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9. Firmware Options and User Programs

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9. Firmware Options and User Programs

9.1. Firmware options

9.1.1. Prolongation of voltage injection for directional relay LR91

The injection of fault voltage in relation to fault current can be prolonged by selecting the parameter **OP = 2** (see Section 5.6.). This is a special injection sequence for testing the ultra high-speed directional comparison scheme LR91.

In the **dynamic** injection mode, step changes of the injection signals take place twice at the transitions between the different parts of the sequence. In certain cases, the second step change at the transition from second to third parts can be interpreted by the LR91 as the next event which can falsify the test results.

To prevent this from happening, this option enables the fault voltages to be injected for approximately a further 15 periods after the injection of fault current has ceased.
All other control parameters (list FF) remain valid.

9.1.2. Injection of user application signals (Option 4)

9.1.2.1. Introduction

The XS92b firmware (Version 2.6 and later) calculates purely sinusoidal injection signals on the basis of the parameters (impedances or current, voltage and phase-angle) entered.
Option 4 facilitates external control of the injection signals generated by the XS92b. The characteristics for the injection signals are transferred as an array of points from a PC to the test set's RAM via a serial interface according to a precisely defined format. The XS92b applies the data directly without any conversion. A description of the data format is contained in this Section.

Conversion programs are necessary to convert existing power system calculation programs to the proper data format. These can be written by the user.

At present, ABB supplies a program called “XSCON” for converting disturbance records in the EVE format or files in the COMTRADE format. The following are thus currently available:

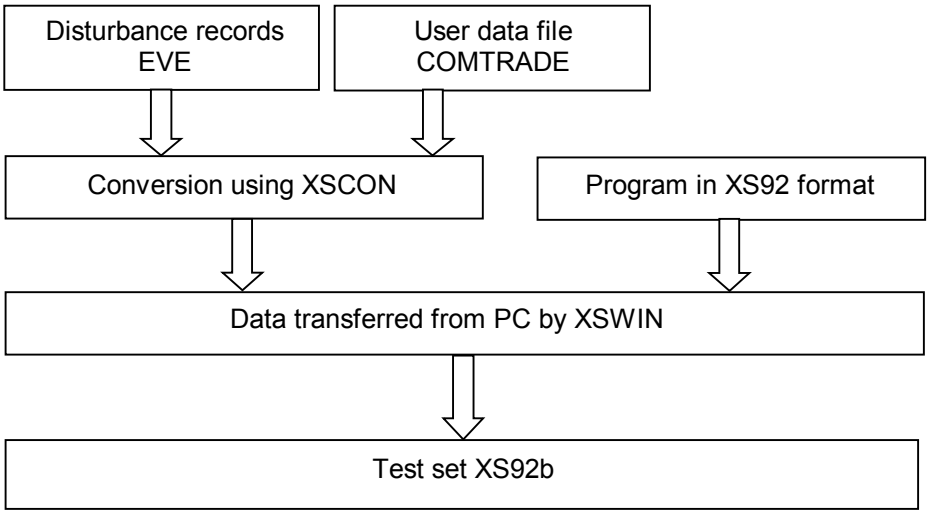

Fig. 9.1 Flow chart for converting and transferring test programs

The following programs are required in addition to the conversion program:

Communications program for transferring data from the PC to the test set XS92b:

- PCXS92
- XSWIN.

9.1.2.2. Structure of an application curve

An application curve for controlling injection by the XS92b consists of two parts:

- the header containing a description of the curve. Syntax is checked completely and semantics partly
- the injection data comprising one load period (may also be zero) and one or several fault periods.

All user characteristics must be of the following structure:

Length;
File name;
Frequency;
Fault code;
Number of periods transferred to XS92b;
Number of channels;
Allocation of channels to phases;
Current and voltage amplifier settings;
Fault starting time;
Parameter for reduced injection signals;
Dummy;
Application curve;
End of file;

9.1.2.3. Description of the data format for user characteristics

a) **Heading:**

a1 Length

Description:	Length of the application curve including header in Bytes, but excluding 'CR', 'LF' and 'EOF'.
Length =	57 + (No. of periods + 1) * 128 * 3 * (No. of channels)
Example:	4 channels, 4 periods → length = 7737
Format:	Integer of 5 ASCII figures xxxxx <CR><LF>
Verification:	Syntax is not checked. After transmission, the length is compared with the number of Bytes transmitted.

a2 Filename

Description:	Name of the application curve. This enables the curve to be loaded onto the YS92 memory board or loaded by the memory board.
Format:	8 ASCII characters ('A' to 'Z', 'a' to 'z', '_', '0' to '9' and ' ') starting with a letter. If a short name is used, it must be filled with blanks to make up the 8 characters. xxxxxxxx <CR><LF>
Verification:	No syntax check.

a3 Frequency

Description: Frequency of the application curve when injected by the XS92b.

Format: Directly given by 5 ASCII characters.
xx.xx <CR><LF>

Verification: As determined by the fault code set prior to injecting the curve.
Note: The frequency may be varied after the curve has been transferred.

a4 Fault code

Description: Fault code to be used by the XS92b for the application curves. It determines which fault currents are available at which sockets for an XS92b fitted with a current amplifier. (The fault current is connected, for example, to the second current channel when the fault code is set to 12.) Refer also to channel allocation. Fault code 3x must be used for an XS92b with three injection currents.
Note: The direction of the current cannot be changed subsequent to transfer by changing the fault code.

Format: Integer of 2 ASCII figures
xx <CR><LF>

Verification: Standard fault codes excluding [0, 2, 3 and 34]

a5 No. of periods

Description: Number of fault periods (i.e. excluding load) injected per channel by the application curve. Only complete periods may be specified, but the injection signals may terminate with any value. All signals are automatically set to zero after injection. The XS92b RAM has sufficient capacity for a total of 204 periods with 128 points each. The maximum number of periods is thus:

$$\frac{204}{\text{Numbre of channels}} - 1$$

Example 1: One voltage and one current, i.e. 2 channels, gives 102 periods per channel, or 1 period of load injection plus 101 periods of fault injection.

Example 2: Three voltages and one current, i.e. 4 channels, gives 51 periods per channel, or 1 period of load injection plus 50 periods of fault injection.

Example 3: Three voltages and three currents, i.e. 6 channels, gives 34 periods per channel, or 1 period of load injection plus 33 periods of fault injection.

Format: Integer of 3 ASCII figures
xxx <CR><LF>

Verification: None

a6 No. of channels

Description: Number of injection signals.

Format: Integer of 1 ASCII figures
x <CR><LF>

Verification: x may be any number between 1 and 4 for a test set with a single current amplifier or between 1 and 6 for a test set with three current amplifiers.

a7 Channel allocation

Description: Defines which channel of the application curve is allocated to which XS92b channel after conversion. XS92b channels 1, 2 and 3 are voltage channels and 4, 5 and 6 current channels. Unused channels are entered as 0. The current of an XS92a with one current amplifier can only be allocated to channel 4. (This current can be connected to any current output socket by appropriately defining the fault code.)
The order of the numbers of selected channels is ascending from left to right. Vacant channels must have a 0.

Example: 123400 corresponds to R, S and T voltages and one current or 250000 corresponds to S voltage and S current.

Format: Integer of 6 ASCII figures
xxxxxx <CR><LF>

Verification: x is a number between 0 and 6.

a8 Amplifier control parameters

Description: This parameter defines the current range (either 20 or 1.3 A) and also whether the test set is fitted with one or three current amplifiers. It is expressed as a 12 bit value:

11	10	9	8	7	6	5	4	3	2	1	0

Bit 0 to 2 : Reserved for future additions (voltage amplifier amplification factor) and must be 0.
Bit 3 : 1→ injection voltage via the transformer (max. 220 V)
Bit 4 : 1 → max. current 1.3 A, channel 4
0 → max. current 20 A, channel 4
Bit 5 : 1 → max. current 1.3 A, channel 5
0 → max. current 20 A, channel 5
Bit 6 : 1 → max. current 1.3 A, channel 6
0 → max. current 20 A, channel 6
Bit 7 : Not used
Bit 8 to 11 : 0000 → 1 current amplifier
0011 → 3 current amplifiers

Bits 4 to 6 : Switch the amplifier to the low current range and thus permit the full dynamic range of the D/A converters to be used at low currents.

Format: 3 Hex-ASCII
xxx <CR><LF>

Verification: x is a character between 0 and F.

a9 Start of fault injection

Description: The data of each channel defines one period at load levels and one or several periods at fault levels (see b) data). The injection of fault levels, however, must not necessarily coincide with the start of the first period of fault injection, so that this period can include an initial part at load levels. In order to measure the operating time of the relay under test correctly, this parameter defines how many points after the end of the first period with only load levels the fault commences (see Fig. 9.2).

Format: Integer of 3 ASCII figures
xxx <CR><LF>

Verification: None

a10 Parameters for injection at reduced currents and voltages

Description: The XS92b's rated voltage is 100 V and the maximum phase-to-phase injection voltage available is 121 V r.m.s. The maximum peak injection current is 30 A. Where higher values would be required to correctly simulate system conditions in a particular application, both injection voltage and current have to be proportionally reduced in order to inject the required impedance. It must be noted, however, that the results obtained with most distance relays will not be absolutely correct (for one thing, the memory feature voltage is too low). Of course, both load and fault quantities have to be reduced. This parameter determines whether or not the injection signals were reduced:

0 → no reduction
1 → reduction

In the case of '1', the XS92b gives a warning "ULOW".

Format: Integer of 1 ASCII figure
x <CR><LF>

Verification: Figure 0 or 1

a11 Dummy

Description: 20 spare Bytes in the header for any future additions

Format: 20 ASCII figures
xxxxxxxxxxxxxxxxxxxx <CR><LF>

Verification: None

b) **Data:**

Description: Injection characteristics are stored in the memory channel by channel, i.e. starting with point 1 and going to point 128 of the load injection for the first channel. (To preserve repeatability, a period must comprise precisely 128 points regardless of frequency.) The fault injection for channel 1 then follows, i.e. 128 points x number of fault periods. The other channels then follow in sequence. A <CR><LF> is written every 16 points. 12 bit D/A converters are used in the XS92b.
The following relationships result taking the amplification factors into account:
Voltage 11 bit: → 100.0 V peak
(315 V peak with fault code 01)
Current 11 bit: → 30.00 A peak
or 11 bit: → 1.875 A peak
An offset component is also included (digital offset):

000 max. negative value
800 zero
FFF max. positive value

Format: 3 Hex-ASCII figures 0 to F per point
(16 times xxx) <CR><LF>

Verification: x is a character between 0 and F.

Example of a user characteristic

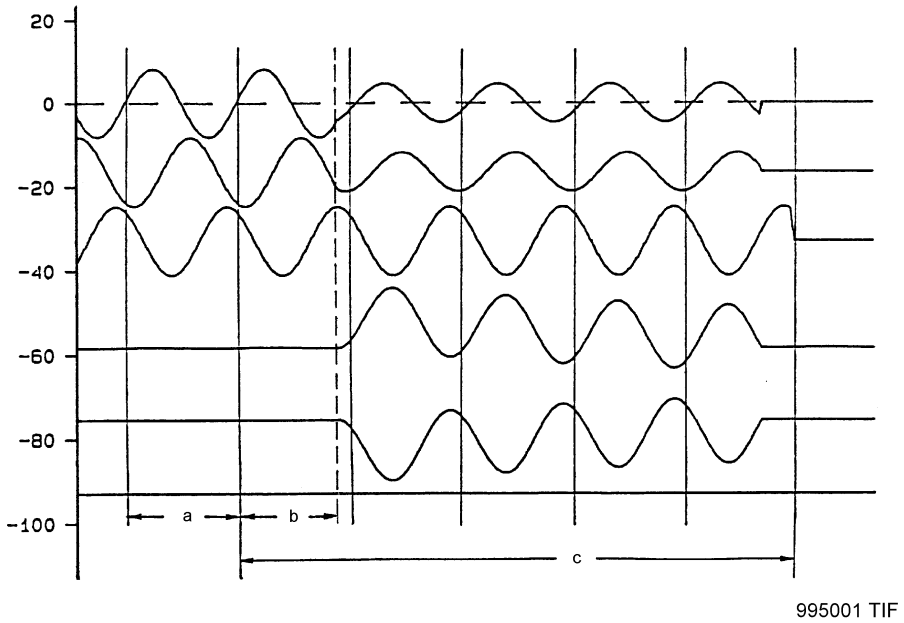

Fig. 9.2 Phase-to-phase fault on a radial line
Duration: 100 ms
a ... 1 load period
b ... start of fault (18 ms)
c ... 5 fault periods

Length:	57 + (5 + 1) * 128 * 3 * 4 = 9273 Bytes
Filename:	TEST2_BV
Frequency:	50 Hz
Fault code:	21 (current injection between R and S phases with the standard version of the XS92b)
Number of periods:	5
Number of channels:	4 (UR, US, UT, IR)
Allocation:	123400 (The current IR is in the XS92b memory under channel 4 and switched to the outputs IR and IS during injection.)
Amplifier setting:	000 (current > 1.3 A rms)
Start of fault:	118 (118 118/128 * 20 ms = 18.4 ms)
Reduced injection signals:	0 (no reduction)

Dummy: 12345678901234567890 (20 Byte text)

Data: 8008518A38F59469969E4A32A7FACAB13B5ABA0BE3C24C62 C9DCD6D0CD3ED6DD99DC1DE6E07E24E3EE54E66E74E7EE84 E87E84...etc.

The example in the correct format presents itself as follows:

9273
TEST2_BV
50.00
21
005
4
123400
000
118
0
12345678901234567890 (Text 20 Bytes)
8008518A38F59469969E4A32A7FACAB13B5ABA0BE3C24C62
C9DCD6DOCD3ED6DD99DC1DE6E07E24E3EE54E66E74E7EE84
E87E84...

...

...800800
800800800800800800800800800800800800800800800800

9.1.2.4. Control procedure

Two specific commands enable curves to be loaded respectively saved:

- LC : load curve
- STOC : store curve.

The parameter 'OP' (option) 4 must also be set to prevent the XS92b from calculating its own injection characteristic and make it use the data in its RAM. Operating time measurement is active for the duration of fault injection (parameter 'TF') and controlled by the inputs "Trip" and IN1 to IN9. The fault duration 'TF' is determined by the number of fault periods and the frequency. Injection, however, does not cease when a trip signal is received.

There are two ways of **starting injection**:

- by pressing the 'Start' ('ESC') button. Beforehand it is necessary to access the manual mode by entering a parameter, e.g. 'U"ENTER'.
- by entering 'F' in an application program.

a) **Loading, erasing and saving application curves**

The LC function (load curve) enables the user to load a curve in the XC92 RAM. This command is entered in the "* XS92b ready*" status in program operation.

There are two methods of saving data files:

- in an external computer (PC)
- on the memory PCB YS92.

a1 Loading characteristics from a PC

In this case, the command "LC" is entered without a name and the following message appears on the XS92b to signal that it is ready to receive data:

Ready to download curve

With the aid of the operator program XSWIN, the user can now transfer a data file to the test set:
After starting the XSWIN program (see Section 4.4.2.), open the "RS232C/Tools" folder (see in Section 4.4.2.8.).

Select “Transfer curve from PC to test set” in the folder and find the directory and the file to be transferred in the “Source” window. Then start the transfer via the “Transfer” button. While data transfer is in progress, the elapsed time is shown on the screen, and a message is displayed when it is finished.

a2 Loading curves from the memory board YS92

To load a curve called "name" (max. 8 characters) from the memory board YS92 enter:

LC name (load curve "name")

a3 Deleting curves from the memory board YS92

Application curves can be deleted in the same way as programs using the command:

DEL name (delete "name")

The characteristic data file called "name" is deleted from the program memory board YS92.

a4 Saving curves on the memory board YS92

An application curve in the XS92b RAM is saved on the memory board YS92 by entering:

STOC (store characteristic)

The name in the data file header is automatically used.

b) **Influence of other XS92b parameters**

The following parameters are taken into account:

FR (frequency, noted in the header)
FC (fault code, noted in the header)
IN1 (digital inputs)
OU1 (digital outputs)
MT (time multiplier)
TL Injection of the load signals is repeated according to the entry for TF.
TI The time measurement can be switched off by setting TI = 0.
TF Providing TF is equal or less than the number of periods times the duration of a period, the fault (one or several periods) is injected once. If TF is longer, then the injection of the fault is repeated until either TF expires or a trip signal is received.
Note: When fault injection is repeated, the entire signal sequence (of fault injection) must be repeated!

9.1.2.5. Hardware requirements

The test curves calculated by an external computer are stored after being transferred in the main memory (RAM) of the control unit XC92. If the control unit is only equipped with 16 kByte of RAM, the capacity is sufficient for just 12 single-phase periods. It is therefore recommended to extend the RAM to 64 kByte when using this option.

The RAM is located at positions A717 and A718 on the processor board on the right-hand side of the control unit XC92 seen from the front (see Fig. 11.7 in the Appendix). Type 62256 (32k * 8 bit) chips should be used for extending the RAM.

Note: The processor board must be revision 'B' or higher. Refer to your local ABB agent for replacement or modification should you have a revision 'A' unit.

9.1.2.6. Remarks

The ability to inject application test curves increases the flexibility of the test set. However, it should be noted that the XS92b performs very few checks, so that the user must accept the responsibility that the curves he uses produce realistic test conditions. The user is also responsible for checking the syntax and semantics of any conversion programs he writes.

The limits of injection signal frequency are not determined by the output units, but by the filters which follow the D/A converters (3rd. degree filters with the 3 dB point at 1000 Hz).