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8. Instructions for Testing Protection Relays

8.1. Testing protection relays with the test set XS92b

8.1.1. General

In this section of the Operating Instructions recommendations are given on how to test the different kinds of protection relays with the test set XS92b.

It is assumed that the user is already familiar with the operation of the test set as described in Sections 2.2. to 2.2.8., 10.1.6. and 4. to 7. of these instructions. The manual test procedure is described, but testing can be simplified and performed much more efficiently, if certain sequences or even the whole test procedure is programmed.

8.1.2. Connection

Before connecting the test set to the relay to be tested

- disconnect the DC circuits as far as necessary with the exception of the auxiliary supply
- disconnect and short-circuit the c.t. circuits
- disconnect the v.t. circuits.

In the case of ABB protection relays, the above is done automatically upon inserting the test plug YX91 R4 into the test socket XX91 on the relay. This operation also establishes the connections to the 2 mm sockets numbered 1 to 12 on the front of AC93 unit. These enable the test set to receive various signals from the relay or, by inserting a jumper, to include the circuit-breaker in the test.

The sockets marked "+" and "–o/o–" are for connecting a potentially-free relay tripping contact. It is recommended to use these sockets whenever possible, because the test set responds to signals from them without having to enter additional parameters. Where a potentially-free contact is not available, the sockets "In1" to In10" may be used.

The switch at the lower left of the XC92 control unit is for selecting whether the trip signal at the socket "–o/o–" is a "logical 0" to "logical 1" transition (N/O contact) or a "logical 1" to "logical 0" transition (N/C contact).

8.1.3. Instructions for testing

The following instructions should be carefully observed to avoid inaccurate test results.

8.1.4. Selecting the current range

The normal current range of the test set XS92b is 0 to 20 A (default value IRA = 30).
There is, however, a lower current range (IRA = 31) from 0 to 1.3 A which should be selected for settings lower than 1 A (especially if the current can fall below 0.2 A) or where source and line impedances are very high (ZS + ZL > 60 Ω).

8.1.5. Testing relays with high impedance burdens

In the case of relays having relatively high impedance inputs (e.g. electromechanical relays with a 1 A rating), it is possible for the "Z>>" monitor in the current amplifier (Section 10.1.6.) to operate at low current levels. This problem can be overcome by connecting a suitable c.t. (ratio n:1) to the sockets "I" and "(I)" on the AC93 output unit instead of shorting them:

Example:
ABB current transformer Type WI 23 Z, 5/1 A

Primary winding ("n") between "I" and "-I//" (L and K)
Secondary winding ("1") between "(I)" and "-I//"
(I and k)

Seen from the amplifier, the impedance of the burden is reduced by a factor $1/n^2$. The following must be observed:

- polarity of the windings
- the injection current is n times smaller than that entered
- amplitude and phase errors of the interposing c.t.

8.1.6. Measuring in the reverse direction

Reversal of the direction of measurement of a distance relay is achieved by reversing the phase of the current, that is by setting the digit in front of the actual fault code to 1. When using the operator program, click on the “Backwards” field in the “Kind of fault” dialogue.

Example:	FC = 021	R-S fault in tripping direction
	FC = 121	R-S fault in reverse direction

The relationship can also be the other way round depending on the grounding of the main c.t's.
When measuring the operating characteristic of cross-polarised relays in the reverse direction, the characteristic will be very small and lie largely in the third quadrant. Since the zero can also be displayed at the same time, two pick-up points are to be expected for each angle. These can be found starting firstly from the origin of the impedance coordinates and secondly by coming in from a high impedance value. Measurement is impossible, however, in the range where the fault impedance is almost equal to the source impedance (see Section 8.1.7.).

8.1.7. Reduction of healthy voltages

As the fault impedance ZL.exp j (PZL) approaches ZS.exp j (PZL + 180), i.e. equal in amplitude but in phase opposition, the injection voltages and current approach infinity. In order to limit the range which cannot be tested, the fault voltage remains constant once it has reached 70 V and instead the healthy voltages are proportionally reduced until they reach 10 V. Upon reaching this limit, "UN<<" appears briefly on the display while injection is proceeding.

The same method is used when fault currents greater than 20 A are calculated. The reason in this case is that especially with relays having a 5 A rating, there is scope for extending the measuring range a little.

This reduction only takes place immediately before the injection of fault quantities when testing dynamically, so that there is a step function at this instant in the amplitude of the healthy voltages. It is possible for this jump to cause some relays to pick up briefly and therefore care must be taken when using this technique.

8.1.8. Phase-angle accuracy for phase-to-phase faults

At low phase-to-phase fault voltages of about 1 V in mode (ZZ) (i.e. ZS/ZL>>), the change in amplitude and phase-angle of the injection voltage is so low for small impedance steps that the resolutions of the processor and injection unit become inadequate. For example, a change of fault voltage from 0.2 to 0.3 V means varying the phase voltages by 0.00022 V and 0.1°. In such cases, using the highest current, respectively the lowest source impedance possible is recommended.

8.1.9. Overlapping of starting and measuring characteristics

When plotting the characteristics of distance relays in the four quadrants of the impedance plane, it should be born in mind that the operating areas of different starting and measuring systems can overlap or appear in areas which only exist theoretically. The size and position of the operating areas depend on the measuring principle used and the settings.

8.2. Testing distance relays

8.2.1. Starting units

If contacts or electronic signals are available as outputs from the starting units, they can be connected to the inputs In1 to In10. (The zero of the relay circuits must be connected to the 0 V socket.) Where the signals of several starting units are connected, it may be necessary to reprogram the scanning of the inputs to correspond to the change of fault code (IN1 respectively IN2).

If no starter outputs are available, the only possibility is to observe the signalling flags on the distance relay. To achieve better accuracy, it is recommended that once the unit has picked up using the automatic search sequence to go back a few steps, set A = 0 and find the pick-up point manually.

8.2.2. Overcurrent starting

The static mode (SQ = 2) is best when testing overcurrent starting units, although dynamic testing is possible. The starting units are selected by virtue of the fault code FC. The following procedure can be used:

- Set MOD = UI, because the current is to be the main parameter.
- Set A = 1 for the automatic search sequence with a stop when running up.
- Enter I about 20% below setting.
- Enter U = 58 V (about load voltage).
- Enter DI = 0.1 or the desired step value.
- Set TI = 2, if a starting unit pick-up signal is available, otherwise TI = 0 or 1.
- Start the search sequence with the "Start" and "+" keys and wait for the test to stop automatically or stop it manually using the "0" key when observing the flags.

The pick-up current can now be read from the display. Where greater accuracy is desired, go back about two steps, set DI = 0.01 and find the pick-up value again.

8.2.3. Underimpedance starting

The best operating mode for measuring an underimpedance characteristic either steady-state or dynamically is ZZ. Most starting characteristics are unaffected by the source impedance. Entering a source impedance ZS can influence the injection current, especially at low starting unit settings. A typical current level for checking starting units is about one to two times rated current. When line and source impedance angles are equal and φK0 = φKS = 0, the following formula can be applied to calculate the output current:

- 57.7 / (1+KS) x ZS + (1+K0) x ZL for earth faults
  (see Section 3.2.3. for exact formula)
- 50 / (ZS+ZL) referred to UN (phase-to-phase) = 100 V
  (see Section 3.2.3. for exact formula).

Steady-state measurement

The procedure is similar to that for overcurrent starting except that ZS, ZL and PZL and possibly K0 and PK0 have to be entered.

As it is of advantage to find the pick-up point by moving along a straight impedance phasor, the step parameter is normally DZL. If it is to be feared that for some special characteristic the intersection will be too tangential using this technique, an alternative is to use DPL and vary the phase-angle in this region. The actual setting of DZL or DPL depends on the required accuracy, but as explained above, it is an advantage to test in several steps with increasingly finer decrements.

The procedure is briefly:

- Select a starting unit by kind of fault and fault code FC.
- Enter ZL about 20% above setting.
- Enter the step parameter DZL or DPL as required.
- Enter A = 2 for a search from higher to lower values.
- Set TI = 2, if a starting pick-up signal is available, otherwise TI = 0 or 1.
- Start the search sequence with the "Start" and "-" keys and wait for the test to stop automatically or stop it manually using the "0" key when observing the flags.

The pick-up impedance can now be read from the display. Where greater accuracy is desired, go back about two steps, set DZL = 0.01 or DPL = 1 and find the pick-up value again. The procedure is then repeated for the next value of impedance (or phase-angle).

Dynamic measurement

The difference compared to steady-state measurement is that the duration of injection TF > 0 must be set, e.g. to 100 and SQ = 1F1. If the search is to be stopped by the relay tripping contact, TF must be set longer than the time of the last distance zone.

8.2.4. Tripping characteristics

Basically, the tripping characteristics of the distance zones are measured in the same way as the underimpedance starting characteristics (Section 8.2.3.). There are, however, the following differences which must be taken into account:

- The behaviour of cross-polarised relays depends on the source impedance, so that the shape of the characteristic is influenced by the setting of ZS.
- The directional sensitivity of the ground fault measuring units of non-switched distance relays can be tested phase-by-phase using fault codes 31 to 33, i.e. three-phase faults with one current. This does not apply to switched distance relays.

At very low settings the current may reach 20 A and cause a reduction of the healthy voltages and this must be taken into account (see Section 8.1.7.). A possible alternative is to use the UI mode and keep the current within limits by varying the fault voltage. Care should also be taken at high values of ZS + ZL or ZS/ZL (see Section 8.1.3.).

Steady-state measurement

Since when measuring a tripping characteristic the timer has normally been excited by a starting unit, there will be undesired switching of zones during the steady-state measurement. Static measurement is thus only possible, if facility is provided for blocking the timer once it has switched to the zone to be measured.

Dynamic measurement

Dynamic measurement enables the distance zones to be plotted automatically. The testing sequence SQ = 1F1 is recommended. The duration of injecting the healthy voltages should not be too short, e.g. TL = 300 ms, for relays equipped with a memory feature. The fault duration TF must be set longer than the slowest operating time of the zone being tested, but shorter than the time of switching to the next zone.

Example:
The 2nd. zone has to be tested.

Time step settings on the relay	:	t 1=0 (instantaneous) t2 = 300 ms t3 = 500 ms t4 = 1100 ms.
Max. time required to measure	:	45 ms
Therefore total 2nd. zone time	:	45 + 300 = 345 ms
Duration of 2nd. zone fault	:	360 > TF <480
Chosen setting	:	TF = 400 ms.

The procedure is briefly:

- Set MOD = ZZ and enter ZL, PZL, K0, PK0, ZS, PZS, KS, PKS.
- Select the measuring unit by kind of fault and fault code FC.
- Enter ZL (or PZL) about 20% above setting.
- Enter the step parameter DZL or DPL as required.
- Enter A = 2 for a search from higher to lower values.
- Set TI = 2, if a starting pick-up signal is available, otherwise TI = 0 or 1.
- Start the search sequence with the "Start" and "-" keys and wait for the test to stop automatically or stop it manually using the "0" key when observing the flags.

The pick-up impedance can now be read from the display. Where greater accuracy is needed, go back about two steps, set DZL for example to 0.01 and find the pick-up value again. The procedure is then repeated for the next impedance value (or phase-angle).

Measurement in mode UI

The characteristic can also be measured in Mode UI, e.g. with a constant fault current I and by varying the fault voltage U using the step parameter DU (or by varying the phase-angle PHI using the step parameter DPI). Greater accuracy is achieved by varying the current using DI, because the resolution is better. Note that for a current lower than 1.3 A, the lower current range should be selected by setting IRA = 1.

8.2.5. Checking directional sensitivity

Close faults are simulated in forwards and reverse directions in order to check the ability of a relay to determine direction. Mode MOD = UI is best for this purpose.
The current I is set to one to two times rated current and the fault voltage U to the desired residual voltage, e.g. U = 0.5 V. The step parameter DU = 0.1 can be used to reduce the voltage. The kind of fault and its direction are determined by the fault code FC (see Section 5.1. for fault direction).

8.2.6. Measuring operating times

When carrying out periodic routine testing, it is a good idea to first measure the operating times, because these reflect the condition of all the basic functions of the relay.
The operating time of a distance relay should be measured using the tripping contact (see Section 8.1.2. "Connections"). The time is displayed on the (handheld) terminal or in the “Injection” window and it can be printed by entering the instructions "PLP T" and "PTL 1" providing a printer is connected.

8.2.7. 1st. zone operating times

Operating times can be measured best using mode ZZ, because the impedance is changed in large steps (10% to 20% of setting) towards the pick-up point.
The following must also be set:

FR = rated frequency
TI = 1 for measuring time
TF > 0 and at least the longest operating time expected
TL > 200 ms
SQ = 1F1, sequence with injection of healthy voltages.

8.2.8. Operating times of the 2nd. and higher zones

The procedure is the same as described in Section 8.2.7. for the 1st. zone with the exception that TF must be set to correspond to the zone being measured: TF > zone time + max. measuring time.

8.2.9. Switching from one zone to the next

The operating times at the change from one zone to the next can be measured accurately by reducing the impedance decrement in this region, e.g. DZL = 0.02.

8.2.10. Operating times of individual units

In order to measure the operating times of individual starting or measuring units instead of the operating time of the whole relay, it is necessary to connect the output of the unit concerned to the test set instead of the tripping contact. This can be either a signalling contact or an electronic output.
The connections should be as short as possible and screened to avoid interference especially in the latter case. Attention must also be paid to the earthing points to avoid ground loops.

8.2.11. Measuring reset times

Reset times are measured from the instant the current ceases to flow to the disappearance of the tripping signal, or the fulfilment of the input signal condition as defined by parameter IN1. The input signal can also be the pick-up of a starting or measuring system. The test set XS92b measures the pick-up or reset time in the dynamic mode. TT = 1 is set to measure the reset time and TT = 0 is set to measure pick-up time.

8.2.12. Testing auto-reclosure functions

Set parameter **OP = 1** to select the special injection sequences for testing the function of auto-reclosure relays (see Section 5.6.).

This option facilitates the simulation of successful and unsuccessful auto-reclosure cycles.

The injection signals can be defined in the normal way using the parameters in lists UI and ZZ.
Variation of injection signals in steps is, however, not possible.

The control parameters have the following significance when **OP = 1** has been selected:

SQ=3 The sequence for unsuccessful auto-reclosure is injected when 'START' is pressed, i.e.

off-load voltages → fault signals → zero injection → fault signals → zero injection (1-F-0-F-0)

SQ=4 The sequence for successful auto-reclosure is injected when 'START' is pressed, i.e.

off-load voltages → fault signals → zero injection → off-load voltages (1-F-0-1)

TL=xxxx determines the duration of the off-load voltages, i.e. the duration of the first part of the sequence in the range 200 to 9999 ms.

TF=xxxx determines the maximum duration of the fault signals -F- in the range 0 to 9999 ms.
If the interrupt condition (see Section 5.4.) is fulfilled during this time, this part of the sequence is terminated at the next zero-crossing of the injection current and the period of zero injection commences.

T0=xxxx determines the duration of zero injection (auto-reclosure dead time) -0- after disappearance of the fault in the range 0 to 9999 ms.

Apart from the above, program parameter ST (see Section 6.1.8.) enables the number of auto-reclosure attempts to be determined, i.e. the number of times the sequence zero injection → fault signals (dead time and reclosure onto the fault) is repeated.

All other control parameters (list FF) remain valid.

8.3. Testing underimpedance and directional relays

The procedure is similar to that for measuring the characteristic of a distance relay. Measurement can be made either with the parameter for dynamic injection (SQ = 1F1) or with the parameter for static injection (SQ = 2). A choice has to be made between varying phase-angle or impedance to find the pick-up point depending on the shape of the characteristic concerned. The fault duration TF must take measuring time and any other time delays into account.
Directional relays which determine the phase relationship between current and voltage are measured directly using calculating mode UI. The pick-up values are determined by selecting the corresponding fault code FC and varying the angle PHI using DPH.

8.4. Testing frequency relays

The following test voltages are available for testing frequency relays:

a) With fault code FC = 2: (signifies FC = 002)	UR-N from 0 to 220 V Output approx. 20 VA at 220 V (AU92)
b) With fault code FC = 3: (signifies FC = 003)	UR-US from 0 to 140 V Output approx. 50 VA at 140 V (AU92)

For this purpose the two voltages UR and US are shifted so that they are in phase opposition, thus making the power of two amplifiers available. The set value is the sum of the two voltages.

All other entries and the test procedure are identical for both fault codes.

8.4.1. Absolute frequency measurement

The starting frequency is determined by parameter FR. DFR defines the step value of frequency change. The search sequence can be controlled manually or automatically by choice of parameter A. The operating signals of the various frequency stages can be connected either to the inputs In1 to In10 or to the trip input.
The time between frequency steps of the automatic search is chosen by setting the fault duration parameter TF such that the evaluation and delay times set on the relay are taken into account.

Example: The task is to measure the pick-up frequency (F_{min}) manually or automatically.

	Manual/ steady-state	**Automatic/ steady-state**
Calculation mode	UI	UI
Relay rated voltage	U=100	U=100
Fault code	FC=3	FC=3
Initial frequency	FR=...	FR=...
Frequency steps	DFR=...	DFR=...
Steady-state injection (continuous test signal)	SQ=2	SQ=2
Termination of the automatic search sequence when the interrupt condition is fulfilled	TI=3	TI=3
Interrupt condition	IN1=1	IN1=1
Duration of injection	TF=0	TF=...
Injection: • manual	A=0	
• automatic		A=2 (reducing parameter value)
'START'	Manual variation of frequency using the "-" and "+" keys	Automatic variation of frequency upon pressing the "-" or "+" key

Measuring the time delay of under or overfrequency stages

Static injection with the XS92b involves measuring the operating time by injecting a voltage and varying the frequency. This enables the time delay settings on frequency relays to be checked.

Procedure

By setting the initial XS92b injection frequency just above the frequency setting of the frequency stage and selecting the direction of frequency variation towards the relay setting, the relay will pick up almost immediately after injection commences and remain so for as long as the frequency variation continues.

Providing injection with variable frequency lasts longer than the set time delay, the test set stops injection upon receiving the tripping signal from the relay and displays the operating time it has measured (see Fig. 8.1).

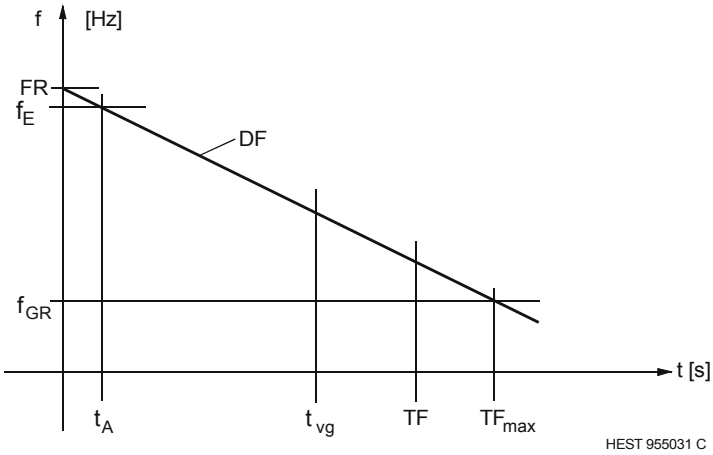

Fig. 8.1 Measuring the time delay setting on a frequency relay

where:

FR	initial XS92b injection frequency
f_E	frequency relay setting
f_{GR}	lower injection frequency limit of the test set
DF	set frequency rate-of-change
t_A	frequency relay pick-up
t_{vg}	measured time delay
TF	set test set fault duration
TF_{max}	max. injection time.

Measuring errors and accuracy

Because the initial injection frequency is set slightly above the relay pick-up frequency and some little time is required before the latter is reached, there is a certain inaccuracy of the operating time measurement. As can be seen from Fig. 8.1, this error is also dependent on the rate-of-change DF.

The correct operating time t_v can thus be obtained from the following:

$$t_v = t_{vg} - t_A$$

and $$t_A = \frac{FR - f_E}{DF} \quad [s]$$

Depending on the accuracy of the frequency relay being tested, the test set permits the initial frequency to be set very close to the pick-up frequency (e.g. within 0.01 to 0.05 Hz).

The maximum delay time $t_{v\ max}$ which can be measured by this method is dependent on the minimum value set for DF and the proximity of the frequency relay setting to the frequency limit f_{GR} of the test set.

The fault duration TF must be less than the maximum operating time delay which can be measured, i.e.

$TF \leq t_{v\ max}$

because time measurement beyond the frequency limit f_{GR} is no longer possible. Where the set time delay is relatively low, it is advisable to set high values for DF to achieve the best possible accuracy.

Measuring the time delay with firmware from Version 2.63

From Version 2.63 onwards, time measurement is usually possible in the steady-state injection mode as well. The parameters are set for "Manually/steady-state" as shown in the example in Section 8.4.1. The frequency FR is set to a value which exceeds the value of the step to be tested by, for example, 0.1 Hz and the frequency step DFR to a value at which the operating range of the step will be safely reached (e.g. DFR = 0.3 Hz). The setting of the fault duration TF must exceed the time delay set on the relay by at least 500 ms.
Injection is started by "Start" or "Esc" and the operating range is reached using "+" or "-", respectively "Step +" or "Step -".
The terminal then displays the time sequence from the beginning of the frequency step up to the receipt of the trip signal.

Test set settings:

- The parameters are entered with their corresponding values

Voltage	U =	
Initial frequency	FR =	
Rate-of-change	DF =	
Fault code	FC =	
Fault duration	TF =	
Multiplier	MT =	
Response upon trip	TI =	
Automatic	A ≠ 0	(only enter, if previously changed)
Calculation mode	MOD = UI	

Testing procedure:

- Press the START button and wait a few seconds until the frequency relay is ready to operate.
- Press the "-" key to initiate a reducing injection frequency ("+" key for an increasing frequency).

Upon receipt of the tripping signal from the frequency relay, the test set displays the frequency at that instant and also the operating time 't = ...' (corresponding to t_{vg}).

8.4.2. Measurement of frequency rate-of-change

The rate at which the injection frequency is varied (df/dt) is determined by the parameter DF. Where the df/dt sensitivity of a frequency relay is dependent on absolute frequency, the range of variation for measurement should be kept as small as possible. The range is set using the duration of injection TF, but this, of course, must be longer than the evaluation and delay time of the frequency relay. A typical setting is 100 to 200 ms. The starting frequency is set using FR and when a rate-of-change stage is combined with an absolute measuring stage, the starting frequency should be set at, or just below the pick-up frequency of the absolute measuring stage.
Once the voltage and the fault code have been set, a df/dt sequence is started with the "+" or "-" key. The DF value must then be increased or decreased in steps until the relay picks up.

8.4.3. Testing the low voltage check

The same fault code also enables the low voltage check of a frequency relay to be tested. Injecting normally at rated frequency, the voltage U is reduced by the step parameter DU, possibly using the automatic search sequence ($A \neq 0$) .

8.5. Testing IDMT and thermal overload relays

The test set XS92b can also be used for testing current-dependent relays such as IDMT and thermal overload relays.
Depending on the relay characteristic, the initial injection signal has to be determined from the maximum possible current setting (20 A) and the minimum injection signal from the maximum time setting (999 s). Dynamic testing is selected by setting SQ = 0F0. The step variable is the current step DI. Since the time has to be measured for each step, A = 0 and TI = 2 are recommended. A pick-up signal or contact must be connected to the test set.
Commencing at the highest current value, the measured points are recorded one at a time by pressing the "-" key. Because TI = 2 was set, the injection current is switched off as soon as the relay picks up, thus keeping the injection time to a minimum.
By changing to the data input mode between measuring points, the operating time can be read using parameter T. In the case of thermal overload relays, either the relay must be reset or allowed to cool down between measuring points.

Note: The thermal overload supervision "T>>" of the current amplifier may pick up when testing relays having especially long time constants (see Section 10.1.6.).

8.6. Testing synchro-check functions

The test set must be equipped with a YU92 or YU92a unit (option) for this test. The function of a synchro-check relay is normally tested by varying two voltages or voltage systems in relation to each other. This involves varying the voltage amplitudes or the phase-angle between them or the rate at which they vary in relation to each other.

8.6.1. Injecting two three-phase voltage systems

General

Test sets with option 3 of the firmware Version 2.6 or later are able to inject two three-phase voltage systems or two independently variable phase voltages designated U1 and U2. The three-phase systems are symmetrical, i.e. the individual voltages of each system have the same amplitude and the phase-angle between them is always 120°.

Voltage system U2 has a fixed frequency of 50 or 60 Hz, but the amplitude can be varied in steps.

The U1 system amplitude and phase-angle can be varied with respect to the U2 system. The frequency of the U1 system can also be varied between 40 and 65 Hz either in steps or according to the setting made for df/dt.

The amplifier AU92 increases the amplitudes of the U1 voltages by a factor of 10 before they are made available at the sockets on the AC93 unit. The amplifier AU92 also supplies the phase voltage U2. An ancillary amplifier is needed for U2 for three-phase injection.

Injection is only possible in the steady-state mode (SQ=2). Refer to the XS92b instructions for how to test manually and how to write test programs for automatic testing.

Hardware requirements

The three-phase U2 voltage system is available at sockets on the front of the YU92 unit. So that the voltages actually injected agree with the settings on the test set, separate amplifiers are required having an amplification factor of 10, an output voltage of 70 V r.m.s., a rated power of ≥ 25 VA and an accuracy equivalent to that of the AU92.

To ensure that the amplifier is suitable for the purpose, using the three-phase amplifier available from ABB Power Automation Ltd., (see Section 10.2.2. ‘Options’) is recommended.

Injection with a second phase voltage U2 necessitates a YU92a unit and a test set with a changeover switch ”U” at the right-hand end of rack 1. The switch must be place in the appropriate position for injection of a second phase voltage. For this purpose, it switches the S phase voltage generated by the amplifier AU92 to become the independent voltage U2.

The YU92/YU92a unit must be inserted at the right-hand end of the uppermost rack next to the memory unit YS92. The outputs for the U2 voltages are the three BNC sockets on its frontplate.

Entering test parameters

List UU: Test parameters for two injection voltages

Parameter designation	Purpose	Range/Value
FR2=xx.xx	U2 system frequency	**50**; 60 Hz
U1=xx.x	U1 phase-to-neutral voltage	**0.0** to 70 V
U2=xx.x	U2 phase-to-neutral voltage	**0.0** to 70 V
PH2=xxx	Phase-angle between the U1 and U2 systems	**0** to 359° *)
DU1=x.x	U1 step value	0.1 to 1.0 V
DU2=x.x	U2 step value	0.1 to 1.0 V
DP2=xx	PH2 angle step value	1 to 10°

*) If 0 is entered for PH2, the phase-angle between U1 at the sockets of YU92 and U2 at the sockets of AX91/92 is 180°. The amplifier for the U1 voltages must rotate the voltages so that they lag by 180° (as in the case of AU92).

Apart from the parameters in this list, various control parameters in the FF list remain active. Some have to be entered (bold), others are optional.

List FF: Parameters for controlling injection

Parameter designation	Purpose	Range/Value
FR=xx.xx	U1 system frequency	40.00 to 65·00 Hz
DFR=x.xx	U1 frequency step value	0.01 to 1.00 Hz
DF=x.x	U1 frequency rate-of-change df/dt	0.4 to 5.0 Hz/s
FC=0	Fault code, must not be set to 01, 02 or 03.	
SQ=2	Steady-state injection. Voltages continuously injected until either the condition defined by parameters IN1 and TI is fulfilled or the ‘0’ button is pressed.	
A=x	Automatic search sequence (see Section 4.3.1.)	0,1 or 2
TF=xxxx	Duration of injection of each step (see Section 4.3.1.)	**0** to 9999 ms
IN1=xxxx	Combination of digital inputs which determine the termination of injection (see Section 4.3.1.)	
TI=x	Test set response upon termination of injection (see Section 4.3.1.)	0,1,**2**,3
MOD=UU	Defines the kind of injection for option 3 (must be UU)	
MT=xxx	Multiplier applicable to parameter TF	**1**, 10 or 100
OP=3	To be set when FR ≠ FR2, i.e. when testing is performed with different frequencies. Otherwise OP = 0.	

8.6.2. Test procedure

There are two possible ways of testing using the XS92b:

a) with two independent three-phase systems. This necessitates a YU92 or YU92a unit and an ancillary three-phase voltage amplifier

b) with two individually set phase voltages supplied by the basic test set. For this purpose, the test set must be equipped with a YU92a unit and be a version with a switch "U" at the right-hand end of rack 1 (supplied after January 1995) or have been correspondingly modified.

For a), the voltage system from the basic test set is connected to one side (e.g. line side) of the synchro-check relay and the voltage system from the ancillary amplifier to the other side (e.g. busbar side). Correspondingly for b), the R phase voltage is connected to one side and the S phase voltage to the other.

The calculation mode "UU" must be selected in the control program.

The parameters in list "FF" and parameters ending with "1" (e.g. FR and U1) refer in the case of a) to the voltage system generated by the test set and in the case of b) to the voltage "UR". All parameters ending with "2" (e.g. U2 or FR2) refer in the case of a) to the voltage system generated by the ancillary amplifier and in the case of b) to the voltage "US".

Because the functions can vary in scope depending on the synchro-check device, only the basic principles are described below.

- Testing the phase-angle check function (OP = 0)
  Set U1 and U2 to their rated values, the angle step DP2 = 1, PH2 = 0, A = 1 and the step duration TF to a high value, e.g. TF = 1000. Start the test and wait if necessary until the function is enabled and start the search by pressing "+" or "F3". Providing the blocking signal is connected to the "Trip" input on the test set, the test stops as soon as the limit angle is reached.

- Testing the amplitude check function (OP = 0)
  Settings as above excepting instead of DP2, set DU1 to the voltage step value, e.g. DU1 = 0.1, and set A = 2. Start the test and after the unit has been enabled, reduce the voltage U1 using "-" or "F4" until the blocking signal is generated.
- Testing the permissible slip (OP = 3)
  The condition must be fulfilled that the set limit for the slip frequency is higher than the minimum possible frequency step of 0.01 Hz available on the test set. A setting for FR about 0.05 Hz lower than f_N + the maximum permissible slip is recommended.
- Other settings: A = 0, TI = 0, TF = 0. Upon starting the test, the function should first block and enable paralleling again after one slip. Then raise the setting by one step using "+" or "F3" and start another slip. The maximum permissible slip frequency is reached when paralleling is not enabled after a slip cycle.
- Testing the time closing is enabled (OP = 0)
  Set U1 = U2 = rated voltage, A = 0, FC = 33, TI = 2 and PH2 = 0. Connect the enable closing signal to the "Trip" input on the test set. Start the test and wait until the unit enables paralleling. The time can be read on the display "t = ...".

If the paralleling signal is a N/C contact, the "Trip" switch on the XC92 unit must be in the down position.