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2. Mechanical Design and Controls

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2. Mechanical Design and Controls

2.1. Principle of operation and mechanical design

2.1.1. Principle of operation

In order to record the characteristic of relays operating with more than one input quantity (e.g. distance relays) under conditions equivalent to those in practice, the test set simulates the influences of fault and source impedance in relation to the kind of fault. This is accomplished by the processor in the test set which calculates the digital values of the test quantities to be applied to the relay.

The basic version of the relay provides three injection voltages and three injection currents. One voltage is the reference to which the phase-angles of all the other injection signals are related. The amplitudes and phase-angles of all the injection signals can be varied.

The processor calculates the test quantities from the values which were entered at the control unit (see block diagram of Fig. 2.3) to the six test signals and stores them in tabular form. To obtain the injection signals, six D/A converters transform the values in the table to analogue variables. These are then filtered and amplified to bring them up to their set values. One period in advance of actual injection, a trigger impulse is generated for triggering an oscilloscope trace.

When programming the variables for the various tests, one can be selected to change by a set increment or decrement before each new test cycle. A test cycle can be initiated either by a pushbutton or automatically.

It can also be determined whether or not the test variables continue to be applied to the relay after it has operated. If injection is stopped when the relay operates, the display shows the last value of the variable in the case of static testing and the value of the variable plus the operating time.

Test cycles can be linked using a simple programming language to achieve longer and more complex testing routines.

2.1.2. Mechanical design

The mechanical design of the test set can be seen from the photograph in Fig. 2.1 and the rack layout in Fig. 2.2. The block diagram (Fig. 2.3) shows the functions performed. The test set comprises two equipment racks which can be carried separately in individual robust cases. A brief description of the functional units is given below.

2.1.3. Current amplifier AI93

The electronic equipment rack contains three linear amplifiers (current source) having a range from DC to 500 Hz (-3 dB limit). Their maximum power is 100 VA at 20 A r.m.s. The voltage supply ensues via an internal network part (module NN93). These amplifiers are force-cooled by fans. They are protected against thermal overload and open-circuit (see Section 10.1.6.).

2.1.4. Voltage amplifier AU92

The AU92 unit contains the power supply unit for the three voltage amplifiers and the DC/DC converter NF92. Voltage amplifiers for the three phase voltages are also included in the AU92. They have a rated output of 25 VA per phase at 70 V r.m.s.

The R (L1) phase output amplifier can be connected by the control unit XC92 to a transformer to provide output voltages up to 220 V r.m.s.

The AU92 is protected electronically against short-circuits and overloads (see Section 10.1.6.).

2.1.5. Output unit AC93

The output unit AC93 includes the socket for the test connector and 4 mm banana socket outlets for monitoring the test variables.

Caution:	High voltage (up to 250 V) can occur across these sockets!

The tripping contact in the relay under test is connected via the test connector to the 'stop' input (2 mm sockets "+" and "–o/o–") on the test set XS92b. Depending on the relay type, connections are established via the test connector and the remaining sockets to station DC circuits for various purposes (e.g. tripping the circuit-breaker).

Caution: High voltage (e.g. station battery voltage) can occur across these sockets due to the connection via the test socket unit XX91!

The current returns via socket 4 on connector "A" or to the 4 mm sockets "-I//" which are commoned (see Section 1.3.6.).

The power system connection and the main switch are located at the rear of the unit AI93. A network filter is also integrated in the connector unit. Overload protection is afforded by a 6 A fuse. A switch is provided for switching between 115 or 230 V AC power supplies.

Caution: If the AC93 module is been removed and the ground connection interrupted, make sure that ground connection is restored before the module is reinserted!

2.1.6. DC/DC converter NF92

This unit operates according to the chopper principle and its purpose is to provide the auxiliary +24 V, -24 V, +15 V and -15 V DC supplies for all the electronic circuits in the AD93 unit (upper rack) of the test set XS92b. The output is short-circuit proof and also protected against overload by a 1.6 A slow fuse (see Fig. 11.3).

2.1.7. Control unit XC92

This unit contains the microprocessor which calculates the injection signals and controls the test sequence, the D/A converters and their output filters for each of the injection signals.

2.1.8. Memory unit YS92 (option)

This unit has a width of one standard division and can be equipped with different kinds of memory devices such as EEPROM, RAM or EPROM (standard equipment with EEPROM). These provide memory capacity for storing testing programmes written e.g. by the user.

2.1.9. Output unit YU92(a) (option)

This unit has a width of two standard divisions and makes provision for 3 additional voltage signals or two independent phase voltages from the AU92. It is also equipped with 6 programmable relay outputs.

2.1.10. Handheld terminal YB92 (option)

The handheld terminal is for entering the values of the test parameters and programming. The most important of these are displayed during testing.

2.1.11. PC

A PC must be connected for controlling the test set XS92b (not included in the scope of supply).

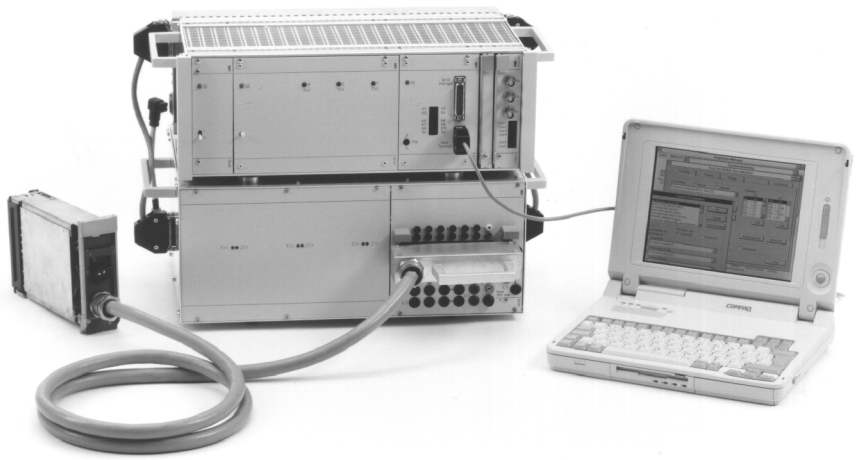
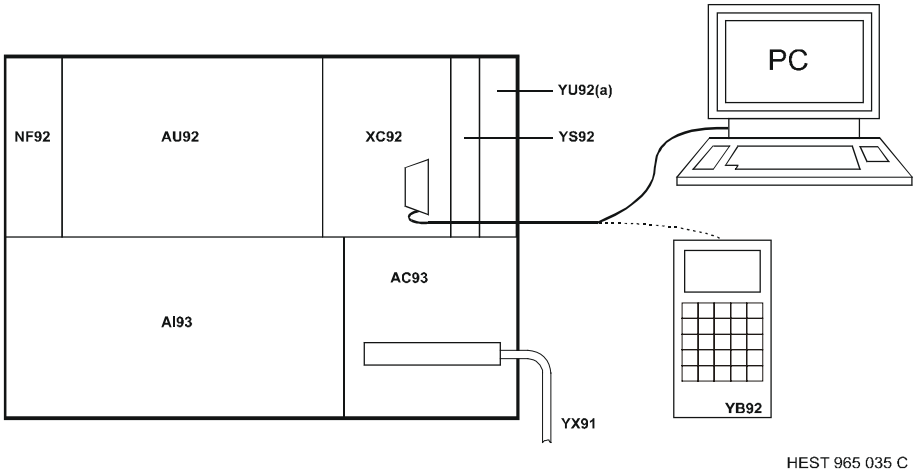


Fig. 2.1 Test set XS92b PC, connecting cable visible on the left and test connector YX91 (Photo 258 732)



NF92	DC/DC converter for the solid-state circuits
AU92	three-phase voltage amplifier
XC92	control unit
YS92	optional memory unit
YU92 (a)	optional output unit for voltages and binary signals
AI93	three-phase current amplifier
AC93	output unit
YX91	test connector
YB92	optional handheld terminal

Fig. 2.2 Rack layout

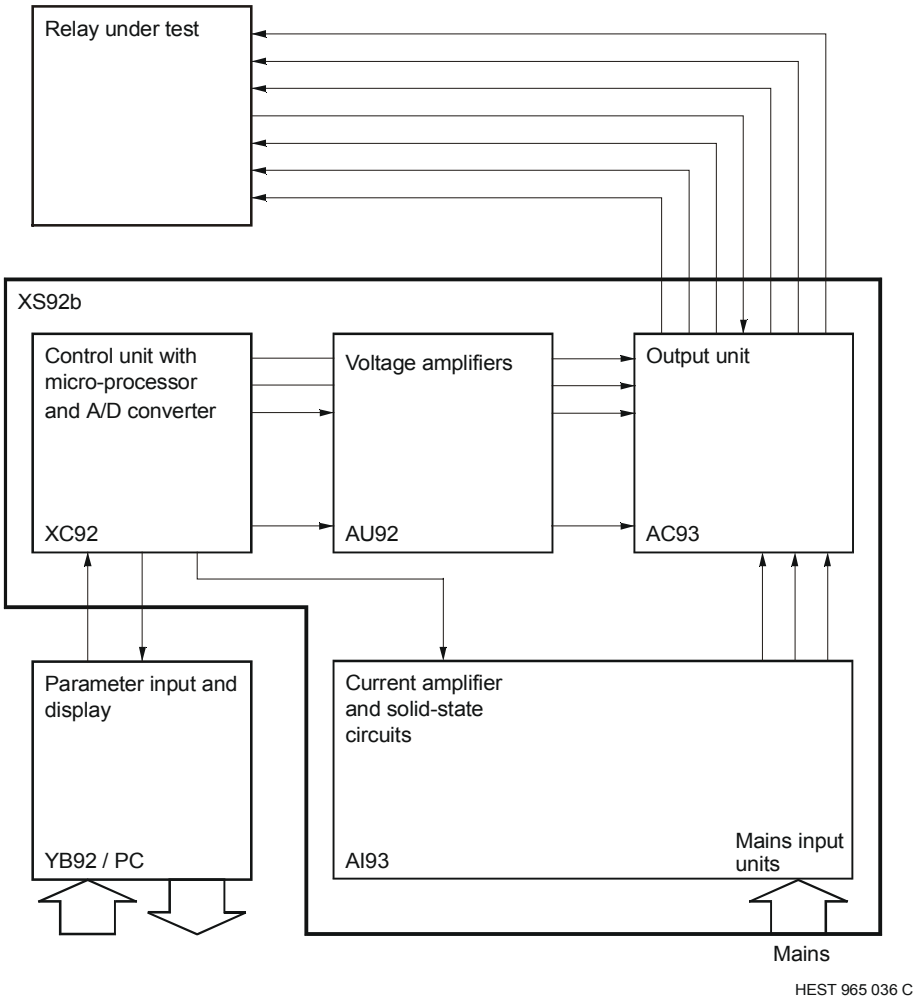


Fig. 2.3 Block diagram

2.2. Connection and programming

2.2.1. General

With the exception of the switches on the front, the test set XS92b is operated using the handheld terminal YB92 or a PC. The values of all the parameters are entered, the testing functions selected and the test cycle started by means of these devices. The operation of the handheld terminal is described in Section 2.2.4. and that of the PC control program in Section 4.4.2. respectively and all the parameters which can be entered are listed in Section 4.2.

2.2.2. Controls

The purposes of the various controls on the front of the racks as shown in Fig. 2.4 to Fig. 2.7 are:

1 **Main switch**
The main switch at the rear of the unit AI93 controls the supplies to the DC/DC converters NF92 and NN93. This switch is used to switch the test set on and off. The main fuse (6.3 A slow) is in the same unit.

2 **Auxiliary DC supply switch**
This switch controls the auxiliary DC supply to all the test set's units and starts the operation of the control unit XC92. It should be left switched on if possible.

3 **Overload reset button on the voltage amplifier AU92**
A high overload causes the voltage amplifier to switch itself off (LED b goes out). It can be reset by pressing button 3. This does not apply if individual phases are overloaded (see Section 10.1.6.).

4 **Trip signal polarity switch**
Depending on the position of the switch, the test set responds to either a positive-going ⊥ (contact makes) or a negative-going ⊤ (contact breaks) signal applied to the trip signal input (2 mm sockets "+" and "–⊘–" on output module AC93).

5 **Binary I/O sockets**
Ten binary inputs can be connected to the 2 mm sockets (In1 to In10) and one binary output signal (Out).

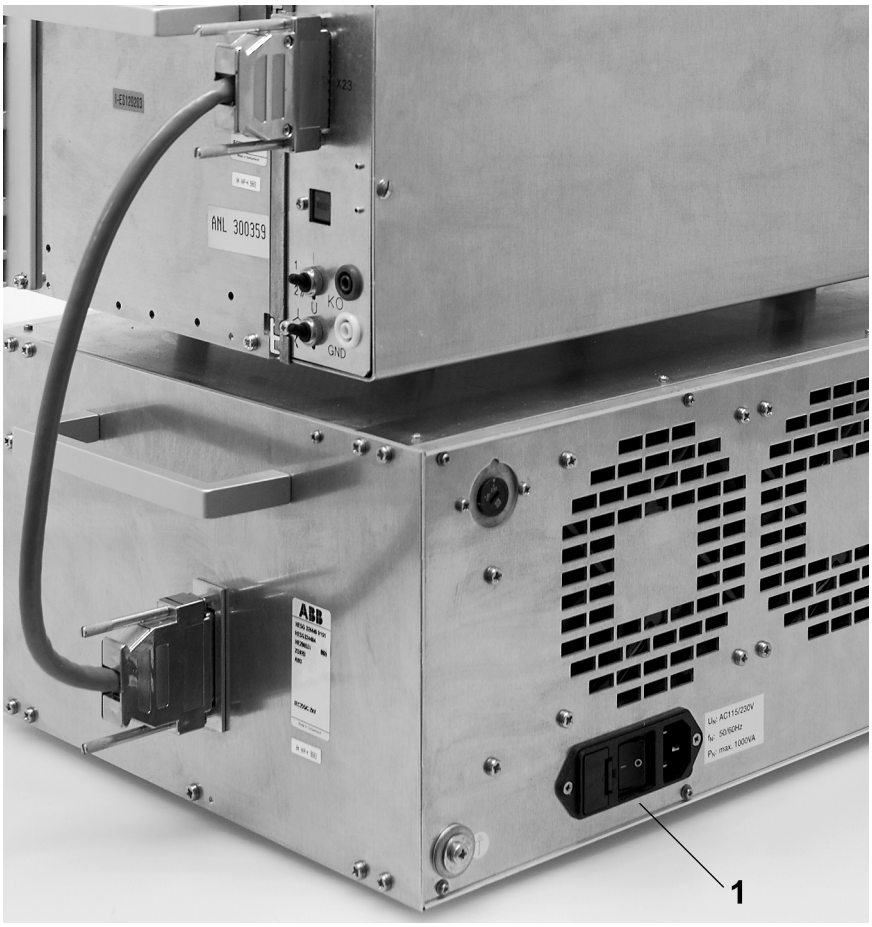


Fig. 2.4 Side view of the test set showing the main switch and the power cable between the two units (Photo 274615)

6 **Serial interface socket** (handheld terminal)
This socket is for connecting the handheld terminal YB92 or a PC using the cables provided.

7 **Serial interface socket**
The connection of a three-core cable conforming to RS232C (V24) to this socket enables the serial input and output of data (e.g. printer output, see Section 7.1.1.).

8 **Voltage outputs YU92a**
The three phase voltages are available at BNC sockets (max. 10 V p-p) for an additional voltage amplifier.

9 **Auxiliary relay outputs YU92a**
The N/O contacts of 6 auxiliary relays are optionally available.

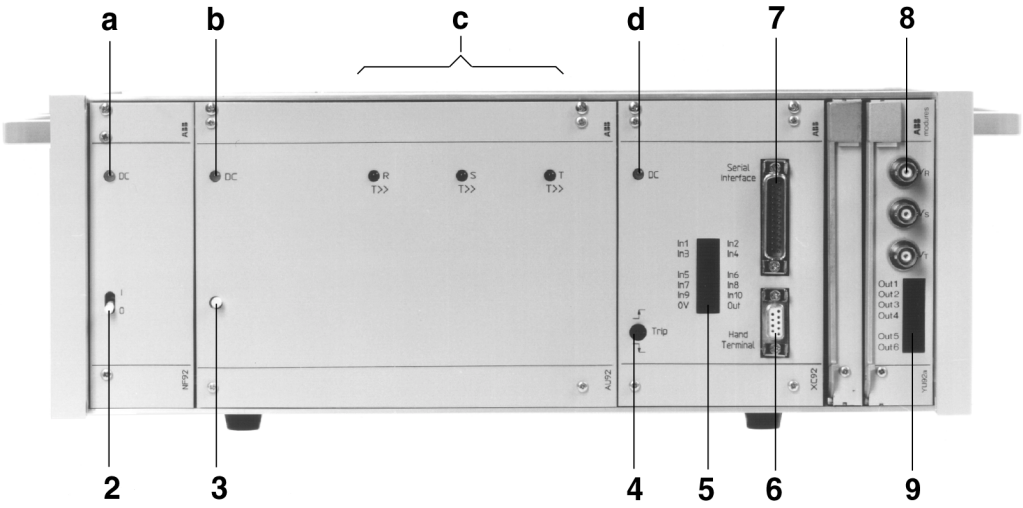


Fig. 2.5 Controls and signals on the upper rack AD93 (Photo 258 734)

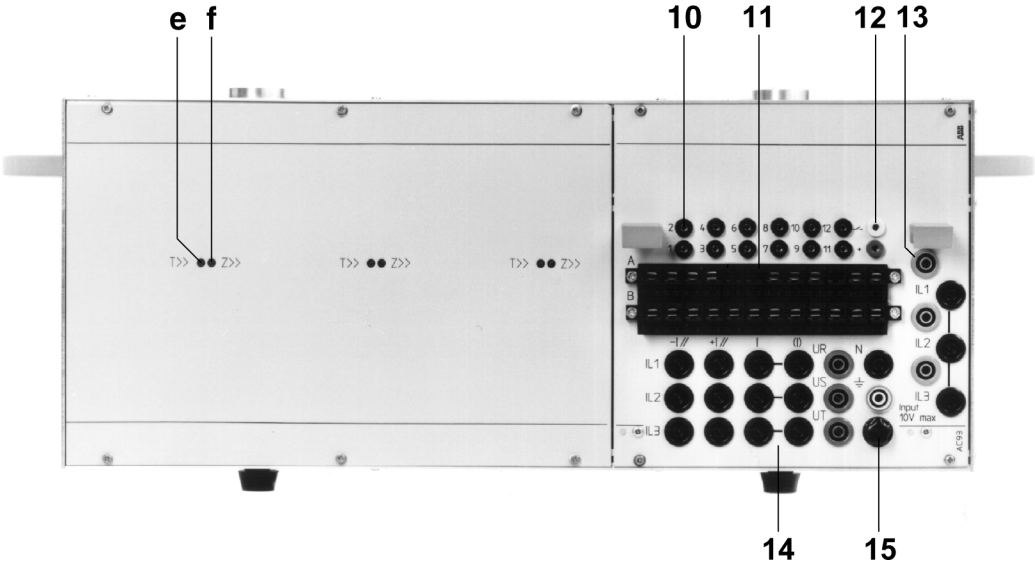


Fig. 2.6 Controls and signals on the lower rack AI93 (Photo 258 735)

10 **2 mm sockets**
These sockets are connected to the plug connector "B" and are used for transferring binary signals from the test connector YX91.

11 **AMP test sockets (connectors "A" and "B")**
These are for connecting the standard test cables between the relay and the test set. The contacts of the socket B are also available at the 2 mm sockets, B1 being connected to 1, B2 to 2 etc.

12 **Input sockets for a trip signal**
Either 2 or 4 mm sockets to which the potentially-free tripping contact of the relay under test is connected.

13 **10 V signal inputs**
Inputs for low-level three-phase signals (max. 10 V DC) when using the AI93 as an independent current amplifier.

14 **Sockets on the front of the AC93 unit**
These sockets (2 mm and 4 mm diameter) enable a relay to be connected to the test set without using a test plug YX91.

15 **Fuse** (800 mA slow)
The fuse protects the test voltage circuit of the test set.

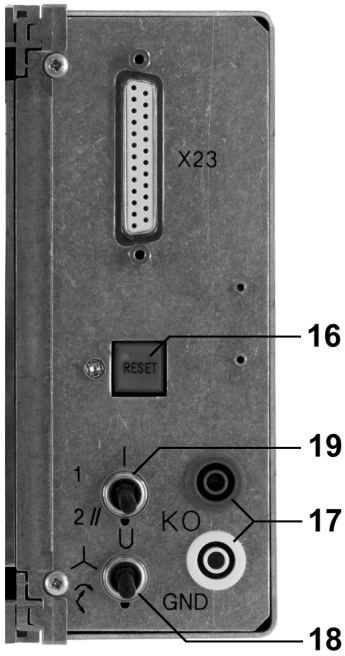


Fig. 2.7 Right side of the upper rack AD93 showing switches "U" and "I" (Photo 274 608)

16 **Reset button**
In the event of a failure, this button resets the control unit XC92. Resetting cancels all data inputs.

17 **CRO trigger**
Trigger signal output for an external instrument, e.g. a cathode ray oscilloscope.

18 **Changeover switch U**
In combination with the YU92a unit (option), this switch facilitates the output of 2 phase voltages with different frequencies, angles and amplitudes.

19 **Changeover switch I**
Switches the current input signals for phases L1 and L2 in parallel onto the corresponding amplifier.

2.2.3. Display elements

As described in Section 2.2.2., the purposes of the display elements shown in Fig. 2.5 and Fig. 2.6 are:

a **Green LED on unit NF92**
The DC/DC converter is standing by.

b **Green LED on unit AU92**
The voltage amplifier is standing by.

c **Red LED's on unit AU92**
These are marked "R", "S" and "T" and signal a thermal overload of an amplifier (see Section 10.1.6.).

d **Green LED on unit XC92**
This LED is marked "DC" and indicates that the control unit is standing by.

e **Red LED on unit AI93**
The LED's marked "T>>" signal a thermal overload of the amplifier (see Section 10.1.6.).

f **Red LED on unit AI93**
The LED's marked "Z>>" signal that the impedance of the current amplifier burden is too high or that the current circuit is open (see Section 10.1.6.).

2.2.4. Handheld terminal (option)

2.2.5. Connection

The handheld terminal YB92 is connected to the test set XS92b by means of the data cable (9 pin Sub D plug) supplied. The corresponding sockets are located on the front of the control unit XC92 (6 in Fig. 2.5). The handheld terminal does not have its own auxiliary supply and is supplied from the test set via the data cable.

The pins of the 9 pin D plug are connected as shown in Fig. 2.8:

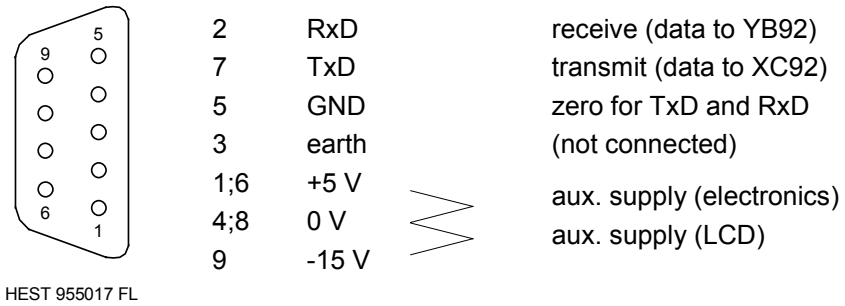


Fig. 2.8 Sub D plug connections

The levels of the RxD and TxD signals correspond to the RS-232-C standard (see Section 7.1.1.).
The standard data transfer rate between the handheld terminal and the control unit XC92 is 4800 Baud. However, the rate can be changed by means of a jumper on the control unit and function ^B on the handheld terminal (see Section 7.1.6.).

2.2.6. Key-pad

There are 25 keys on the handheld terminal (see Fig. 2.9), 21 of which have double functions. All the letters of the alphabet and the figures 0 to 9 can be selected when making entries.

Alphanumeric keys

Upon pressing an alphanumeric key the lower character is "echoed" by the test set and appears on the lower line of the display.

A total of 16 characters can be displayed, if more are entered, they shift to the left (in EDT and TYP mode), otherwise the last character on the right will be overwritten.

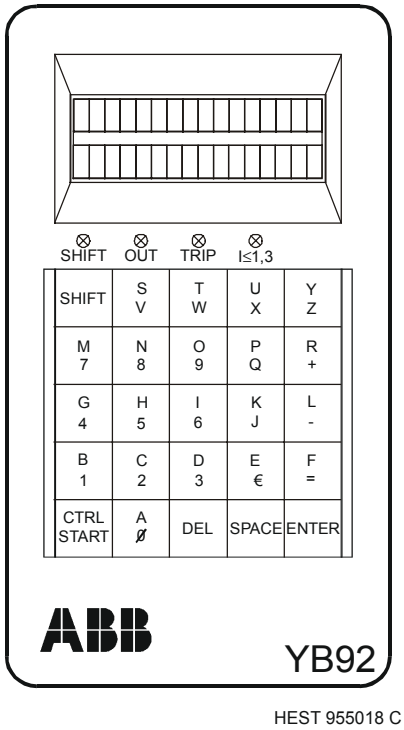


Fig. 2.9 Key-pad and display on the handheld terminal YB92

'SHIFT' key

The 'SHIFT' key must be pressed to select the upper characters of the double keys. The 'SHIFT' key also latches and the upper characters remain effective until the 'SHIFT' key is pressed a second time.

The red LED "Shift" above the keys is lit for as long as the shift function is active.

'DEL' key

The last character entered, i.e. the one just to the left of the cursor (see section 2.2.7.), can be cancelled by pressing the key 'DEL' (delete).

'SPACE' key

This key simply moves the cursor one character to the right to leave a blank space.

'ENTER' key

An entry is concluded by pressing the 'ENTER' key. Its function corresponds to "carriage return/line feed" on a computer terminal.

If a command or data have been entered, they are transmitted to the test set and cursor returns to the beginning of the line. The test set receives the instructions or data which have been entered, checks them for syntax errors and stores them (see Section 4.2.). Any errors are appropriately displayed (see Section 10.1.6.).

'CTRL/START' key

Testing is started by pressing this key once the data and the parameters have been entered. It is not permissible for the 'SHIFT' key to have been pressed beforehand.

Should 'SHIFT' be activated, then special functions can be selected by simultaneously pressing 'CTRL/START' and another key, i.e.:

- 'CTRL' and 'B' (^B) — for setting the Baud rate on the handheld terminal (Section 7.1.6.)
- 'CTRL' and 'C' (^C) — interrupts system commands forprogramming, change from manual operation
- 'CTRL' and 'D' (^D) — conclusion of printer output after TYPE instruction (Section 6.1.9.), or step-by-step execution of the user program (see Section 6.2.4.)
- 'CTRL' and 'E' (^E) — complete reset of the test set (RAM erased, hardware and default values reinitialised).

Keys with repeat function

If the keys '+', '-' and 'DEL' are held depressed longer than 0.5 s, the corresponding character is repeated continuously at a rate of 4 characters per second.

2.2.7. Display

The handheld terminal YB92 has a two-line dot matrix LCD which is controlled by the test set. It has two sixteen-character lines and the key-pad only writes on the bottom line.

Upon switching on the test set with the handheld terminal connected, the transmission rate "4800 BAUD" appears for about two seconds on the display followed by "*X92b ready*". Data and instructions may now be entered via the key-pad. Initially the cursor "_" is at the extreme left of the bottom line.

Note: Should the display "*X92b ready*" not appear or be illegible after switching on, then the Baud rates set on the control unit XC92 and the handheld terminal YB92 are not the same and must be corrected (see Sections 7.1.5. and 7.1.6.).

There are also four LED's on the handheld terminal with the following functions:

- "SHIFT" (red)

  This lights up after pressing the "SHIFT" key the first time to show that the shift function has been selected and the upper characters of the double keys are effective.

- "OUT" (yellow)

  This lights up during injection of the test (fault) signals.

- "TRIP" (green)

  This lights up after having received the interrupt condition set for the parameters IN1 and IN2 (see Section 4.3.1., FF list).

- "I ≤ 1.3" (yellow)

  The current range is set to 0 to 1.3 A (see Section 4.3.1.).

All four LED's light for about two seconds to test their integrity when the handheld terminal is initially energised. Should this not be the case, consult the error list (see Section 10.1.6.).

2.2.8. Entering data using a PC

When operating the test set XS92b via a PC, the programs "PCXS92" (DOS) or "XSWIN" (MS Windows) have to be installed. The program XSWIN and its installation are given in Section 4.2. When using a PC and the program "PCXS92" or "XSWIN" instead of a handheld terminal YB92 (see Section 4.4.3.), the test set responds as follows upon switching on:

~ a
~ b
~ c

"* XS92b ready *"

a, b and c are the control characters for the LED's on the handheld terminal,

a means "OUT"
b means "TRIP"
c means "I ≤ 1.3"

see Section 2.2.7.

~(126 decimal) means "switch off" and | (124 decimal) | means "switch on".

Other signals also appear on the PC which are overwritten in the case of the handheld terminal.

Only upper case characters may be entered.

The key marked 'ESC' (ASCII code decimal 27) is equivalent to the 'START' key on the YB92. "Stop" is accomplished by the '0' key in both cases.