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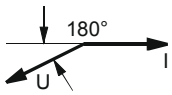
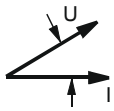
5. Functions of Individual Control Parameters

5.1. Specifying the kind of fault and frequency

(parameters FC, FR, DFR and DF)

5.1.1. Power direction, kind of fault

The value of the parameter FC (**f**ault **c**ode) specifies the kind of fault and its direction (power direction). For this definition, it is assumed that the starpoint of the ct's is on bus side.

FC=xyz	(default value FC = 000). **The x digit** determines the fault direction; this is defined (assuming the c.t. start-point is on the busbar side) as follows:
x=0  HEST 955024 C	Fault in the **forwards** direction (tripping direction), i.e. when the angle PHI is set to 0° (list UI, see Section 4.3.3.), the current I and the voltage U are in **opposition** at 180°. For example, for PHI=30[°], PHI plus 180° must be taken into account.
x=1  HEST 955025 C	Fault in the **reverse** direction (tripping direction), i.e. when the angle PHI is set to 0° (list UI, see Section 4.3.3.), the current I and the voltage U have the **same** direction. For example, for **PHI=30**[°], only PHI has to be taken into account.

The digits y and z determine the kind of fault. A distinction is made between two main groups of faults:

a) Faults corresponding to those in a three-phase radial system (rated frequency 50 or 60 Hz)

b) Faults involving injection signals of special amplitude and/or frequency.

The following tables show the relationship between the setting for yz from list UI and the kind of fault and its **amplitudes** injected.

a) **Faults in a three-phase power system**

Operator program XSWIN: These kinds of faults are selected via the buttons on the “Test Method” and “Test Library …” screens. The “Control Parameters” button enables the side of the c.t’s with the star-point and the direction of the fault to be set.

Ground faults

with yz=11 L1 phase-to-neutral ($U = U_{L1}$, $I = I_{L1}$)
with yz=12 L2 phase-to-neutral ($U = U_{L2}$, $I = I_{L2}$)
with yz=13 L3 phase-to-neutral ($U = U_{L3}$, $I = I_{L3}$)

Phase-to-phase faults (no ground contact)

with yz=21 L1 phase-to-L2 phase ($U = U_{L1L2}$, $I = I_{L1} = - I_{L2}$)
with yz=22 L2 phase-to-L3 phase ($U = U_{L2L3}$, $I = I_{L2} = - I_{L3}$)
with yz=23 L3 phase-to-L1 phase ($U = U_{L3L1}$, $I = I_{L3} = - I_{L1}$)

Three-phase faults

with yz=31/32 or 33 L1, L2, L3 phases ($U = U_{L1} = U_{L2} = U_{L3}$, $I = I_{L1} = I_{L2} = I_{L3}$)

For XS92b and XS92a units equipped with three current amplifiers, three currents are always supplied for yz = 31 to 34 (IRA = 30 or 31, see Section 5.5.).

Fault codes when MOD = UI3 selected

Using the current amplifier AI93 (3 currents) all inputs (IR...PIT) are considered, provided that IRA = 30 or 31 (see Section 5.5.) has been set. The fault code FC does not influence injection (however, it must not be 00, 01, 02 or 03).

b) **Special kinds of faults**

Operator program XSWIN: These kinds of faults are selected in the control parameters screens.

Faults yz = 00, 01, 02 and 03 belong to this group. Injection commences at 'START' and is maintained up to interruption regardless of the set sequence (parameter SQ) or fault duration (parameters TF and MT).

In the case of yz = 00, 01, 02 and 03, the parameter MOD is changed automatically to UI (see Fig. 4.13) at the instant of 'START'! The magnitude of the injection signals is thus determined by parameters in list UI (see Section 4.3.3.).

FC=000 injection of off-load signals ($U_{L1} = U_{L2} = U_{L3} = 57.7$ V). The voltages are at 120° to each other. Apart from the rated frequency (50 or 60 Hz, parameter FR), no other inputs have to be made. Parameter MOD remains unchanged and injection is interrupted by pressing the '0' key (STOP).

FC=x01 injection of current and one voltage ($U = U_{L1}$, $I = I_{L1}$; U = 0 to 220 V, max. 20 VA!). Apart from the rated frequency (50/60 Hz), all the parameters in lists UI and DUI are taken into account (automatic change to MOD = UI). Step values and therefore the automatic search sequence (parameter A, see Section 5.3.) are possible. Injection is interrupted by pressing the '0' key (STOP) or when the interrupt condition is satisfied (parameters IN and TI, see Section 5.4.). This kind of injection is used, for example, for testing a voltage or current relay.

FC=002 injection of a voltage (U_{L1}) with variable frequency ($U = U_{L1}$), U = 0 to 220 V, max. 20 VA, frequency 40 to 70 Hz).

FC=003 injection of a voltage ($U_{L1,L2}$) with variable frequency ($U = U_{L1,L2}$, U = 0 to 140 V, max. 50 VA, frequency 40 to 70 Hz). The entry made for U refers in this case to $U_{L1,L2}$ (U_{L1} and U_{L2} are in opposition and equal to U/2).

The following applies to codes 002 and 003:
U, DU, LUH and LUL from lists UI and DUI are taken into account (automatic change to MOD = UI, **no** current injection!). The frequency of the injection voltage depends on the parameters FR, DFR, DF and TF (see Section 5.1.2.). The automatic search sequence is thus possible with step values (parameter A). Injection is interrupted by pressing the “STOP” key or when the interrupt condition is satisfied (see Section 5.4.). These two fault codes are used mostly for testing frequency relays.

5.1.2. Injection signal frequency

The frequency of the injection signal is determined by the parameters FR (**FR**equency), DFR (**D**elta **FR**equency = frequency step) and DF (frequency rate-of-change **df**/dt).

FR=xx.xx (default value FR = 50.0 Hz) determines the frequency of the injection signal **after 'START'**. The frequency can be chosen in the range 40 to 70 Hz in steps of 0.01 Hz for all fault codes FC = 002 to 033 (e.g. 49.83 Hz).

DFR=x.xx (default value DFR = 0) determines the increment or decrement of **one** frequency step (see Section 5.3.). This can only be entered for fault codes FC = 002 and 003. A step can change the frequency by 0.01 to 1 Hz, 0.01 Hz being the smallest step. DFR

is automatically set to zero, if some other step parameter (e.g. DU) or a rate-of-change (parameter DF) is entered.

DF=x.x (default value DF = 0) defines the frequency rate-of-change in Hz/s. This can only be entered for fault codes FC = 002 and 003 and can be chosen in the range 0.4 to 5 Hz/s in steps of 0.1 Hz/s.
The frequency variation is linear with time and commences the instant either the '+' (increasing) or '-' (decreasing) key is pressed after 'START' has taken place and continues until:

- either the interrupt condition is satisfied (see Section 5.4.)
- or the duration of injection (parameters TF and MT) has expired
- or the limit 70 Hz respectively 40 Hz is reached, after which the final value of the frequency is shown. The parameter DF is automatically set to zero, if a step parameter (e.g. DU or DFR) is entered.

5.2. Steady-state and dynamic injection and duration

(parameters SQ, TO, TL, TF and MT)

5.2.1. Steady-state and dynamic injection

Operator program XSWIN: The kind of injection is selected on via the “Control parameters” button or the “Fast setting” button.

Steady-state injection

SQ=x (default value (SQ = 2). The parameter SQ (**S**e-**Q**uence) determines whether injection is to be **steady-state** (or dynamic).

with x=2 **Injection** of the fault commences immediately after 'START', the amplitude of, and phase relationship between the injection signals being defined by the corresponding parameters (e.g. from list ZZ). The parameters and therefore the injection signals can be varied in steps (see Section 5.3.). Injection is interrupted by pressing the '0' key (STOP) or when the interrupt condition is satisfied (see Section 5.4.).

with x=0 This can only be set **under program control**. A zero signal is injected following 'START' (in program 'F' until either the set fault duration (parameters TF and MT) is reached or the interrupt condition is satisfied (see Section 5.4.).

with x=1 This can only be set **under program control**. The off-load voltage is injected following 'START' (in program 'F') until either the set fault duration (Parameters TF and MT) is reached or the interrupt condition is satisfied (see Section 5.4.).

Dynamic injection

SQ=xyz In the case of **dynamic** injection, the parts of the injection sequence are defined by the letters (xyz) of the parameter SQ (see Section 5.6. "Options" for special injection sequences).

Dynamic injection means that the status of the injection signals varies according to a pre-determined sequence.
I.e. the voltage can change abruptly from its off-load value (1st. part of the injection sequence) to a value determined by the parameters (2nd. part of the injection sequence).
In a 3rd. part of the sequence, the voltage can return to its off-load value or to zero.

The following values can be entered for SQ = xyz:

(1st. part)

with x=0 Zero is injected following 'START' (signals with zero amplitude). The duration is determined by the parameter TO.

with x=1 Off-load voltages are injected following 'START'. The duration it determined by the parameter TL.

(2nd. part)

with y=F The fault is injected at the end of the 1st. part of the sequence at amplitudes determined by the parameters of the corresponding list (e.g. list ZZ). The duration of the 2nd. part of the sequence (fault duration) depends on the values of the parameters TF, MT, TI and TT and also on the response of the relay under test (see Sections 5.2.2. and 5.4.). The type of fault is determined by the parameter FC.

(3rd. part)

with z=0 The 3rd. part of the sequence is a period of injection at zero amplitude.

with z=1 The 3rd. part of the sequence is a period of injection at the off-load voltages.

There is no setting for the duration of the 3rd. part of the sequence. It depends on whether a further injection sequence is to follow or not.

The following sequences (values of SQ) are possible for dynamic injection:

SQ=0F0	zero	→ fault	→ zero
SQ=1F0	off-load voltages	→ fault	→ zero
SQ=0F1	zero	→ fault	→ off-load voltages
SQ=1F1	off-load voltages	→ fault	→ off-load voltages.

Caution:

If the final part of the sequence is the injection of the off-load voltages, the automatic search sequence (see Section 5.3.) must be arranged to interrupt the injection signals. This is done in the manual mode by pressing the '0' key and in the program mode by means of the instruction 'STP'.

5.2.2. Duration of the injection signals

Operator program XSWIN: The duration settings are selected by clicking on the “Control parameters” button and then “Duration of the injection signal” or via the “Fast setting” button.

TO=xxxx (default value TO = 100 ms) determines the duration of injection at zero amplitude in the 1st. part of the injection sequence (SQ = 0yz) in the range 100 to 9999 ms.

TL=xxxx (default value TL = 100 ms) determines the duration of injection of the off-load voltages in the 1st. part of the injection sequence (SQ = 1yz) in the range 100 to 9999 ms.

The effective minimum duration of the 1st. part of the injection sequence depends on the time taken to calculate the fault signals which are injected in the 2nd. part and can be as much as 100 ms.

TF=xxxx (default value TF = 0 ms) defines together with the parameter MT the duration of uninterrupted fault injection, i.e. the time window during which an interruption of fault injection can be initiated by external signals (see Section 5.4.). The parameter TF can be set in the range 0 to 9999 ms.

MT=xxx (default value MT = 1) is a multiplier for parameter TF. Its value determines the maximum possible duration of injection, the accuracy of time measurement and the display format of the measured time (see Section 5.4.3.).

for xxx=1	max. injection duration (MT x TF) =	9999 ms =	9.999s
for xxx=10	max. injection duration (MT x TF) =	99990 ms =	99.99s
for xxx=100	max. injection duration (MT x TF) =	999900 ms =	999.9s

If fault injection is not interrupted by an external signal, it is continued in the following fashion after the set fault duration (MT x TF) has expired.

Steady-state injection:

Providing a step parameter has been entered and parameter A = 1 or A = 2 has been set (see Section 5.3.), newly calculated, automatically varied fault signals are injected.

If A = 0 has been set, a further (manual) step is executed upon entering '+' or '-', but not before the end of the fault duration.

Parameters TF and MT have no influence on the duration of fault injection, as long as no step parameter is activated.

Dynamic injection:

In this case, the injection sequence proceeds to the 3rd. part as defined by the last digit of the parameter SQ code (see Section 5.2.1.).

5.3. Pick-up value step search sequence

(parameter A, step parameter D.. and limit L..)

Testing protection equipment usually consists in checking the pick-up points of the various measuring units in relation to their operating characteristics.

Depending on the plane in which the characteristic is represented (voltage/current or impedance plane), the injection signals can be directly specified and calculated with the aid of the parameters U, I or Z (parameter MOD, see Section 5.5.).

5.3.1. Varying injection signals in steps

By entering a step parameter, e.g. DLZ for parameter ZL (see Section 4.3.2.), provision is made for the main parameter and the corresponding injection signals to be steadily varied in steps until:

- either the relay under test responds to the injection signals, i.e. produces a signal itself (external interruption of injection, see Section 5.4.)
- the limit of the range of variation is reached
- injection is terminated by pressing the “STOP” key.

Each injection, incremented or decremented by one step is initiated by entering the parameter and corresponding step parameter and pressing:

'START' Injection of the fault signal starts immediately for **steady-state** injection (parameter SQ), while the whole sequence is injected for **dynamic** injection. In the latter case, the test set does not respond to external signals, if automatic testing is set with A>0 (see Section 5.3.2.).

'+' if the injection signals are to be incremented

'-' if the injection signals are to be decremented. The fault signals are recalculated and then injected (a new sequence in the case of **dynamic** injection). The test set responds to the external signals as specified (see Section 5.4.).

The value of the current parameter is displayed during injection.

It is essential that only one step parameter in a list (e.g. list DUI, see Section 4.3.3.) be activated at any one time by entering a value other than zero for it.

Activating one step parameter of a list deactivates all the other step parameters in the same list, and where applicable also the parameters DFR and DF (see Section 5.2.1.), by setting them to zero.

5.3.2. Pick-up value search sequence

In order to find the relay's pick-up value, a fault signal is injected and varied in steps either **manually or automatically**. Using the **operator program XSWIN**, the step variations are selected by clicking on the "Control parameters" button and then on "Pick-up value step search sequence" or on the "Fast setting" button and then on "Pick-up value step search sequence (A)".

In the case of **steady-state** injection (SQ=2), only the injection of the fault signals is repeated, while in the case of **dynamic** injection, the whole sequence is repeated (SQ = xyz, see Section 5.2.1.).

A=x (default value A = 0) determines whether a variable injection signal is repeated manually or automatically.
If the signal is repeated automatically, the value of A determines whether the interrupt condition has to be fulfilled when the signal is being incremented or decremented.

with x=0 Each step change of a parameter by the amount of the step value and the consequential recalculation of the injection signal has to be initiated **manually** by pressing either the '+' or '-' key. Up to this instant, the previous fault signal is injected in the **steady-state** mode and the last part of the injection sequence in the **dynamic** mode. Injection is terminated by pressing the "STOP" key. "ENTER" must be pressed before new parameters can be entered.

with x=1 As soon as the '+' or '-' key is pressed after pressing 'Start', recalculation and injection of the fault signal is repeated **automatically** until interrupted. Interruption occurs when:

- the pick-up of the relay under test fulfils the interrupt condition for an **increasing parameter value** (see Section 5.4.)
- the limit of the variable parameter range is reached as defined by the parameter L.. (see Section 5.3.3.)
- the “STOP” key is pressed.

In the two latter cases, variation of the parameter is discontinued, but injection is maintained at the level reached as for A = 0. The “STOP” key must be pressed to terminate injection.

with x=2 As soon as the '+' or '-' key is pressed after pressing 'START', recalculation and injection of the fault signal is repeated **automatically** until interrupted. Interruption occurs when:

- the pick-up of the relay under test fulfils the interrupt condition for a **decreasing parameter value** (see Section 5.4.)
- the limit of the variable parameter range is reached as defined by the parameter L.. (see Section 5.3.3.)
- the “STOP” key is pressed.

In the two latter cases, variation of the parameter is discontinued, but the injection is maintained at the level reached as for A = 0. The “STOP” key must be pressed to terminate injection.

Instructions for the automatic pick-up search sequence

The difference between A = 1 and A = 2 is of advantage especially when the initial search for pick-up values is in coarse steps and the measured pick-up is well above the pick-up setting.
After restarting, the direction of variation can be reversed and the injected signal reduced without interruption below the set threshold in spite of the fact that the unit has picked up.
The search can then be repeated with a smaller step change (after changing the direction of variation once again).

This procedure is particularly efficient when included in a test program (see Sections 6.1.6. and 6.1.10.).

The direction of variation of the injection signal may also be changed while injection is in progress by pressing the key with the corresponding sign. The change does not take effect, however, until after the fault duration MT X TF.

The sequence of the repetitions depends on the time required for recalculation, the set fault duration (MT x TF) and in the case of **dynamic** injection, on the parameters TO respectively TL (see Section 5.2.2.).
If it is necessary for a signal, e.g. the voltage U, to change rapidly for a certain step value DU, MT x TF has to be set to a low value and vice versa.

For **static** injection, there is also a minimum duration of step injection which is determined by the time required to calculate the injection signals for the next step.

5.3.3. Limits of the ranges of variable parameters

The limits of variation of the injection signals are determined by the corresponding parameter L.., e.g. LIH for the maximum value of the fault current parameter I (see Section 4.3.3.).
The settings of these limits ensure that the injection signals remain within a preset range.
They are used, for example, to protect a protection relay against inadmissible injection signals.
A further application of these settings is to limit the time taken by the automatic pick-up value search sequence in cases when the relay should have picked up, but does not.

5.4. Stopping injection by external signals, time measurement or stop signal

(parameters IN1, IN2, TI, TT, T, OU1, OU2)

5.4.1. Digital inputs and interrupt condition

Different measuring units and timers of the relay under test may respond to the injection signals, i.e. the relay may issue several signals simultaneously.
Before the test set XS92b is able to evaluate the behaviour of the relay correctly, it must distinguish between the signals coming from the relay.

External signals can be applied to the following digital inputs:

Tripping signal input

This input (socket on the output unit AC93) is electrically connected to the injection signal outputs.
Therefore it must be switched to the socket '+' (15 V) by a potentially-free contact on the auxiliary tripping relay of the relay under test.
It is designed to withstand **brief** overvoltages up to ± 250 V with respect to the socket 'N' (or socket A 11 on the AX92).

The sense of the signal depends on the position of the switch 'Trip' (4 in Fig. 2.5):

switch up		logical '0'	≤ 2 V
		logical '1'	≥ 10 V
switch down		logical '0'	≥ 10 V
		logical '1'	≤ 2 V

Since the switch 'Trip' provides facility for reversing the logical sense of the signal, either a N/O (switch up) or N/C (switch down) contact can be used.

Inputs In1 to In10

The inputs of the XC92 unit (5 in Fig. 2.5, input resistance 1 MΩ) are electrically insulated from the electronic circuits. The corresponding logical signal levels referred to the '0V' socket are defined as follows:

logical '0'	-250 V to 1 V
logical '1'	7 V to 250 V.

The input for the parameters IN1 and IN2 described below is unnecessary when unsing the **operator program XSWIN**, because the inputs can be directly selected by clicking on them in the selection dialogue accessible via the “Control parameters” button.

IN1=xxxx (default value IN1 = 1) specifies the combination of the above digital inputs which is scanned for the **interrupt condition**.
This condition is satisfied when all the nominated inputs are simultaneously at logical '1'. The value of the parameter IN1 is an **octal number** in the range 0 to 3777. The inputs are assigned to the digits of the code as follows:

:	In10	In9	:	In8	In7	In6	:	In5	In4	In3	:	In2	In1	Trip	:
	IN1 = x			x				x				x			

Each input of the above series can be viewed as a Bit of the octal number. The input counts as part of the interrupt condition when its Bit is set to '1' (see example in Section 5.4.3.).

IN2=xxxx (default value IN2 = 0) defines the active status of the binary inputs to be scanned.
It follows from this that the inputs selected by IN1 can be checked for logical '0' and logical '1'.
The value of parameter IN2 is an **octal number** in the range 0 to 3777:

:	In10	In9	:	In8	In7	In6	:	In5	In4	In3	:	In2	In1	Trip	:
	IN2 = x			x				x				x			

When entering values for the conversion of IN1 with MUL, DIV, ADD or SUB, the corresponding decimal value has to be entered under EDT during editing. The octal number will then appear in the program listing.

With the **operator program XSWIN** the IN1 and IN2 inputs can be selected directly by clicking on them in the "Control parameter" dialogue.

5.4.2. Response when the interrupt condition is fulfilled and measurement of operating or reset times

The value of the parameter TI determines the response of the test set XS92b once the interrupt condition specified by IN1 or IN2 has been fulfilled. In the case of **dynamic** injection (parameter SQ), parameter TI and the value of parameter TT determine whether a protection relay time has to be measured and if so which.

Operator program XSWIN: The interrupt conditions are selected by clicking on the “Control parameters” button and then on “Response, time measurement upon interruption”.

TI=x (default value TI = 2) defines the response of the test set when the interrupt condition is fulfilled (parameters IN1 and IN2).

with x=0 The test set does not respond to the interrupt condition, but continues to inject the fault signals until the set fault duration (parameters TF and MT) has expired (dynamic injection), respectively until injection is interrupted by pressing the “STOP” key (steady-state injection).

with x=1 The time which elapses until the interrupt condition is fulfilled is measured during injection (see also parameter TT), but injection of the fault signals is continued.

with x=2 Injection is interrupted as soon as the interrupt condition is fulfilled.
At the same time, the operating time of the protection relay is measured and the third part of the injection sequence (see Section 5.2.1.).

with x=3 The only response upon fulfilment of the interrupt condition in the **steady-state** injection mode is the discontinuation of the automatic search sequence (parameter A), i.e. the variation of the parameter in steps ceases. Injection of the step reached, however, continues until the “STOP” key is pressed.
The test set's response during **dynamic** injection is the same as for TI = 2.

TT=x (default value TT = 0) determines which protection relay time is to be measured.

with x=0 The operating time is measured from the commencement of fault injection until the interrupt condition (parameter IN1 (IN2)) is fulfilled. This is normally the time taken by the relay to **trip**.

with x=1 The **resetting** time is measured from the instant fault injection ceases, i.e. from the start of the third part of the injection sequence, until the interrupt condition disappears.

5.4.3. Accuracy and display of the time measured

Providing parameter TI has been set to zero, the time of every injection sequence is measured and the result displayed on the (handheld) terminal for 't ...'.
The time measured is also stored under parameter T.

If the interrupt condition is not fulfilled during injection, t equals the set fault duration MT x TF and parameter T is zero.

T=... is only displayed upon entering 'T' and pressing 'ENTER'. It shows the last time measured in seconds.

The accuracy of the time measurement and the display format of t and T depend on the value of the parameter MT (see Section 5.2.2.):

Parameter MT	**MT = 1**	**MT = 10**	**MT = 100**	
Accuracy	± 0.5	± 17	± 17	[ms]
t display	0.00 to 9.99	0.00 to 99.9	0.00 to 999	[s]
T display	0.0 to 9.999	0.0 to 99.99	0.0 to 999.9	[s]

For **steady-state** injection, the time from the beginning of injection or from a step change up to the instant the interrupt condition is fulfilled (e.g. the receipt of a pick-up signal) is measured and displayed on the terminal. The parameter T is assigned the value of the time measured. Parameter T becomes 0 should the interrupt condition not be fulfilled.

Example 1 (only for the terminal mode or handheld terminal)

Fault injection has to be interrupted when the relay tripping contact closes and another signal applies a logical '0' to input In5.
The operating time has be measured with the greatest possible accuracy and tripping should normally take place within 200 ms of the beginning of injection.

Settings:

SQ=1F0	dynamic injection (e.g. SQ = 1F0)
MT=1, TF=200	maximum accuracy, MT x TF = 200 ms
IN1=41	(i.e. 0 0 : 0 0 0 : 1 0 0 : 0 0 1 : binary) The two inputs In5 **and** Trip are polled.
IN2=40	(i.e. 0 0 : 0 0 0 : 1 0 0 : 0 0 0 : binary) In5: logical "0" Trip: logical "1"
TI=2	Injection is discontinued when the interrupt condition is satisfied.
TT=0	The operating (tripping) time of the relay is measured.

5.4.4. Output signal

OU1=x (default value OU1 = 1) determines whether the signal 'Out' (5 in Fig. 2.5) is set to logical '1' while injection is in progress. The output is electrically insulated from the high-power injection output and the signal levels with reference to the '0 V' socket are defined as follows:

logical '0': 0 to 0.5 V
logical '1': 11 to 13 V.

Current can flow into the signal output when it is at logical '0' and flow from it when it is at logical '1'. The internal resistance is about 2 kΩ.

with x=0 The signal output is not set and remains at logical '0'.

with x=1 The signal output is set to logical '1' throughout injection.

OU2=xx (default value OU2 = 0) is defined as an octal number which switches over additional outputs located in the YU92a unit (option).

OU2=43 (corresponds to 100011) switches over relays 1, 2 and 6.

In the **operator program XSWIN** the required outputs can be directly selected by clicking on the “Control parameters” button and then on the outputs.

5.5. Determining the mode of calculation and current range

(parameters MOD and IRA)

Using the **operator program XSWIN**, the method of calculating the test signals is selected by clicking on the "Test Method" button and then on the desired method in the list.

MOD = xxx (default value MOD = ZZ) enables the user to determine from which list of parameters the values are taken for calculating the injection signals. Permissible lists are those with the designations ZZ (DZ), UI (DUI), UI3 (DU3) and UU (see Section 4.3.).

with xx=ZZ The injection signals are calculated using the values of the parameters in list ZZ (impedances).
The corresponding step parameters and limits are taken from list DZ.
Using impedance values to calculate the injection signals is especially of advantage when the operating characteristic of the relay under test is represented in the impedance plane.

with xx=UI The injection signals are calculated using the values of the parameters in list UI (fault voltage and current), i.e. the injection signals are directly defined by U, I and their phase-angle PHI.
The corresponding step parameters and limits are taken from list DUI.
This mode of calculation is better when the operating characteristic of the relay under test is represented in a voltage/current plane, or when injection has to take place at a particular current and/or voltage.

with xxx=UI3 The list UI3 (injection voltages and currents) determines the magnitudes of the injection signals.
The corresponding step parameters are taken from list DU3.
As can be seen from these lists, amplitudes and phase-angles (referred to U_R) may be individually entered for all signals.
The parameter IRA below must be modified for the injection of three voltages and three currents.

with xxx=UU This list permits the output of 2 three-phase voltage systems U1 and U2 with different amplitudes, phase-angles and frequencies, providing the op-

	tional YU92a unit and an additional voltage amplifier are fitted.
IRA=x	(default value IRA = 30) determines the maximum current injected by the test set in the **steady-state** injection mode (parameter SQ) and the accuracy of the injection current. The current range of IRA=x is switched over automatically for **dynamic** injection, but not the range of IRA=xy.
with x=0	The injection current can be in the range 0 to 20 A. The accuracy is about ± 1% of setting, respectively 0.15 % of full range, whichever is greater. Because of its greater accuracy, x = 1 is recommended when using currents in the range 0 to 1.3 A.
with x=1	The injection current can be in the range 0 to 1.3 A. The accuracy is about ± 1 % of setting, respectively 0.15 % of full range, whichever is greater.
IRA=xy	determines the maximum current injected by the test set in the **steady-state** injection mode (parameter SQ) and the accuracy of the current signal and it also switches over for the injection of three currents. The current range of IRA=xy is automatically switched over for **dynamic** injection, but not the range of IRA=x.
with xy=30	Three currents are injected with this setting. AC93 is required for directly injecting three currents. The setting range and accuracy of the three injection currents correspond to IRA = 0.
with xy=31	Three currents are injected with this setting. AC93 is required for directly injecting three currents. The setting range and accuracy of the three injection currents correspond to IRA = 1.

5.6. Special test options

(parameter OP)

OP=x (default value OP = 0) enables the generation of special injection signals (**OP**tions), such as are necessary, for example, for testing auto-reclosure relays.

with x=0 No special injection signals generated; the test set functions as described in Sections 5.1. to 5.5.

with x=1 **for testing auto-reclosure relays using special injection sequences**.

The special injection sequences concerned in this case simulate either successful or unsuccessful auto-reclosure attempts (see Section 9.1.1.).

with x=2 **prolongs the injection of fault voltage beyond the interruption of fault current.**

This special injection sequence is for testing the ultra high-speed directional comparison scheme LR91 (see Section 9.1.2.).

with x=3 **for the injection of 2 three-phase voltage systems**

This option permits the testing of synchrocheck equipment at different frequencies whether the test set has a supplementary voltage amplifier or not, e.g. supplementary rack 4 (see Section 8.6.1.).

with x=4 **for the injection of user characteristics**

This option enables externally calculated (or digitised) injection characteristics to be downloaded to, stored in and injected by the test set (see Section 9.1.2.) (x = 4 is automatically set during downloading).

5.7. Special functions

The following parameters are not in any parameter list, but can be entered in the terminal mode at any point. The operator program, however, jumps to the FF list.

SSI = xxx (default value SSI = 000) changes the ratio of voltages and currents transferred via the optional low-signal interface YU93.

mit xxx=100 adjusts the ratio such that for an input of the rated values UN = 100 V and IN = 1 A, the corresponding low-signal outputs are U = 6.5 V and I = 125 mV.

mit xxx=110 adjusts the ratio such that for an input of the rated values UN = 110 V and IN = 1 A, the corresponding low-signal outputs are U = 6.5 V and I = 125 mV.

HAR = x (default value = 0) gives the order of the harmonics that can be added to the voltage and current values in mode (UI). Range x = 2 to 9, i.e. 2nd. to 9th. harmonic.

API = xx (default value = 0) gives the percentage harmonic content in relation to the fundamental of the fault current. The phase-angle of the fundamental is fixed at 0°. Range xx = 00 to 50 %.

DHI = x.x (default value = 0) enables a step value to be entered for the harmonic content in the current. Range x.x = 0.0 to 1.0 %.

APU = xx (default value = 0) gives the percentage harmonic content in relation to the fundamental of the fault voltage. The phase-angle of the fundamental is fixed at 0°. Range xx = 00 to 50 %.

DHI = x.x (default value = 0) enables a step value to be entered for the harmonic content in the voltage. Range x.x = 0.0 to 1.0 %.

EXT = x (default value = 0) enables injection to be started by an external signal. Input In10 on the control unit XC92 hast to be used. Steady-state injection and dynamic injection sequences can be started, but not those that include an automatic search sequence or incrementation by step values when restarted. Dynamic injection can be repeated by another starting impulse. x = 1 for external start.