The model also simulates the non-linear magnetization and saturation of the transformer.



In a series capacitor station, besides the capacitors, there are also by-pass switches and protective spark gaps, or alternatively, zinc oxide varistors. Since the influence of the series capacitor station may vary during the development of a fault, the line protection at the end-points of the line is affected in a manner that may be difficult to predict. All the components of a series capacitor station are, therefore, represented in the simulator model in order to make the test results realistic.

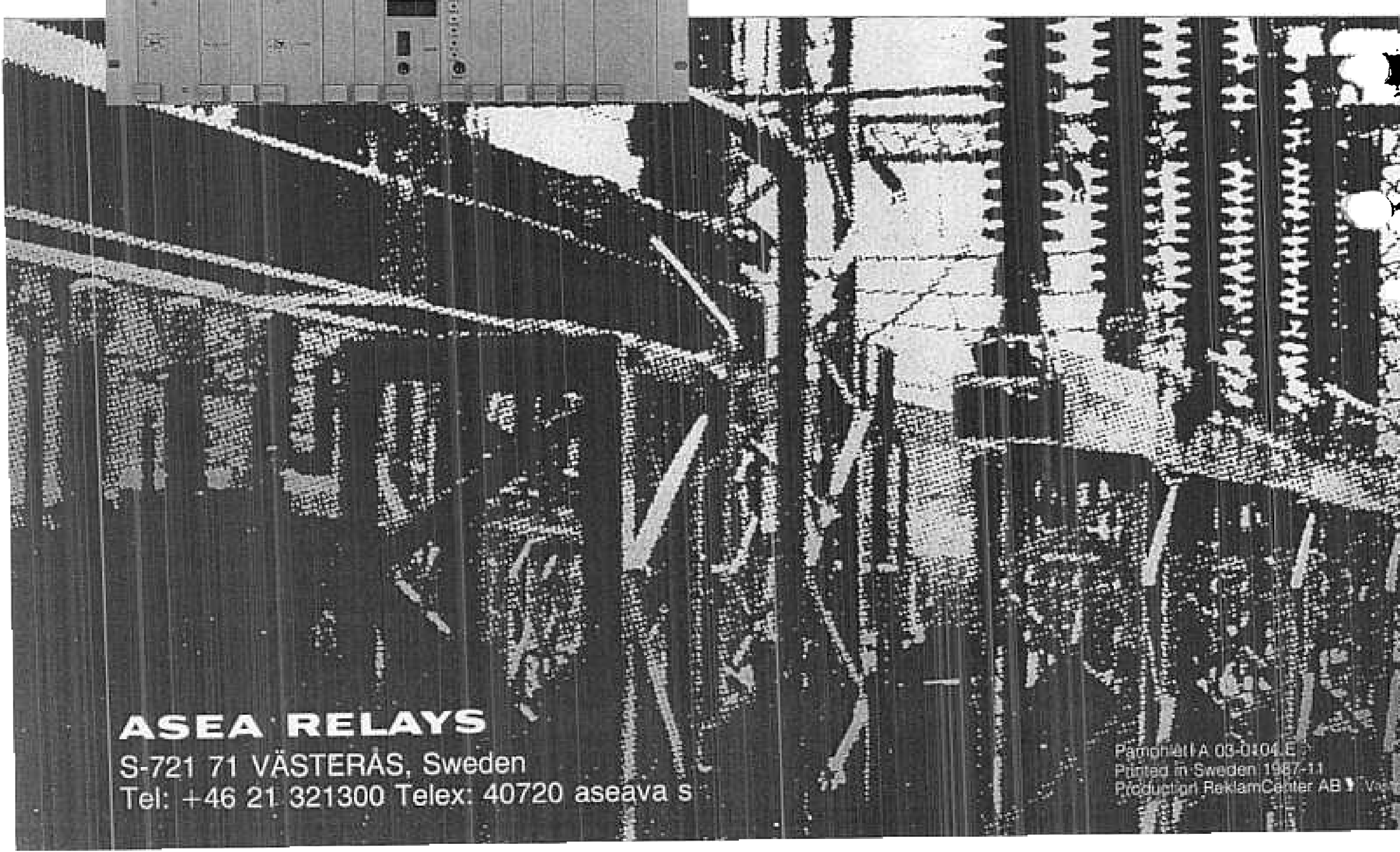




Knowledge gives security

A modern protective relay must make decisions, within a few milliseconds, on disconnection of a power system. The stability of a power system depends on correct functioning of the relays. Unnecessary disconnection may lead to more serious breakdowns in power distribution than can be tolerated.

By testing your protective relays in our simulator, you can quickly predict how the relays will behave under various disturbances. This knowledge is invaluable in building up a stable and reliable power network.



ASEA RELAYS
S-721 71 VÄSTERÅS, Sweden
Tel: +46 21 321300 Telex: 40720 aseava s

Pamphlet A 03-0104 E
Printed in Sweden 1987-11
Production ReklamCenter AB