ASEA BROWN BOVERI

ABB Relays

RAZFE performance during two-phase faults using the TURH test set

For the detection of short circuits the RAZFE distance relay uses ZK-relays with directional circular characteristic.

It is however, not certain that the ZK-relays will operate for close-up short circuits involving earth.

To cover such faults RAZFE is designed to use also the two phase to earth relays involved in the fault for detection.

The characteristics of the two phase to earth relays are rotated under the conditions of two-phase faults. One phase to earth relay will overreach and one phase to earth relay will underreach. The output signals from the two phase to earth relays are combined for the starting and tripping at two-phase faults.

This means that when checking the RAZFE performance for two-phase faults the obtained characteristic is always a combination of the ZK relays and the phase to earth relays characteristics.

The size and the position of the ZK circles are mainly dependent on the source impedance. When testing, preferably a test method which simulates zero-source impedance can be used to obtain reproducable and conformable test results at different reach settings and/or current levels. Zero-source impedance for the ZK-relays can be simulated in a number of ways. Depending on the test set-up the phase to earth relays can be influenced in different ways and rotated by different amounts. The phase to earth relays can also be influenced in different ways by the different adjustment to the one type of test apparatus. It is therefore not possible to predict the RAZFE performance during two-phase faults without thorough knowledge of the test apparatus and the RAZFE logic, measuring principle and settings.

Figures 1, 2 and 3 show the RAZFE operating characteristics during two-phase faults when checked with TURH test set.

It can be seen how the phase to earth relay reactance reach limits, the RAZFE blinders and directional characteristics are rotated depending on the TURH p-setting.

From figures 1, 2 and 3 can also be understood that it is possible to limit the influence of the phase to earth relays on the operating characteristics during measurement, by limiting the resistive reach of the earth relays to a low value (low b-setting).

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In Figure 1 TURH p-setting = 1 which means that symmetrical voltage is supplied to all three phases. The shown fault type is ST. The SN relay characteristic will then rotate $+30^{\circ}$ and the TN relay characteristic will rotate -30°. The same situation will occur in a network fed from a single source with zero source impedance during an ST-fault. If the source impedance is not zero the characteristic will also be displaced.

The RAZFE operating characteristic for the first step will, at the chosen settings, follow ZK1 between 110°-50°. Between 50°-20° the operating characteristic will follow the reactance reach limit L1TN. After that the operating characteristic follows the directional determining line D1S since starting is not obtained outside D1S. Where D1S cuts the ZK3 circle, the operating characteristic follows ZK3.

It can be seen here that the operating characteristic can be considerably influenced by reducing the RAZFE b-setting. The blinders B1S, B2S and B1T, B2T will then come closer to origin and only a small part of the operating characteristic around origin can show an irregular shape. L1S and L1T are blocked outside B1S, B2S and B1T, B2T and the operating characteristic outside the blinders will follow the circle ZK1. Inside the blinders the operating characteristic follows the circle ZK3.

In Figure 2 the TURH p-setting = 0.25 which means that the phase to earth relay characteristics are rotated approximately 67°.

The RAZFE operating characteristic will then follow the larger part of the circle ZK1 and only close to origin L1, D1 and ZK3.

B12S and B12T are now rotated to such an extent that reducing the RAZFE b-setting will not always influence the operating characteristic.

When using the TURH p-setting = 0.25 the RAZFE step 1 reach is set relatively short. This means that the relation between reactive reach and minimum resistive reach is not as large as in Figure 1. The blinders B12S and B12T can therefore not come as close to origin as previously.

In Figure 3 the TURH p-setting = 0.05 which means that the phase to earth relay characteristics are rotated approximately 90°.

The RAZFE operating characteristic will then follow the circle ZK1 and only in a very small area around origin will the operating characteristic deviate from ZK1.

Reducing the RAZFE b-setting will not influence the operating characteristic.

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From the above it can be concluded that depending on the RAZFE settings and the TURH settings a combination of the Figures 1 and 2 or 2 and 3 can be the finally obtained operating characteristic giving an irregular shaped operating characteristic.

We therefore recommend that when checking the RAZFE performance for two-phase faults the RAZFE b-setting is set to 2. This will give an operating characteristic which will follow the circle ZK1 and only at a small area around origin follows the circle ZK3 or the direction determining lines D1S and D1T.

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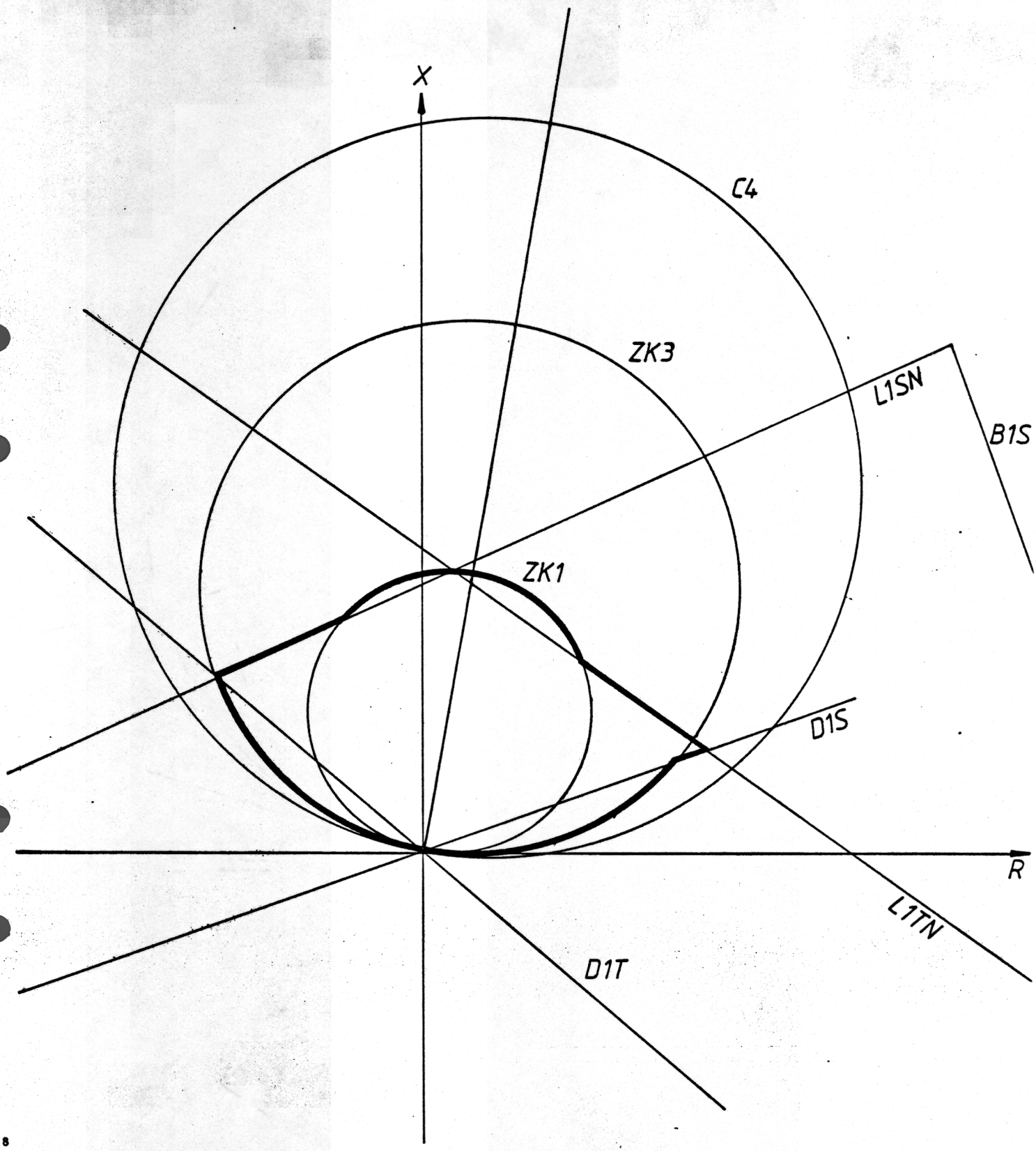

Fig. 1 Two-phase fault step 1

RAZFE settings
ZK1 = 10Ω/phase
ZK3 = 20Ω/phase
b = 32

TURH settings
P = 1

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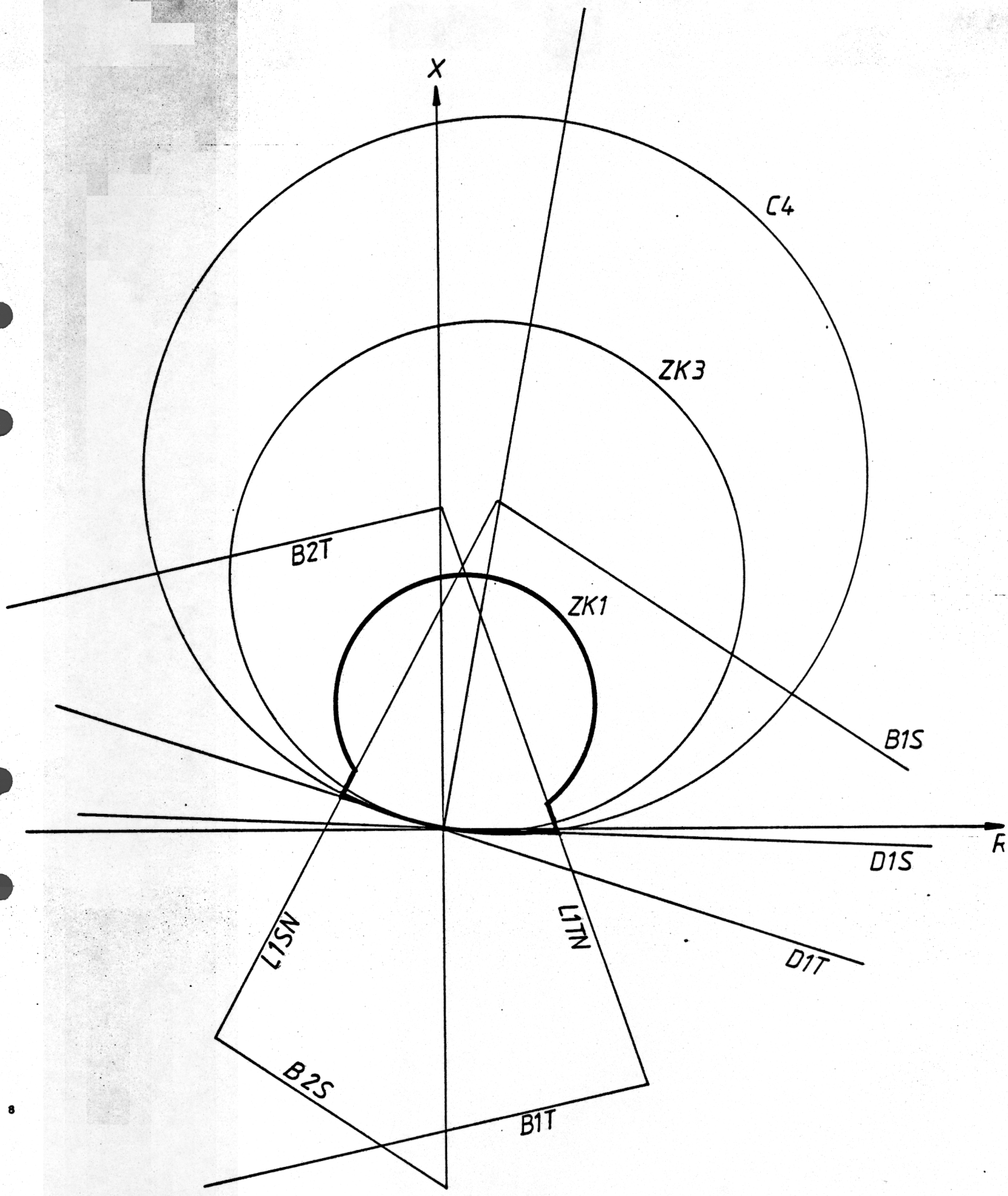

Fig. 2 Two-phase fault step 1

RAZFE settings
Zk1 = 2.5 Ω/phase
Zk3 = 5 Ω/phase
b = 8

TURH settings
P = 0.25

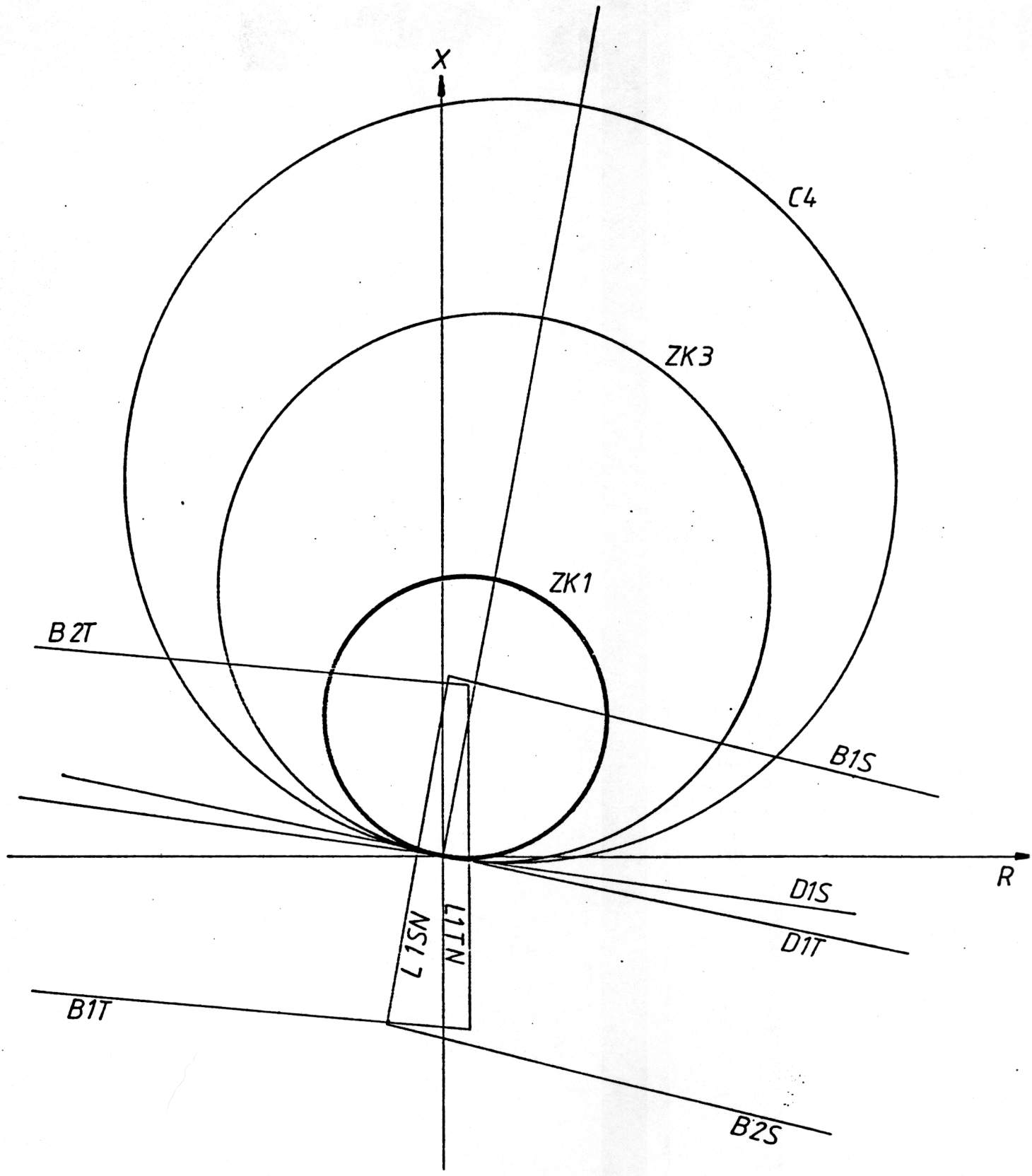

Fig. 3 Two-phase fault step 1

RAZFE settings
ZK1 = 0.5 Ω/phase
ZK3 = 1.0 Ω/phase
b = 4

TURH setting
P = 0.05