SIPROTEC

Centralized Numerical Busbar Protection 7SS60

3.1

Manual

E50417-G1176-C132-A3

Preface

Aim of this manual

This manual describes the functions, operation, installation, and commissioning of the device. In particular, you will find:

- Description of the system configuration → Chapter 4;
- Description of the system functions and setting possibilities → Chapter 5;
- Hints on control during operation → Chapter 6;
- Instructions for installation and commissioning → Chapter 7;
- List of the technical data → Chapter 9;
- Summary of the most significant data for the experienced user in the Appendix.

Target audience

Protection engineers, commissioners, persons who are involved in setting, testing and maintenance of protection, automation, and control devices, as well as operation personnel in electrical plants and power stations.

Validity of this manual

This manual is valid for: SIPROTEC 7SS60; firmware version 3.1.

Indication of Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 73/23 EEC).

Conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 50081 and EN 50082 (for EMC directive) and the standards EN 60255-6 (for low-voltage directive).

The device is designed in accordance with the international standards of IEC 255 and the German standards DIN 57 435 part 303 (corresponding to VDE 0435 part 303).

Additional support

For any questions concerning your SIPROTEC system, please contact your Siemens representative.

Training courses

Individual course offers may be found in our Training Catalog, or questions can be directed to our training centre.

Instructions and warnings

The warnings and notes contained in this manual serve for your own safety and for an appropriate lifetime of the device. Please observe them!

The following terms and definitions are used:

DANGER

indicates that death, severe personal injury or substantial property damage will result if proper precautions are not taken.

Warning

indicates that death, severe personal injury or substantial property damage can result if proper precautions are not taken.

Caution

indicates that minor personal injury or property damage can result if proper precautions are not taken. This is especially valid for damage on or in the device itself and consequential damage thereof.

Note
indicates information about the device or respective part of the instruction manual which is essential to highlight.

Warning!

Hazardous voltages are present in this electrical equipment during operation. Non–observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

The successful and safe operation of this device is dependent on proper handling, installation, operation, and maintenance by qualified personnel under observance of all warnings and hints contained in this manual.

In particular the general erection and safety regulations (e.g. IEC, DIN, VDE, EN or other national and international standards) regarding the correct use of hoisting gear must be observed. Non–observance can result in death, personal injury or substantial property damage.

QUALIFIED PERSONNEL

For the purpose of this instruction manual and product labels, a qualified person is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he or she has the following qualifications:

- Is trained and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.
- Is trained in the proper care and use of protective equipment in accordance with established safety practices.
- Is trained in rendering first aid.

Typographical and symbol conventions

The following text formats are used when literal information from the device or to the device appear in the text flow:

Parameter names, i.e. designators of configuration or function parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with DIGSI), are marked in bold letters of a monospace type style.

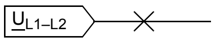
Parameter options, i.e. possible settings of text parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with DIGSI), are written in italic style, additionally. This applies also for options in menus.

Annunciations, i.e. designators for information, which may be output by the relay or required from other devices or from the switch gear, are marked in a monospace type style in quotes.

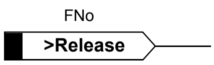
Deviations may be permitted in drawings when the type of designator can be obviously derived from the illustration.

Internal logical input signal of the device

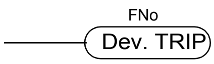
Internal logical output signal of the device



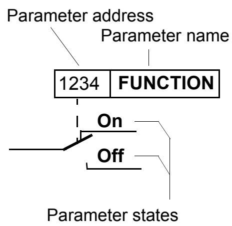
Incoming internal signal of an analog magnitude



External binary input signal with function number FNo (binary input, input annunciation)



External binary output signal with function number FNo (device annunciation)



Example of a parameter switch **FUNCTION** with the address 1234 and the possible states **On** and **Off**

The other symbols used are mainly taken from the standards IEC 60617–12 and IEC 60617–13, or derived from them.

Disclaimer of liability
Although we have carefully checked the contents of this publication for conformity with the hardware and software described, we cannot guarantee complete conformity since errors cannot be excluded.
The information provided in this manual is checked at regular intervals and any corrections which might become necessary are included in the next releases. Any suggestions for improvement are welcome.

The contents of this manual is subject to change without prior notice. Release 3.11.01

Contents

Introduction 1

The SIPROTEC 7SS60 device is introduced in this chapter. An overview of the application and characteristics of the 7SS60 is given.

1.1 Overall function

Measuring principle

The main function of the 7SS60 protection system is a busbar protection that operates with the differential current measuring principle. The algorithm of the 7SS60 relies on Kirchhoff's current law, which states that in fault-free condition the vectorial sum ΔI flowing into a closed busbar section must be zero. This summated current will be referred to in this chapter as differential current I_d.

Restraint

Some slight deviations from this law may be caused by current transformer errors, inaccuracies in the matching of the transformation ratios and measuring inaccuracies. Further errors, which may be due, for instance, to transformer saturation in case of high-current external short-circuits, are counteracted by a load-dependent supplementary restraint. From the load condition the restraint current I_R is derived. This restraint current is formed as the summated magnitudes of all currents in the peripheral module 7TM700.

Detection of measured values

The differential and the restraint current are fed into the 7SS601 measuring system. In systems with multiple busbars or sectionalized busbars, each selective section uses one 7SS601 measuring system (variant with summation current transformer) or three measuring systems (phase-selective measurement). The correct allocation of the feeder currents to the appropriate 7SS601 measuring system is ensured by the peripheral module 7TR710 (preferential treatment/isolator replica).

Pick-up characteristic

The characteristic can be set in the parameters for Id> (pick-up value) and for the k factor, which considers the linear and non-linear current transformer errors. The setting for the pick-up value must be chosen according to the smallest fault current to be expected. Differential currents above the set characteristic lead to tripping. The threshold for the differential current supervision is set in the parameter ID thr.

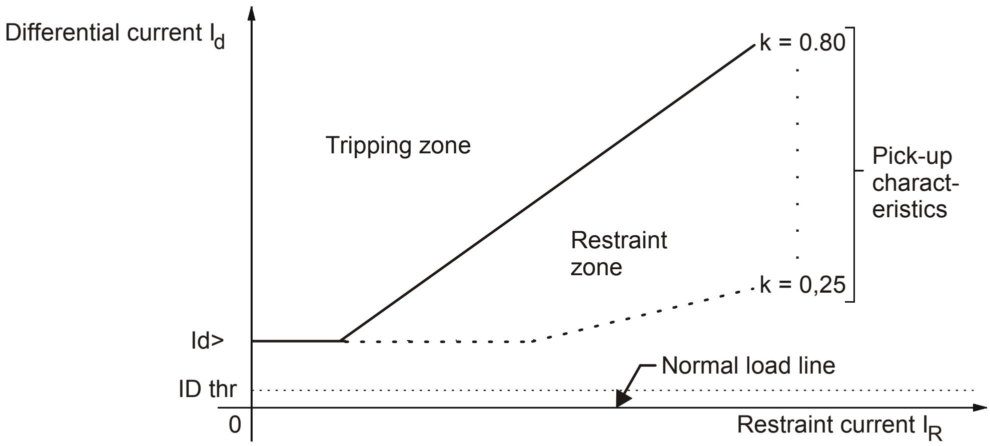


Figure 1-1 Characteristic of the 7SS601 measuring system

Selective tripping, isolator replica

If a measuring system 7SS601 recognizes a tripping condition, the circuit breakers of the involved feeders must be tripped. This requires an isolator replica which is generated on the module 7TR710 (isolator replica/preferential treatment) from the position of the isolators. Basing on this isolator replica a TRIP command of a measuring system is distributed to the circuit breakers.

Functional components

The 7SS60 digital busbar protection has two separate functional parts. One part is the 7SS601 measuring system. The measuring system detects and processes the measured values. It evaluates the restraint current I_R and the differential current I_d and makes a tripping decision where required. The other part of the system, which will be referred to as peripheral system, has the task of summating the feeder currents and feeding the current sum into the measured value detection system. The current summation takes into account the switchgear status of the station.

If selective protection is desired for each phase, each phase is allocated its own measuring system. Otherwise, the three phase currents are combined in a summation current transformer, and the result processed. In that case only one measuring system is required.

If a busbar is divided into two sections by a sectionalizing isolator or a bus coupler, each section must have its own measuring system. Accordingly, six measuring systems are required for the phase-selective protection.

7SS601 measuring system

The 7SS601 measuring system can detect one alternating current I_d and one pulsating direct current I_R. The measuring inputs are galvanically isolated from the electronic equipment by a current transformer or an optocoupler.

3 binary inputs are provided for the detection of external binary signals.

The system has 2 command relays with supervision. Command relay 1 consists of 2 relays connected in parallel. This relay cannot be marshalled; the function **BP Trip (FNo. 7914)** is permanently allocated to it. Command relay 2 is available for having command functions marshalled to it. All command relays have a NO contact.

It has also 3 signal relays with changeover contacts, one of which is used for output of the device blocked annunciation. The relay functionality (NC or NO) can be selected by a jumper setting. The module is equipped with a serial RS485 interface. The converter for the auxiliary power supply is integrated in the module.

Peripheral system

Depending on the type and size of the systems that are to be protected by the 7SS60 busbar protection, different types and numbers of peripheral modules are needed. The peripheral modules are installed in a 7XP204 housing; the number of housings required is determined by the number of modules used. Each 7XP204 housing can hold up to 4 peripheral modules.

The following modules are available for the different functions:

- **Restraint/command output module 7TM700**
- **Preferential treatment/isolator replica module 7TR710**
- **Command output module 7TS720**

Restraint/command output module 7TM700

This module comprises 5 units for the formation of restraint currents. It has also 5 independent TRIP command relays with 2 NO contacts each for multiplication of TRIP commands generated by the 7SS601 measuring system.

The secondary current from the main current transformer of a feeder is normalized to 100 mA by a matching or summation current transformer and fed into the I_d summation path of the associated measuring system. The summation current I_d is thus equivalent to the vectorial addition of all feeder currents. Beside I_d, the measuring system requires a restraint value, which is formed by adding up the magnitudes of all currents. The restraint units are used to form the current magnitudes. They rectify the feeder currents and add them up in the I_R summation path.

Isolator replica module/preferential treatment module

This module can be used to implement 2 different functions which will be presented in the following.

Isolator replica

The isolator replica function detects the status of 2 isolators.

It allows e.g. to recognize the status of both isolators in a double busbar system. The isolator status determines the allocation of the feeder currents to the appropriate measuring system. It also ensures the stability and greatest possible selectivity of the protection system during dynamic processes such as switching operations.

Preferential treatment

If, during a changeover of a feeder in a double busbar system, both isolators of a feeder are closed for a short time, no selective protection of the two busbars is possible. The same is true for busbar sections that are connected by closing a sectionalizing isolator. Whereas each of the two sections has so far been protected by its own measuring system, the protection function is assumed by only one measuring system after connecting the two sections. This is referred to as preferential treatment.

As several relays or modules may be involved in the switching action, there may be an undefined allocation of the differential and restraint currents to the measuring systems during a few milliseconds caused by different relay switching times.

The blocking pulse required for system stability is generated automatically on the module within the corresponding time.

Also an auxiliary relay is included with two changeover contacts.

Command output module 7TS720

This module comprises 8 independent command relays with 2 NO contacts each for multiplication of the TRIP command generated by the 7SS601 measuring system.

It is necessary to multiply the TRIP command if the two NO contacts of the 7TR710 modules are not sufficient for command output to the circuit breakers. The measuring system initiates the TRIP command first through a NO contact. In the simplest case, an auxiliary voltage is fed directly from this contact onto the 7TS720 module, where it causes one or more relay coils to pick up.

Transformers

The differential current input I_d of the 7SS60 is designed for 1 x I_n = 100 mA. Therefore, a transformer must be provided between the 7SS60 and the main current transformer. In phase-selective protection systems, matching transformers are used; otherwise there will be summation current transformers.

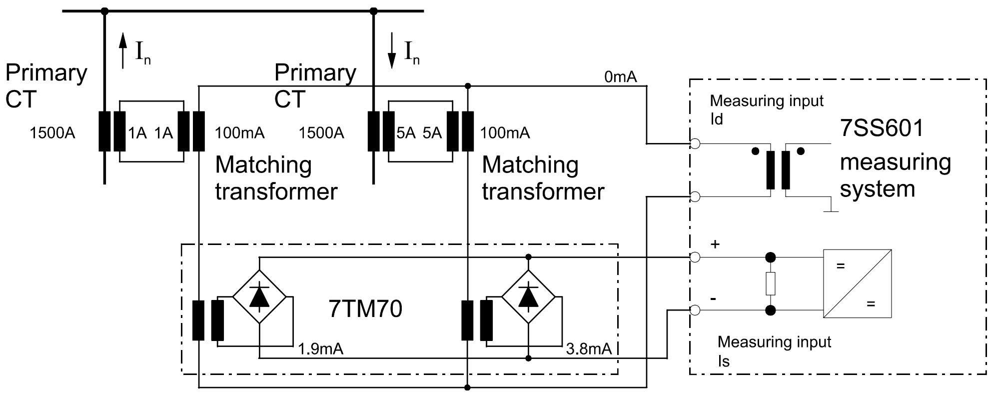


Figure 1-2 Principle diagram of transformers in the 7SS60 (one phase of a phase-selective protection system)

Wiring

The 7SS60 busbar protection system is suited for a large variety of power systems, from single busbar configurations without sectionalizing isolators to double busbars with sectionalizing isolators and transversal couplers. The summation currents I_d and I_R are distributed among the measuring systems by relay modules that provide for connection of nearly all relay contacts to connecting points. This provides for a high degree of flexibility of the modules. One configuration task is to design the wiring between the modules, the modules and the 7SS601 measuring systems, and to the primary equipment, in accordance with the desired function.

Mounting

The 7SS60 busbar protection system is made up of individual components which are then mounted station-specifically in cubicles or mounting panels.

1.2 Application scope

The 7SS60 busbar protection is an easily settable numerical differential current protection for busbars.

It is suitable for all voltage levels and can be adapted to a large variety of busbar configurations. The components available are designed in particular for:

- $1^1/_2$ - circuit breaker systems
- single busbars (with/without sectionalizing isolators)
- double busbars with sectionalizing isolators, longitudinal couplers and transversal couplers

These types of systems are shown in the following figures.

Single-phase measurement can be achieved by using external summation current transformers. The use of matching transformers allows phase-selective measurement.

For extra security, an additional measuring system (check zone) can be implemented.

The busbar protection system is designed to be the successor of the 7SS1 static busbar protection. Where it replaces this system, the existing matching transformers and summation current transformers can be used with the new system as well.

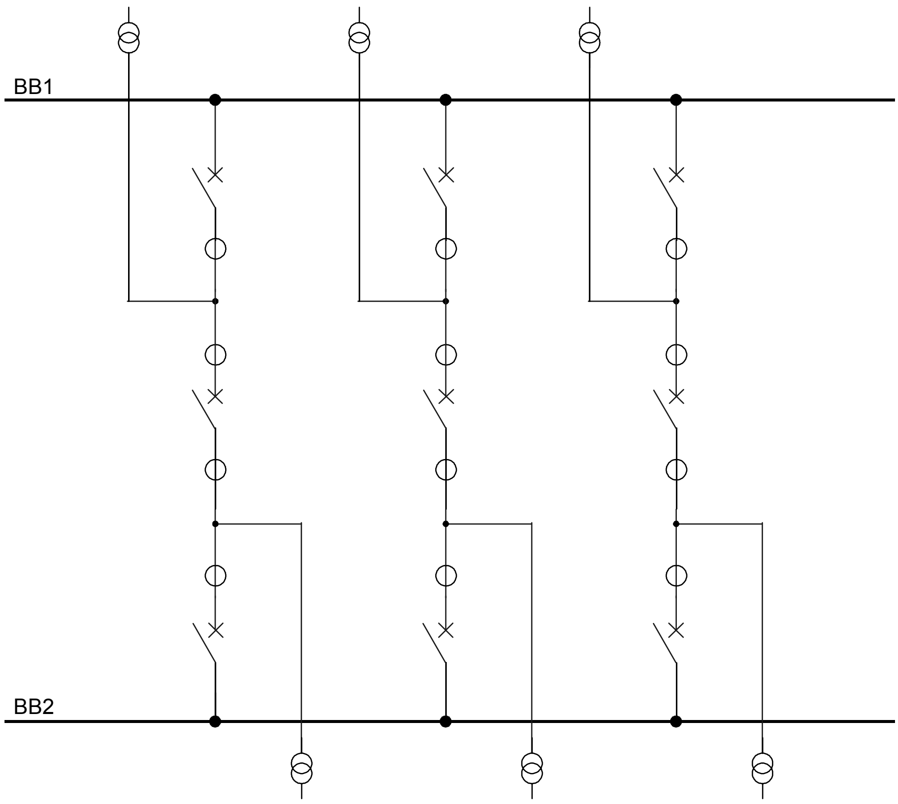


Figure 1-3 $1^1/_2$ - circuit breaker system

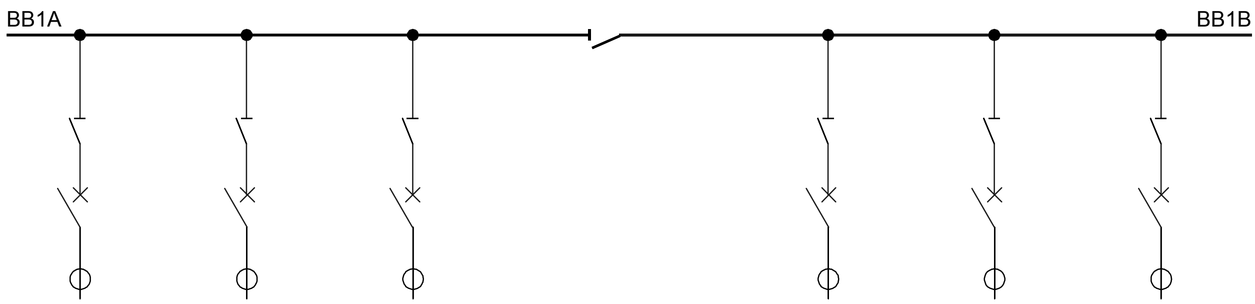


Figure 1-4   Single busbar with sectionalizing isolator

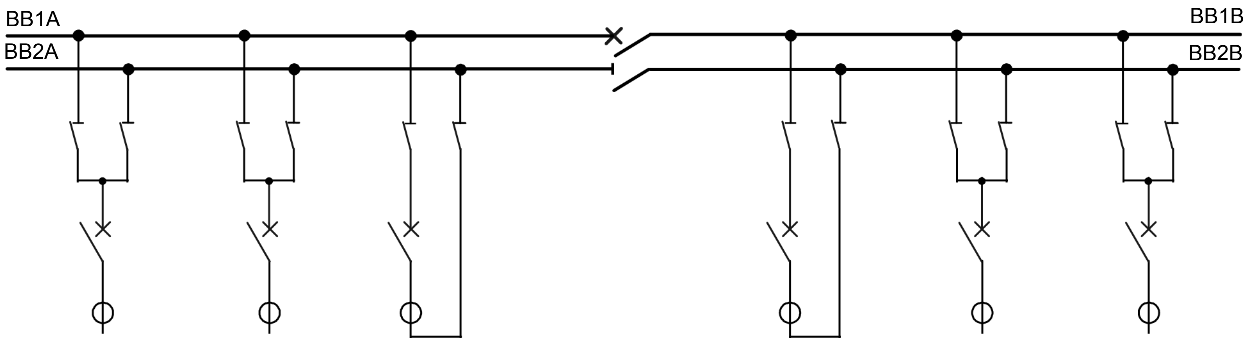


Figure 1-5   Double busbar with couplers and sectionalizing isolator

1.3 Features

The 7SS60 busbar protection has the following features:

- Busbar protection operating on the differential current principle; one measuring system per busbar section or, depending on the configuration, per phase and zone; optionally one additional measuring system for the check zone (isolator-independent measuring system)
- Full galvanic and interference-immune isolation between the internal processing circuits and the measuring, control and supply circuits of the system by screened measuring transducers, binary input and output modules and DC voltage converters
- Fully digital measured value processing and protection functions, from the sampling and digitizing of the measured values to the TRIP decisions for the circuit breakers
- High degree of security against overfunction, and detection of external faults even with unfavourable transformer configuration
- Differential current supervision of transformer circuits, with blocking option for TRIP command
- Blocking of TRIP command possible by fast binary input
- Low demands on current transformers
- Numerical system with powerful 16-bit microprocessor system
- Easy menu-guided operation via integrated keypad and display panel or by connected PC using DIGSI
- Storage of fault annunciations and of instantaneous values for fault recording
- Continuous monitoring of the hardware and software of the 7SS601 measuring system, as well as of the primary current transformers and their supply conductors
- Integrated commissioning aids

Design and Connection System 2

This chapter describes the design and the connection system of the 7SS60. You will find information on the available housing variants and on the types of connections used.

This chapter also specifies recommended and reliable wiring data as well as suitable accessories and tools.

2.1 7SS601 measuring system

Housing

All protection functions including dc/dc converter are accommodated on a printed circuit board of double Europe format. This p.c.b. forms, complemented by a guide plate, a multi-pin terminal module (p.c.b. side) and a front unit, the plug-in module which is mounted in a 7XP20 housing. The inner part of the housing is free from enamel and thus functions as a large contact plane and shield with solid electrical conductivity and mates with the earthing plates of the module. Connection to earth is made before the plugs make contact. An earthing area marked with an earth symbol has been provided at the housing rear. At this area an earthing strip must be connected with two earthing screws in order to ensure solid low-impedance earthing.

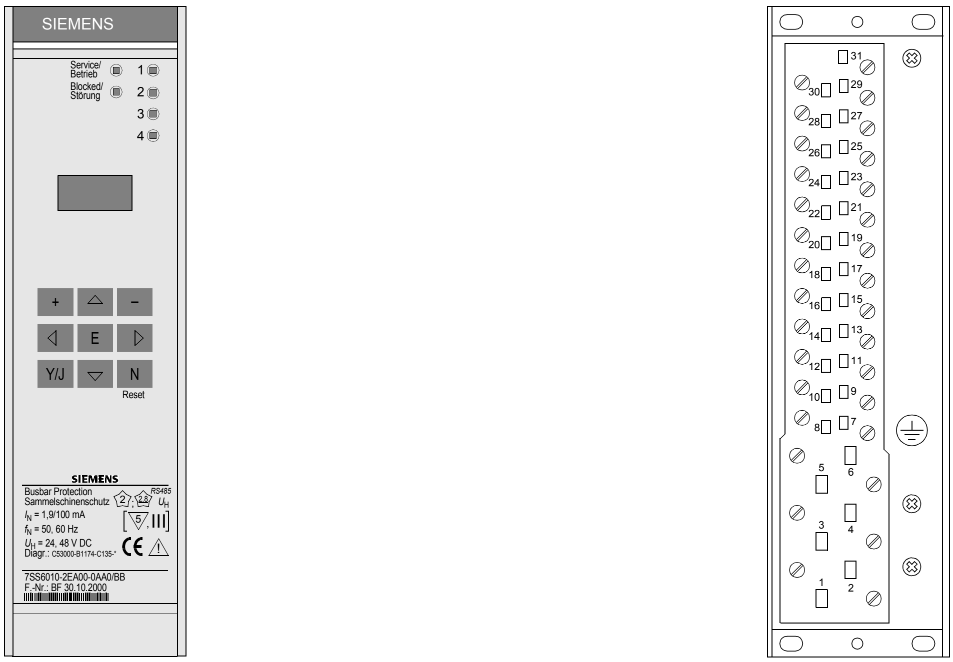


Figure 2-1 Front view (left) and rear view (right) of the 7SS601 measuring system

The terminal allocation of the measurement system is shown in Section A.2.

Connection system

Current connections (terminals 1 to 6)

Screw terminals (ring-type cable lug)	for bolts of 6 mm
max. outside diameter	13 mm
Type	e.g. PDIG of Messrs. Tyco Electronics AMP
for conductor cross-sections of	2.7 to 6.6 mm AWG 12 to 10
in parallel double leaf-spring-crimp contact for conductor cross-sections of	2.5 to 4.0 mm AWG 13 to 11
max. tightening torque	3.5 Nm

Control connections (terminals 7 to 31)

Screw terminals (ring-type cable lug)	for bolts of 4 mm
max. outside diameter	9 mm
Type	e.g. PDIG of Messrs. Tyco Electronics AMP
for conductor cross-sections of	1.0 to 2.6 mm AWG 17 to 13
in parallel double leaf-spring-crimp contact for conductor cross-sections of	0.5 to 2.5 mm AWG 20 to 13
max. tightening torque	1.8 Nm

2.2 Peripheral modules

Housing

The peripheral modules are accommodated in one or more 7XP204 housings. One housing can hold up to 4 peripheral modules in any order.

Two angle brackets are required to fit the housing into a frame or cabinet.You can look up the order number in chapter A.1 in the appendix.

The housing has a labelling strip inserted on its front for identification of the modules contained in it.

The rear plate has cutouts for the connectors. The cutouts provided are sufficient for the maximum degree of expansion. If the housing contains less modules, the cutouts that are not required are closed by metal blanking plates.

An earthing area marked with an earth symbol has been provided at the housing rear. At this area an earthing strip must be connected with two earthing screws in order to ensure solid low-impedance earthing.

In addition, the housing bears a rating sticker with basic information.

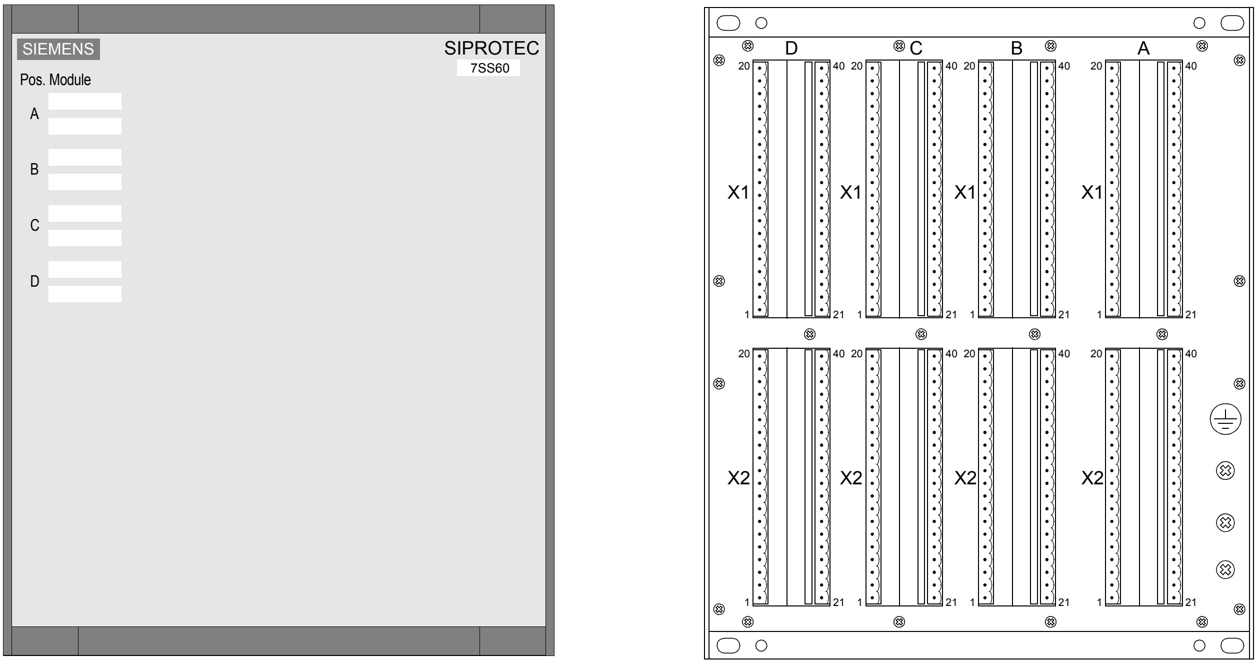


Figure 2-2 Front view (left) and rear view (right) of the 7XP204 housing for peripheral modules

The connector allocation depends on the type of peripheral module and is shown in section A.2.

Connection system

Each peripheral module is delivered with 8 plug-on connectors with screw terminals. Further plug-on connectors can be ordered as spare parts, see chapter A.1.

Connectors with screw terminals

Type	COMBICON system of Messrs. PHOENIX CONTACT Front-MSTB 2,5/10-ST
for conductor cross-sections of	0.2 to 2.5 mm^2 (rigid and flexible) AWG 24 to 12 0.25 to 2.5 mm^2 (with end sleeve)
Multiple conductor connection (2 conductors of same cross-section)	0.2 to 1.0 mm^2 (rigid) 0.2 to 1.5 mm^2 (flexible) 0.25 to 1.0 mm^2 (rigid with end sleeve, without plastic collar) 0.5 to 1.5 mm^2 (flexible with TWIN end sleeve with plastic collar)
Stripping length	10 mm
Recommended tightening torque	0.5 to 0.6 Nm

Mounting slots peripheral modules

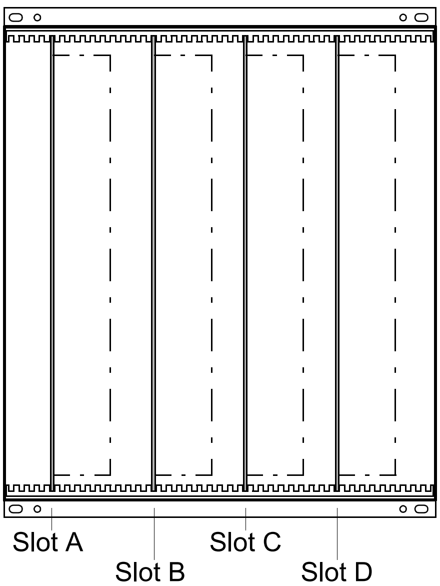


Figure 2-3 Mounting slots for the peripheral modules in the 7XP204 housing (front view)

The module guiding grooves are marked.

Getting Started 3

This chapter describes the first steps that you should take after receiving your SIPROTEC 7SS60 devices and modules. After unpacking, please check whether the version and rated data match your requirements.

For an electrical check, you can navigate in the user interface without any measured values. You can also connect the measuring system 7SS601 to a PC and operate it from the computer using the DIGSI communication software.

In the last section you will find hints on what to observe for a long-term storage of the system.

3.1 Unpacking and repacking of devices and modules

The devices and modules are packed in the factory such that the requirements of IEC 60255-21 are fulfilled.

Unpacking and repacking must be performed with the usual care, without force and only with the aid of suitable tools. The devices and modules must be visually checked to ensure that they have not been mechanically damaged.

Please observe the instruction leaflet and any other documentation that may be part of the delivery.

The shipping packaging can be reused in the same manner for further shipment. If other packaging is used, shock requirements under IEC 60255-21-1 Class 2 and IEC 60255-21-2 Class 1 must be met.

The devices and modules should be in the final operating area for a minimum of two hours before the power source is first applied. This time allows the device to attain temperature equilibrium, and prevents dampness and condensation.

3.2 Incoming inspection of devices and modules

3.2.1 Check of the rated data

Ordering code

First of all, check the complete ordering code (MLFB) of the units and modules to ensure that the versions delivered comply with the required rated data and functions, and that the necessary and desired accessories are complete. The complete ordering code of the devices and modules can be found on their rating stickers.

The 7SS601 measuring system has its rating sticker on the front of the housing.

The peripheral modules come with a rating sticker that is placed the housing in which the peripheral module is installed during assembly of the system.

The ordering code and the meaning of its digits are shown in Table A-1. The most important point is the matching of the rated device data to the station ratings. This information is found on the rating sticker. The measuring system is delivered with the binary inputs set in such a way that a dc voltage of the same level as the auxiliary supply voltage is required for their activation. The jumper settings are listed in Appendix A.4. The delivery status of the peripheral modules is shown in Appendix A.5.

3.2.2 Electrical check

The operating conditions must accord with VDE 0100 and VDE 0105 Part 1.

The unit should be in the final operating area for a minimum of two hours before the power source is first applied. This time allows the device to attain temperature equilibrium, and prevents dampness and condensation.

Warning!

Some of the following checks are carried out in presence of hazardous voltages. They must only be performed by qualified personnel which is thoroughly familiar with all safety regulations and precautionary measures and pays due attention to them.

For a first electrical check of the system, it is sufficient to ensure a reliable earthing and to connect the auxiliary supply voltage:

7SS60 overall system

- ❑ Connect an auxiliary supply voltage of the correct level and polarity to the inputs of the unit via a switch or m.c.b. Please observe the connection diagrams in Appendix A.2 and A.3.
- ❑ Close the protective switch or m.c.b. to apply the auxiliary supply voltage.

7SS601 measuring system

- Connect the earth of the device to the protective earth of the location. Units for cubicle or panel flush mounting have the earthing screws on their back.
- The green **Service/Betrieb** LED on the front plate must light after at most 0.5 s, and the red **Blocked/Störung** LED must go off after at most 10 s.
- After at most 15 s the start-up messages indicating the ordering code and the firmware version must disappear from the display. Instead, the measured values of the differential current I_d and the restraint current I_R should appear. Depending on the preset marshalling, some of the LEDs may light already.

3.3 User interface

3.3.1 Operation from the user interface of the 7SS601 measuring system

Digital protection and automation devices are operated through the integrated keypad and the display panel in a device-user dialog. All parameters required for operation can be entered and all the information can be read out from here. It is also possible to operate the system from a PC that is connected to the serial interface.

Membrane keypad/ display panel

Figure 3-1 shows a front view of the 7SS601 measuring system.

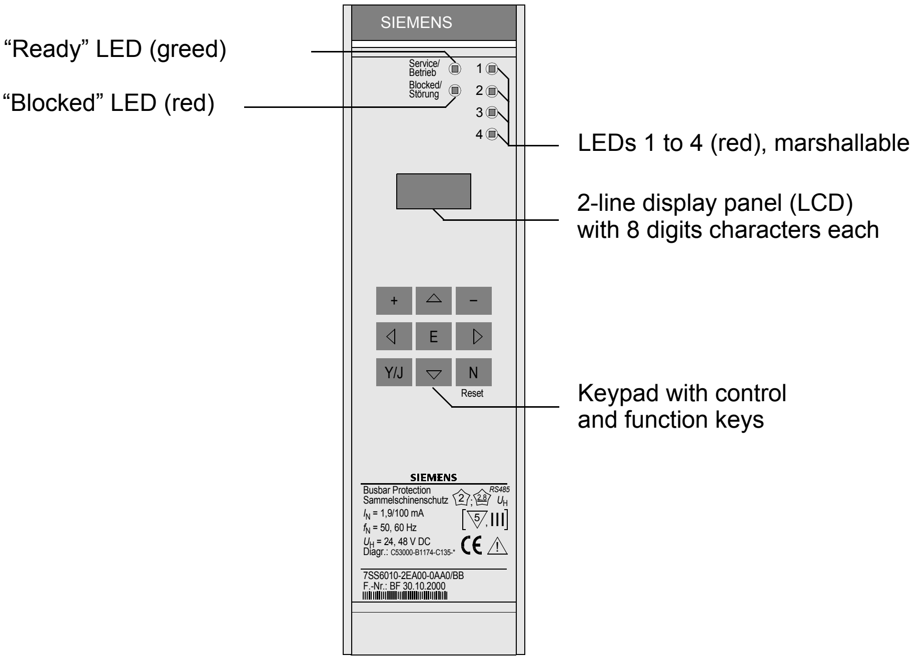


Figure 3-1 Front view of the 7SS601 measuring system with keypad and display panel

An LC display with 2 lines of 8 characters each is provided for display.

Parameters are displayed with a 2-digit number in the upper display line on the left. This number represents the address block.

The keypad comprises 9 keys, including a YES and a NO key and control keys that are used to navigate through the hierarchically structured operating menu tree. The keys have the following meanings:

Keys for changing numerical values and predefined user options:

+	Increases the set value
–	Decreases the set value

YES/NO keys:

Y/J	YES key: Operator confirms the displayed question
N	NO key: Operator negates the displayed question. This key is also used to reset memorized LED indications and fault alarms.

Keys for scrolling in the display:

▼	Forward scrolling: the display shows the next operating position of the same operation level
▲	Backward scrolling: the display shows the previous operating position of the same operation level
▶	Forward scrolling to the next operation level: the display shows the associated operating object in the next operation level
◀	Backward scrolling to the previous operation level: the displays shows the associated operating object in the previous operation level

Confirmation keys:

E	ENTER key: All changes of the display made by numerical entries or by pressing the **Y/J** and **N** keys must be confirmed with the ENTER key to be accepted by the device. The ENTER key is also used to acknowledge messages from the device if an entry is rejected; in that case a new entry must be made and confirmed with the ENTER key.

By depressing the **N** key, spontaneous fault alarms are reset and the quiescent-state indications reactivated. The marshallable LEDs on the front light up during the reset, so that the proper functioning of the LEDs can be checked as well.

3.3.2 Operation from a PC

You can make settings, start test procedures and read out data from a PC with the DIGSI communication software in the same way as with the integrated keypad, with the additional comfort of a monitor display and operator guidance through the menu.

All data can be stored on data carrier and read in from there (e.g. during configuration). If a printer is connected, the data can be printed out for documentation.

When operating the firmware from a PC, please observe the relevant operating manuals. The DIGSI communication software is suited for processing protection data.

3.3.3 Operating prerequisites

For most operational functions, the input of a password is necessary. This applies to all entries via operator keypad or user interface which concern the functions of the 7SS601 measuring system, such as:

- setting of operational parameters (thresholds, functions),
- marshalling of command relays, alarms, binary inputs, LED indications,
- system design parameters for operating language, interface and device configuration,
- starting of test procedures.

The password is not required for readout of annunciations, operational data, fault data and setting values.

The preparatory instructions in subsection 4.2.1 describe in detail how to enter the password and to adapt the PC interface.

3.4 Storage

If units or modules are to be stored, the following storage conditions should be observed:

SIPROTEC devices and modules should be stored in dry and clean rooms. For storage of devices, peripheral modules or related spare modules the applicable temperature range is between –25 °C and +55 °C (refer also to section 9.1 under Technical Data).

It is recommended to limit the temperature range for storage to values between +10 °C and +35 °C in order to avoid early ageing of the electrolytic capacitors in the power supplies.

The relative humidity must not cause condensation or ice.

Furthermore it is recommended to connect the devices and modules to auxiliary voltage for about 1 or 2 days every two years, so that the electrolytic capacitors in the power supplies are formatted. The same procedure should be followed before installing these devices. In case of extreme climatic conditions (tropical), this pre-heats the device and avoids condensation.

The units and modules should be in the final operating area for a minimum of two hours before the power source is first applied. This time allows the device to attain temperature equilibrium, and prevents dampness and condensation.

Configuration 4

The configuration of the SIPROTEC 7SS60 device comprises two parts.

The first part includes the selection and interconnection of the necessary components according to the station configuration. The system configuration is dealt within a separate document. This chapter tells you, from the example of a single-busbar station with sectionalizing isolator, which components you need to perform what tasks.

In the second part you will learn how to proceed for the configuration of the 7SS601 measuring system, in particular how to:

- enter the password
- change the operating language
- detect/output annunciations and commands at the inputs/outputs
- set the serial link
- set the date and time

4.1 Designing a system configuration

The following example of a single-busbar station with longitudinal sectionalizers shows you the functions that are assumed by the individual modules.

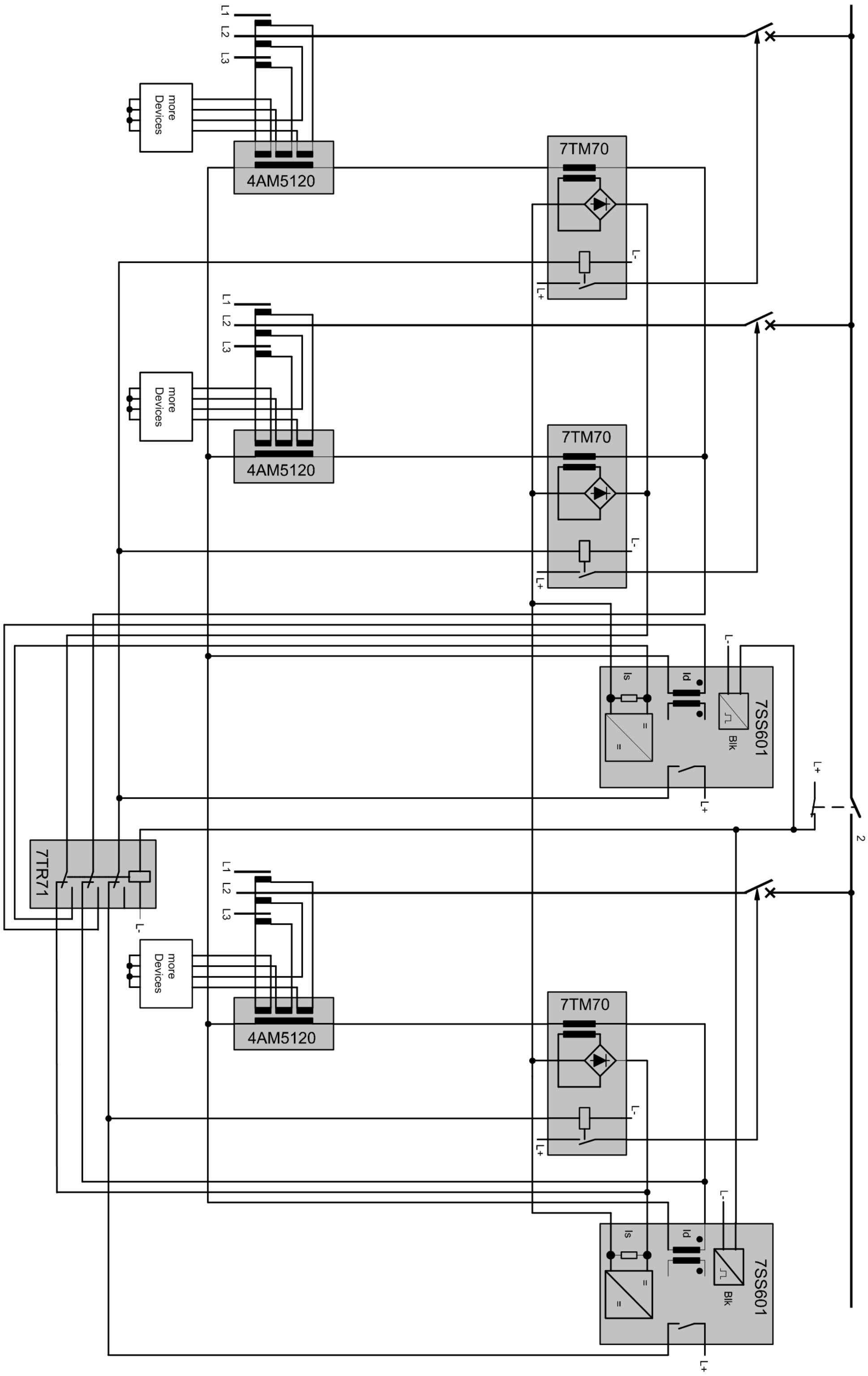


Figure 4-1 Example of a single busbar with longitudinal sectionalizers and summation current transformers

For the above example you need the following:

- Two 7SS601 measuring systems:
  These are needed for the detection and evaluation of the differential and restraint currents.
- One 7TM70 restraint/command output module:
  3 of the 5 restraint units are used for the formation of restraint currents. Also 3 of the 5 independent TRIP command relays are used with 2 NO contacts each for multiplication of TRIP commands generated by the 7SS601 measuring system.
- One 7TR71 preferential treatment/isolator replica module:
  One of the two existing preferential treatment modules is used.
  When the longitudinal sectionalizers is closed, no selective protection of the two busbars is possible. Therefore, one of the two measuring systems is preferred in this condition (in the above example the right one). The detection of such a condition and the necessary switchover is performed by this module 7TR71.
- One 7XP204 housing:
  Accommodates the 7TM70 module and the 7TR71 module.
- 3 summation current transformers 4AM5120-3DA00-0AN2 or -4DA00-0AN2.

4.2 Configuration of the measuring system

Note:

If the protection is operated from a personal computer using the DIGSI communication software, the test addresses are identified by a four-digit number. This number will be stated in brackets in the section below.

4.2.1 Entering a password

For most operational functions, the input of a password is necessary. The “password” is a predefined key sequence which must be entered before any inputs can be made. This applies for all entries via operator keypad or user interface which concern the functions of the 7SS601 measuring system, such as:

- system design parameters for operating language, interface and device configuration,
- marshalling of command relays, alarms, binary inputs, LED indications,
- setting of operational parameters (thresholds, functions),
- starting of test procedures.

In order to indicate authorized operation and to prevent unintended alterations, the password must be entered before any alteration can be performed.

When a menu item is selected which requires password input, press one of the keys **+** or **–** to inform the system of the intended alteration. The display then shows the prompt “CW :” which indicates that the password is required. The password itself consists of the key sequence **– + –**.

The entered characters do not appear in the display; instead only a symbol “@” appears. After confirmation of the correct input with **E** the display responds with “CW OK_”. Press the key **E** again.

If the password is not correct, the display shows “CW WRONG”. Pressing the keys **+** or **–** allows another attempt at password entry.

By pressing the enter key **E** one more time the menu item is displayed again, this time with an underscore to indicate that alterations can now be made. Use the keys **+** or **–** in order to change the presented text or numerical values. A flashing cursor indicates that the system operates now in alteration mode, starting with the first alteration and ending after confirmation of the altered item with the enter key **E**. The alteration mode is equally ended when the setting menu is left or after an internal waiting time.

Subsection 3.3.1 describes how to navigate in the operation tree.

4.2.2 Changing the operating language

4.2.2.1 Function description

Block 71

The operating language can be changed in the parameter **71 LANGUA (7101)**. The available operating languages are currently English and German.

When the system is delivered from the factory, the display shows function names and outputs in the English language.

4.2.2.2 Hints on setting

The block **PARAME.** is reached from the initial display of the operative system by pressing the ▼ key once. Press ▶ to change to the second level, which starts with the address block **01 POWER SYST.DAT**. In this level, press the ▼ key several times until block **71NT OP** appears.

Pressing the ▶ key brings you within the block to the parameter **71 LANGUA**, where the operating language can be changed.

The available languages can be called up by repeatedly pressing the **+** or **–** key. Each language is spelled in the corresponding national language. The required language is selected with the enter key **E**.

4.2.2.3 Overview of parameters

DIGSI addr.	Parameter	Possible settings	Default setting	Explanation
7101	71LANGUA	ENGLISH DEUTSCH	ENGLISH	Selection of the operating language

4.2.3 Marshalling of binary inputs, binary outputs and LED indicators

4.2.3.1 Introduction

Block 60

When the device is delivered from the factory, the LED indicators on the front cover, the binary inputs and the output relays have already information assigned to them. The assignment of most items of information can, however, be rearranged to adapt them to the on-site conditions.

The marshalling procedure assigns certain items of information which the system generates or requires to certain physical interfaces (e.g. input and output units), or to logical interfaces.

The user decides which information will be linked with which interface of the system. In addition, certain properties can be allocated to information and to interfaces.

Note:

Annunciation of previous events can be lost during marshalling. Therefore, the operational and the fault annunciation buffer should be read out before alterations are made later on.

Before you begin with the marshalling procedure, you should have a concept that matches the required input and output information to the number of physically available inputs and outputs of the device.

Marshalling of the inputs, outputs and LEDs is performed by means of the integrated user interface or via the serial link. The operation of the user interface is described in detail in section 3.3.1. Marshalling begins at the address block **60**.

The input of the password is required for marshalling (refer to section 4.2.1). Without password entry, parameters can be read out but not changed. A flashing cursor indicates that the system operates now in alteration mode, starting with the first alteration after entering the password and ending with the end of the marshalling procedure.

Example for binary outputs

A fault is registered by the differential current supervision function. This event is generated in the device as a logical annunciation signal and should be available at certain terminals of the unit as a NO contact. Since specific unit terminals are hard-wired to a specific (physical) signal relay, e.g. to the signal relay 2, the processor must be advised that the logical signal “Ids flt” should be transmitted to the signal relay 2. Thus, when marshalling is performed two statements of the operator are important: **which** (logical) annunciation should trigger **which** (physical) signal relay? Up to 20 logical annunciations can trigger one (physical) signal relay.

Example for binary inputs

A similar situation applies to binary inputs. In this case external information (e.g. **>BP blo**) is connected to the unit via a (physical) input module and should initiate a (logical) function, namely blocking. The corresponding question to the operator is then: **which** signal from a (physical) input relay should initiate **which** reaction in the device?

Logical annunciation functions can be used in multiple manner. For instance, one annunciation function can trigger several signal relays, several command relays, additionally be indicated by LEDs, and be controlled by a binary input unit.

The marshalling procedure is set up such that for each (physical) input or output unit (binary input, signal relay, LED or command relay) the operator will be asked which (logical functions should be allocated.

The offered logical functions are tabulated in the following sections.

With the device operative, the marshalling blocks are reached from the initial display as follows:

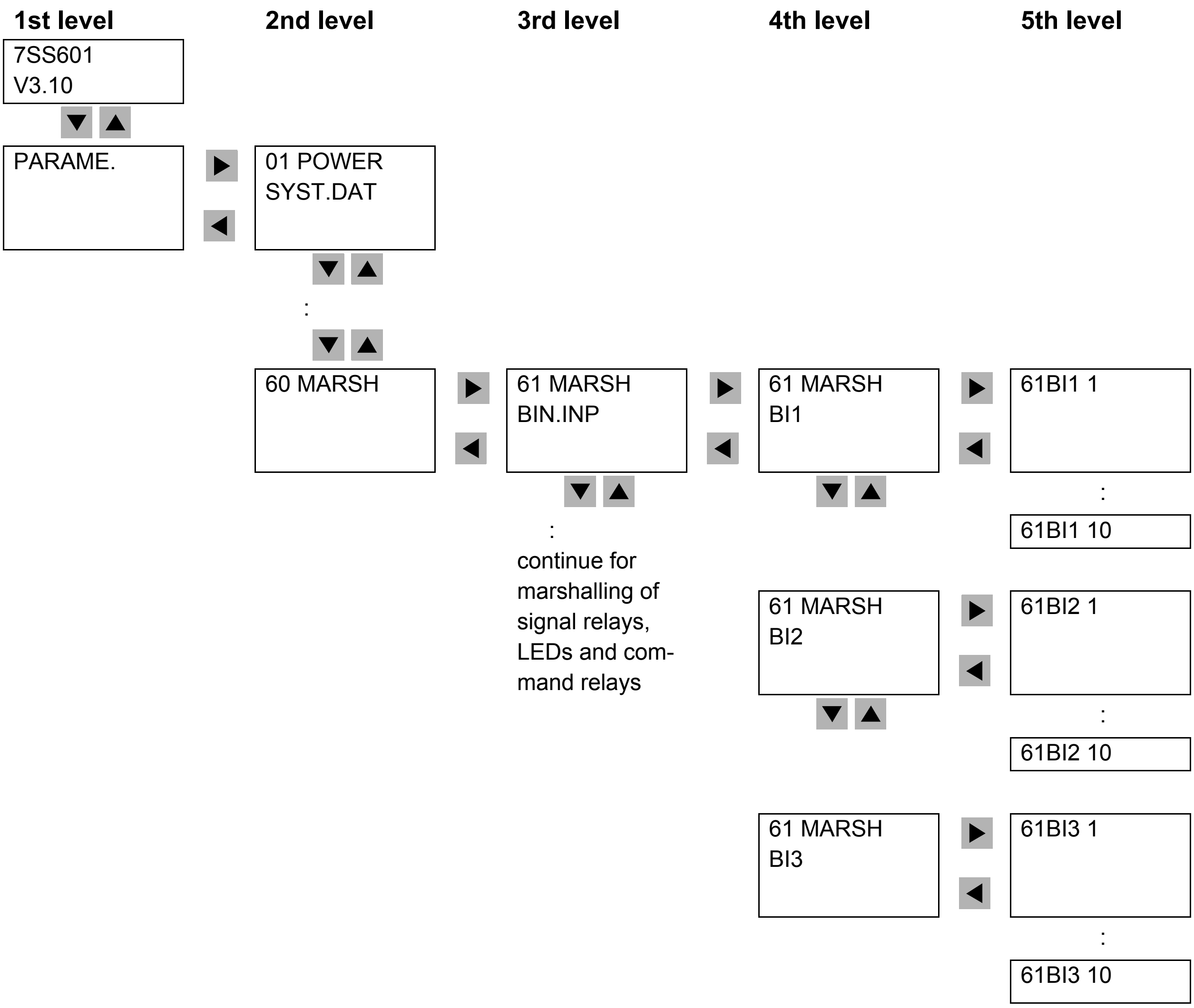
- ❑ press key ▼ (forwards); the block **PARAME.** will appear
- ❑ press key ▶ (next operation level) to move in the 2nd operation level to block **01 POWER SYST.DAT**.
- ❑ scroll with key ▼ until block **60 MARSH** appears in the display

With the key ▶ you can move to the next address block (e.g. **61 MARSH BIN.INP**, Marshalling binary inputs).

Within a block, you can change with key ▶ to the 4th level, where you can scroll forwards with ▼ and back with ▲. Each forward or backward step leads to display of the next input, output or LED position. In the display the physical input/output unit forms the heading.

Key ▶ leads to the 5th level, in which the logical functions are actually selected for assignment. The display shows, in the upper line, the physical input/output unit, this time with a one to two digit index number. The second display line shows the logical function which is presently allocated.

Table 4-1 Extract from the operation structure and illustration of selection of the marshalling blocks



On this 5th level all marshallable input and output functions can be paged through after password input by repeated used of the key **+**. Backscrolling is possible with the key **–**.

When the required function appears, press the enter key **E**. After this, further functions can be assigned to the same physical input or output module (with further index numbers) by using key ▼. Each selection must be confirmed by pressing the **E** key. If a selection place is to be assigned to no function, selection is made with the function **not all**. (not allocated).

You can leave the selection level by pressing the key ◀. The display shows again the previous selection level. Now you can scroll with key ▼ to the next (physical) input/output module or with ▲ to the previous one to repeat the selection procedure, as above.

In the following paragraphs, allocation possibilities for binary inputs, binary outputs and LED indicators are given. The function numbers and designations are listed completely in the Appendix A.7.

If one tries to leave an item or operation level by pressing one of the arrow keys without having confirmed the allocation with the enter key **E**, the display will show the question “SAVE NEW SETTING ?”. Confirm with the YES key **Y/J** that the new settings shall become valid now. The next text is displayed now. If you press the NO key **N** instead, all alterations which have been changed since the **E** key was last pressed are lost, and the old text is displayed. Thus, erroneous alterations can be made ineffective. Press the arrow key again in order to change really the operating item or level.

When the marshalling procedure is terminated by pressing the enter key **E**, the allocations are permanently secured in EEPROMs and protected against power outage.

4.2.3.2 Marshalling of the binary inputs

Block 61

The unit contains 3 binary inputs which are designated BI 1 to BI 3. They can be marshalled in address block **61**. The block is reached from the initial display in level 1 as follows: press the key ▼ (forwards), move to the 2nd operation level by key ▶ (next level); press the key ▼ repeatedly until block **60** appears in the display. Key ▶ leads to operation level 3 with address block **61 MARSH BIN.INP**.

The selection procedure is carried out as described in section 4.2.3.1.

A choice can be made for each individual input function as to whether the desired function should become operative in the “normally open” mode or in the “normally closed” mode, which means:

- ( ) **normally open** mode:
  The input acts as an NO contact, i.e. the control voltage at the input terminals activates the function;
- (**C**) **normally closed** mode:
  The input acts as an NC contact, i.e. control voltage at the input terminals turns off the function, control voltage absent activates the function.

When scrolling through the display with **+** or **–**, each input function is displayed without any index (which indicates the **normally open** mode) and with the index **C** (**normally closed** mode). The selected function must then be confirmed with the enter key **E**.

Table 4-2 shows a complete list of all binary input functions with their associated function number (FNo.).

Note:

Conventional binary inputs are level-triggered whereas the binary input of the 7SS601 that caters to the function **Blocking pulse input** is edge-triggered. After a level change has been detected, the TRIP command output is blocked for a fixed time. This ensures that the blocking duration is constant, regardless of the duration of the signal that stimulated the input. The **Blocking pulse** function is marshallable. Only the binary input to which the **Blocking pulse** is marshalled is edge-triggered; all other binary inputs are level-triggered.

The assignment of the binary inputs as delivered from the factory is shown in the block diagram in Appendix A.2. Table 4-3 shows all binary inputs as preset from the factory. .

Table 4-2 Marshallable binary input functions

FNo.	Text on the LC display	Logical functions
1 5 7701 7900 7901	not all. >LED r. >LO Res >BP blo >BP bPu	not allocated >Reset LED indicators >Lock Out Reset >Block busbar protection >Busbar protection blocking pulse

Table 4-3 Presettings of binary inputs

4th level	5th level	FNo.	Remark
MARSHALLING	**MARSH. BIN.INP**		**Block heading**
61 MARSH BI 1	6 1 B I 1 1 > L E D r .	5	>Reset LED indicators
61 MARSH BI 2	6 1B I 2 1 > B P b P u	7901	>Busbar protection blocking pulse
61 MARSH BI 3	6 1 B I 3 1 n o t a l l .	1	not allocated

4.2.3.3 Marshalling of the signal relays

Block 62

The unit contains signal outputs relays. Signal relay 1 has “Dev.OK” (device operative) permanently allocated. This signal is output when no disturbance has been detected by the self-monitoring function of the unit.

The signal relays SR 2 and SR 3 can be marshalled in address block **62**. The block is reached from the initial display in level 1 as follows: press the key ▼ (forwards), move to the 2nd operation level by key ▶ (next level); press the key ▼ repeatedly until block **60** appears in the display. Key ▶ leads to operation level 3 with address block **62 MARSH SIG.REL**. The selection procedure is carried out as described in subsection4.2.3.1.

Multiple allocating is possible, i.e a logical signal can be marshalled to more than one signal relay (refer to subsection 4.2.3.1).

Table 4-4 shows a complete list of all signal functions with their associated function number (FNo.).

The assignment of the signal relays as delivered from the factory is shown in Appendix A.3. Table 4-5 shows all signal relays as preset from the factory.

Following password input, all marshallable functions can be scrolled through on the display by repeated use of the key **+**. Backscrolling in the offered suggestions is possible with the key **–**. When the required function appears, press the enter key **E**. After this, further functions can be allocated to signal relay 1 (with further index numbers 1 to 20) by using the key ▼. Each selection must be confirmed by pressing the key **E**.

If a selection place is to be assigned to physical unit, selection is made with the function **not all**. (not allocated).

Leave the selection level for signal relay 1 with key ◄. You can then go to the next signal relay with the arrow key ▼.

Note on Table 4-4:

Annunciations which are indicated by a leading **>** sign represent the direct confirmation of the binary inputs and are identical with them. They are available as long as the corresponding binary input is energized.

Table 4-4 Marshallable output functions

FNo.	Text on the LC display	Logical functions
1	not all.	Not allocated
5	>LED r.	>Reset LED indicators
7701	>LO Res	>Lock Out reset
7721	Lockout	Lock Out state
7900	>BP blo	>Block busbar protection
7901	>BP bPu	>Busbar protection blocking pulse
7910	BP blk.	Busbar protection blocked
7911	BP act.	Busbar protection active
7914	BP Trip	Busbar protection: Trip
7920	IdS act	IDIFF supervision active
7921	IdS flt	IDIFF supervision: fault detected

Table 4-5 Presettings of signal relays

4th level	5th level	FNo.	Remark
MARSHALLING	**Signal relays**		**Block heading**
62 MARSH SIG.RE 2	62 SIG2 1 BP Trip	7914	Busbar protection: Trip
62 MARSH SIG.RE 3	62 SIG3 1 BP blk.	7910	Busbar protection blocked

4.2.3.4 Marshalling of the LED indicators

Block 63

The unit contains 6 LEDs for optical indications, 4 of which can be marshalled. They are designated LED 1 to LED 4 and can be marshalled in address block **63**. The block is reached from the initial display in level 1 as follows: press the key ▼ (forwards), move to the 2nd operation level by key ▶ (next level); press the key ▼ repeatedly until block **60** appears in the display. Key ▶ leads to operation level 3 with address block **62 MARSH LED IND**.
The selection procedure is carried out as described in Subsection 4.2.3.1.

Multiple allocation is possible, i.e a logical signal can be marshalled to more than one LED (refer to Subsection 4.2.3.1).

Apart from the logical functions, each LED can be marshalled to operate either in the memorized mode or non-memorized mode. Each annunciation function is displayed with the index “M” (“M” = memorized).

The marshallable annunciation functions are the same as those listed in Table 4-4. Table 4-6 shows all LED indicators as they are preset from the factory.

The selected function must be confirmed by the enter key **E**.

Following password input, all marshallable output functions can be scrolled through on the display by repeated use of the key **+**. Backscrolling in the offered suggestions is possible with the key **–**. When the required function appears, press the enter key **E**. After this, further functions can be allocated to LED 1 (with further index numbers 1 to 20) by using the key ▼. Each selection must be confirmed by pressing the key **E**. If a selection place is to be assigned to physical unit, selection is made with the function **not all**. (not allocated).

Leave the selection level for LED 1 with key ◀. You can then go to the LED with the arrow key ▼.

Table 4-6 Presettings of LED indicators

4th level	5th level	FNo.	Remark
MARSHALLING	**LEDs**		**Block heading**
63 MARSH LED 1	6 3 L E D 1 1 B P T r i p	7914	Busbar protection: Trip
63 MARSH LED 2	6 3 L E D 2 1 I d s f l t	7921	IDIFF supervision: Fault detected
63 MARSH LED 3	6 3 L E D 3 1 B P b l k	7910	Busbar protection blocked
63 MARSH LED 4	6 3 L E D 4 1 n o t a l l .	1	not allocated

4.2.3.5 Marshalling of the command (trip) relays

Block 64

The unit contains 2 command relays with tripping capability which are designated CMD.RE 1 and CMD.RE 2. Command relay CMD.RE 2 can be marshalled in the address block **64**. The block is reached from the initial display in level 1 as follows: press the key ▼ (forwards), move to the 2nd operation level by key ▶ (next level); press the key ▼ repeatedly until block **60** appears in the display. Key ▶ leads to operation level 3 with address block **64 MARSH CMD.REL**.
The selection procedure is carried out as described in section 4.2.3.1.

Multiple allocation is possible, i.e. a logical signal can be marshalled to more than one command relay (refer to section 4.2.3.1).

All annunciation functions as shown in Table 4-4 can be marshalled to output command relays. Command functions are naturally not effective when the corresponding protection function has been deactivated or configured to alarm output only.

The assignment of the command relays as delivered from the factory is shown in the block diagram in Appendix A.2.

Table 4-7 shows all binary inputs as preset from the factory.

Following password input, all marshallable functions can be scrolled through on the display by repeated use of the key **+**. Backscrolling in the offered suggestions is possible with the key **–**.

When the required function appears, press the enter key **E**. After this, further functions can be allocated to command relay 1 (with further index numbers 1 to 20) by using the key ▼. Each selection must be confirmed by pressing the key **E**. If a selection place is to be assigned to physical unit, selection is made with the function **not all**. (not allocated).

Leave the selection level for command relay 1 with key ◀. You can then go to the next command relay with the arrow key ▼.

Table 4-7 Presettings of command functions

4th level	5th level	FNo.	Remark
MARSHALLING	**Command relays**		**Block heading**
64 MARSH CMD.RE 2	6 4 C M D 2 1 I d s f l t	7921	IDIFF supervision: fault detected

4.2.4 Serial interface

4.2.4.1 Function description

Block 72

The 7SS601 measuring system is equipped with a serial RS485 interface. To adapt it to a PC interface, an RS485/RS232 converter is required. Communication via this interface requires some data arrangements such as identification of the device, transmission format and transmission rate.

These data are entered to the device in address block **72**. password input is necessary (refer to section 4.2.1). The data must be matched to the connected devices.

4.2.4.2 Hints on setting

Device address

The identification number of the device within the substation can be set in parameter **72DEVICE (7201)**. The number can be chosen at liberty, but must be used only once within the plant system. Setting values between 1 and 254 are possible.

If several modules are series-connected, each 7SS601 **device** must be assigned a different address in the protection and the PC before operation with the DIGSI PC is started.

Feeder address

The feeder address is understood to be the unique number of the feeder within the substation. It is set in parameter **72FEEDER (7202)**. Setting values between 1 and 254 are possible.

Substation address

In case more than one substation is addressed, an identification number for each substation can be assigned in parameter **72SUBSTA (7203)**. Setting values between 1 and 254 are possible.

Data format

In the parameter **72 PC-SE (7211)** the data format of the serial interface can be matched to the application. The recommended data format for the Siemens protection data processing program is **DIGSI V3**. The other setting option is **ASCII**, e.g. for terminal programs.

Transmission gaps

The setting of the GAPS in the parameter **72 GAPS (7214)** is relevant only when the device is intended to communicate via a modem. The setting is the maximum time period which is tolerated by the device when gaps occur during transmission of a telegram. Gaps may occur, when modems are used, by compression of data, error correction, and differences of the baud rate. Setting values between 0.0 s and 5.0 s are possible. With good transmission quality between the modems, 1.0 s is recommended. The value should be increased when transmission quality is not so good. It must be noted that GAPS must be smaller than the setting of **reaction time protection relay** in the protection software DIGSI V3. Recommended value:

$$\text{GAPS} \approx \frac{\text{Reaction time protection relay}}{2}$$

Higher values for **reaction time protection relay** reduce the transmission speed in case of transmission errors. If the interface is connected directly to a personal computer, GAPS may be set to 0.0 s.

Baud rate

In the parameter **72 BAUD (7215)** the baud rate for serial transmission can be changed. The baud rate can be selected by repeatedly pressing the key **+** or **–**.

Character format

The format for the characters transmitted in a telegram can be set in parameter **72PARITY (7216)** to match the following transmission media:

- **DIGSI V3** with even parity and 1 stop bit
- Transmission with odd parity and 1 stop bit (**8O1**)
- Transmission with no parity and 2 stop bits (**8N2**)
- Transmission with no parity and 1 stop bit (**8N1**)

4.2.4.3 Overview of parameters

Addr.	Parameter	Possible settings	Default setting	Explanation
7201	72DEVICE	minimum setting:.........1 maximum setting:....254	1	ID number of the device within the substation
7202	72FEEDER	minimum setting:.........1 maximum setting:....254	1	Number of feeder within the substation (feeder address)
7203	72SUBSTA	minimum setting:.........1 maximum setting:....254	1	ID number of substation, if more than one substation can be addressed
7211	72 PC-INT	DIGSI V3 ASCII	DIGSI V3	Data format for the interface
7214	72 GAPS	minimum setting:.....0.0 s maximum setting:....5.0 s	1.0 s	Maximum permissible transmission gap between telegrams for modem transmission
7215	72PCBAUD	1200 Baud 2400 Baud 4800 Baud 9600 Baud 19200 Baud	9600 Baud	Transmission baud rate for serial PC- interface
7216	72 PARITY	DIGSI V3 8O1 8N2 8N1	DIGSI V3	Parity of transmission telegrams

4.2.5 Setting of date and time

4.2.5.1 Function description

The date and time should not be set until the device is finally installed and connected to the supply voltage, because an outage of the auxiliary voltage resets the clock.

The address block for this setting is reached from the initial display. Press the key ▼ three times until the block **ADDITION FUNCTION** is displayed. Key ▶ is pressed to change to the next operation level with the block **TIME SETTING**. Change to the next operation level with key ▶. The date and time are displayed now. Scroll on with key ▼ to find the setting blocks for date and time.

After the relay has been switched on, first the date 01.01.95 appears and the time since the start-up of the processor system (connection of the supply voltage).

No password is required to change the date and time. Day, month and year can be altered using the keys **+** and **–**. Press the key ▶ to move between the day, month and year. Each time a value is changed, the enter key **E** must be pressed before the next number can be changed. Proceed in analog manner to change the time.

Note:

When the day is changed, the display firstly allows 31 days. Only when the month and year is changed can the relay check the plausibility of the complete date (leap year or not). After confirmation with the enter key **E**, the day may be reduced to an existing number.

4.2.5.2 Hints on setting

Date

In the parameter **DATE** a new date can be entered in the order day, month, year.

Time

In the parameter **TIME** a new time can be entered. First the hour is entered, then the minutes. The seconds are not changed. They are automatically set to zero when the enter key is pressed.

Functions 5

This chapter explains the various functions of the SIPROTEC 7SS60 and shows the setting possibilities for each function. It also gives information and - where required - formulae for determination of the setting values.

5.1 Measurement method

Basic principle

The measurement method by which the 7SS60 numerical busbar protection detects a short-circuit in the protected zone relies on Kirchhoff's current law. This law states that the vectorial sum of all currents flowing into a closed area must be zero.

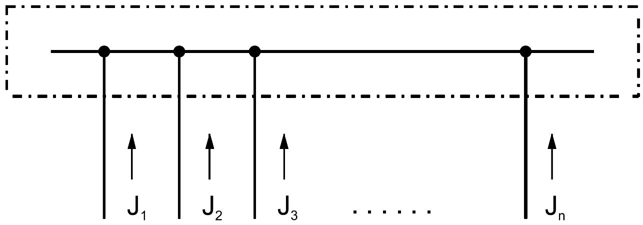


Figure 5-1 Busbar with n feeders

Assuming that the currents J_1, J_2, J_3 to J_n flow in the feeders connected to the busbar, the following equation applies in the fault-free condition (the currents flowing towards the busbar are defined as positive, and the currents flowing away from the busbar as negative):

$$J_1 + J_2 + J_3 \ldots + J_n = 0$$

If this equation is not fulfilled, there must be some other - impermissible - path through which a current flows. This means that there is a fault in the busbar region.

This law is superior, as the basis for busbar protection, to any other known way of measurement. Its simplicity is unequalled: a single quantity, the sum of currents, characterizes, and can be used to detect, faulty conditions. This sum of all currents can be formed at any time, even over a whole cycle, and if formed as such, using instantaneous current values, full use of above law can be made.

The above considerations apply strictly to the primary-side conditions in a high-voltage switching station. Protection systems, however, cannot carry out direct measurements of currents in high-voltage systems. Protection equipment measurement systems, performing the current comparisons, are connected through current transformers. The secondary windings provide the currents scaled down according to the transformation ratio while retaining the same phase relation. Furthermore, the current transformers, due to the isolation of their secondary circuits from the high-voltage system and by appropriate earthing measures, can keep dangerous high voltages away from the protection system.

The characteristics of the current transformers are an important factor for the correct operation of the protection. Their physical locations mark the limits of the protection zone covered by the protection system.

Since the current transformers proportionally transform the primary currents flowing in the system, a single-phase busbar protection that monitors the summated feeder currents would have the basic circuit shown in Figure 5-2.

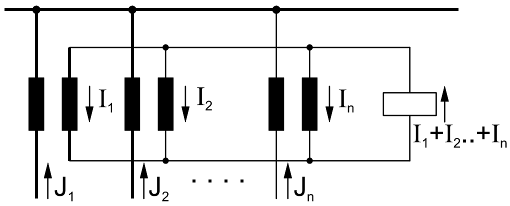


Figure 5-2 Differential protection of a busbar with n feeders, 1-phase, without restraining devices

For simplicity's sake, it is assumed that the current transformers of all feeders have the same transformation ratio. Although such a busbar protection would certainly detect any short-circuit inside the protection zone, the transformation errors of the current transformers, which are unavoidable to some degree, are also liable to cause spurious tripping as a result of an external short-circuit. In that case, for instance with a close-up fault on one of the feeder bays, the current flowing into the short-circuit is shared on the infeed side by several bays. The current transformers in the infeeding bays carry only a fraction of the total fault current while the current transformer in the faulted feeder bay carries the full current in its primary winding. If the fault current is very high, this set of current transformers may therefore be saturated, so tending to deliver only a fraction of the actual current on the secondary side while the rest of the current transformers, due to the distribution of currents among several bays, perform properly. Although the sum of the currents is zero on the primary side, the sum of the currents in Figure 5-2 is now no longer zero.

In conventional differential protection systems where the sum of the currents is zero on the primary side, for busbars and similar objects, this difficulty is countered by employment of the so-called stabilization (restraining) devices.

If the short-circuit does not occur at the voltage peak of the cycle, a dc component is initially superimposed on the short-circuit current which decays with a time constant $\tau = L / R$ of the impedance from source to fault. With the growing output ratings of the generator units, these time constants in the supply system tend to grow longer. A superimposed dc component speeds up the magnetic saturation in the transformer cores, thus considerably affecting the transformation task.

Several measures have been introduced into the 7SS601 measuring system of the 7SS60 busbar protection to cope with these problems. It was thus possible to give the 7SS60 busbar protection system a maximum degree of security against spurious operation for external short-circuits while ensuring, in the event of internal short-circuits, that a tripping signal is initiated within a very short time.

The measuring circuit of the 7SS60 busbar protection system is characterized by the following features:

Basic principle	• Monitoring the sum of the currents as the tripping quantity
Measures taken to guard against the disturbing influences due to current-transformer saturation	• Restraint
Measures taken to obtain very short operating times	• Separate evaluation of the current transformer currents during the first milliseconds after the occurrence of a fault (anticipating the current transformer saturation)

Basic circuit, supervision

The simple circuit shown in Figure 5-2 is sufficient to derive the sum of all feeder currents in one phase, provided that the current transformers of all feeders have the same transformation ratio. In most cases, however, the current transformers of the feeders in a power system will have different transformation ratios because the incoming and outgoing lines carry different rated currents and the transformers are matched to these currents. To provide the uniform transformation ratio required by the busbar protection, matching CTs are installed upstream of the protection system input; these transformers are designed to convert the input from the main current transformers into an identical transformation ratio for all feeders. In the 7SS60 system the matchting CTs are also responsible for matching to the nominal current of the measuring inputs. The output current of the matching CTs is 100 mA with a primary nominal current.

To the single-phase protection circuit shown in Figure 5-2, matching CTs would be added, as shown in Figure 5-3.

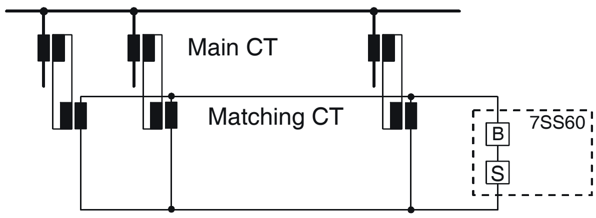


Figure 5-3 Differential protection of a busbar, with matching CTs

The 7SS601 measuring system includes a busbar protection function B and a supervision function S, which monitors the connection circuit of the protection. The supervision is set to pick up at much lower currents than the protection function, which is designed for short-circuit currents, so that it can respond to such a low current in the summation path even at normal load currents.

The supervision function detects faults and interruptions in the current transformer circuits.

If now, in this error condition, a short-circuit occurs outside the protected area, e.g. in the feeder, the current would not be recognized by the measuring system and therefore appear as differential current. If no countermeasures were taken, the protection would initiate a TRIP command. As a result, a busbar would be spuriously tripped in the critical period following the tripping of the faulted line, when the healthy station components are of particular importance to maintain the supply of the power system.

This is prevented by the supervision function, which detects a fault current flowing even at load current conditions. After a specified time delay, which is necessary for the system to settle down after a tripped short-circuit, an alarm is raised if the current persists, and the tripping can be blocked according to the setting. In this way, the supervision prevents the tripping of the busbar, even if due to an error in the connection circuit all criteria for the output of a TRIP command would be fulfilled.

In addition, the alarm output by the supervision informs the user of the circuit error.

Restraint

The restraint (stabilization) has the function of reducing the influence on the measurement of transformation inaccuracies (e.g. for transformer saturation) in the various feeders to such a degree that spurious behaviour of the protection system is prevented.

The vectorial sum I_d of all feeder currents acts as tripping quantity.

$I_d = | I_1 + I_2 + ... + I_n |$

The value sum of the all feeders is counterbalanced by the restraint quantity I_R.

$I_R = | I_1 | + | I_2 | + ... + | I_n |$

The restraint R is determined by setting the restraint factor.

$R = k \cdot I_R$

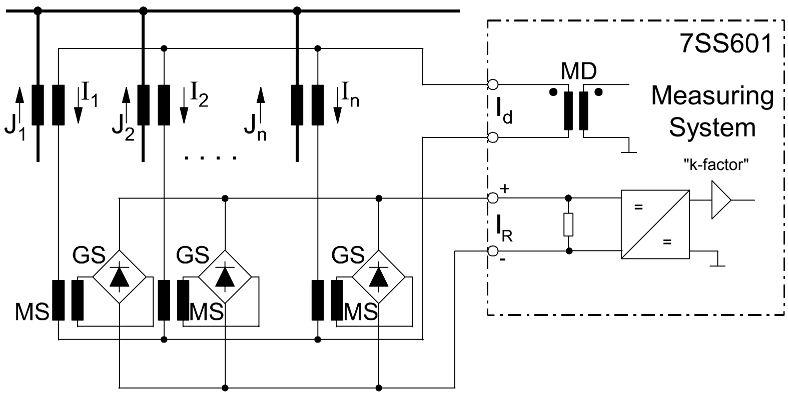


Figure 5-4 Differential current measuring circuit with restraint in the 7SS60 busbar protection system

For an explanation of the circuit shown in Figure 5-4, let us consider first the conditions at a given point in time. The n feeders of the busbars carry the currents J_1, J_2 ... J_n. These are defined as positive as they flow towards the busbar. The secondary currents I_1, I_2 ... I_n from the current transformers, which are proportional to the primary currents if we assume (for the moment) an ideal transmission behaviour, flow individually through the primary windings of the measuring transducers **MS** and summated through the primary winding of the measuring transducer **MD**. On the secondary side, each transducer **MS** of the restraint module feeds a measuring rectifier **GS**. Regardless of the direction of the individual currents in the measuring transducers, the current direction at the output of the measuring rectifiers is fixed and the same at the considered and any other point in time.

The input I_d thus detects the vectorial sum of the currents, and the input I_R the summated magnitudes of the currents.

Check zone

The safety of operation of the busbar protection system 7SS60 can be further increased by an additional so-called check zone.

This requires an additional measuring system which - regardless of the position of the isolator - monitors the current sums of all busbar feeders. Possible tripping failures originating from faulty information sent to the real state of the isolator are thus excluded.

When a busbar fault occurs, a TRIP-command decision is only given if both the measuring system belonging to the faulty busbar section and the check zone measuring system gives the decision for tripping (2 out of 2 decision).

An even higher degree of safety can be achieved by using separate transformer cores for the check zone.

To avoid over-restraint, address **10k fac (1506)** in the check zone measuring system has to be a lower level (see Subsection 5.4.2).

5.2 Formation of measuring currents from the transformer currents

The measuring quantities used by the busbar protection for the current comparison are the secondary currents supplied by the feeder transformers. They are, however, not fed directly into the measuring circuit but first transformed by means of matching CTs. In the following the reasons are explained:

- For the measuring circuit it is necessary to **reproduce** the corresponding switch position of the power system. Therefore the rated currents must be changed over. The secondary currents of the transformers (rated current 1 A or 5 A) are not suited for this purpose because the changeover contacts therefore needed to be designed for currents (appearing when a fault occurs) that are much more higher. If the currents are transformed, the changeover contact is less strained. This means that the contact need not be designed for very high currents.
- Usually the current transformers in the outputs do not have the same transformation ratio. However, the measuring circuit requires a consistent transformation of the currents. For the protection differences resulting from the transformation must be balanced by matching CTs.
- The currents of the 3 phases can be summated to a single-phase alternating current by means of a matching CT. In this way, only one measuring system is necessary to protect the 3 phases of the power system. As a consequence, the protection each time picks up differently in its sensitivity, depending on which phase is affected by the fault. In most cases this level of protection is sufficient.

The 7SS60 busbar protection is designed for a rated input current of 100 mA. With the current transformer carrying rated current at the primary side, the current for this feeder that is fed into the protection for comparison will be 100 mA. This applies if 3 phase currents are summated to a single-phase alternating current for a common measuring circuit and if each phase has its own measuring circuit. The latter is preferentially used for protection equipment for busbars in systems of very high rated insulation voltages (380 or 220 kV). However, the consistency of the pickup values for all types of faults costs much more effort. Another reason for using this method preferentially is that the safety is twice or three times higher for tripping in case of two-phase or three-phase faults.

Depending on whether differential protection is applied on all 3 phases together or on each single phase, one has to distinguish between 2 types of input circuits. Each method requires different matching transformers.

There are 2 basic principles:

- phase-selective protection (3 measuring systems in each busbar section)
- protection with summation current transformers (one measuring system in each busbar section)

If summation current transformers are used, a smaller number of modules is sufficient to form a protection system. On the other hand, the asymmetric analog summation of the currents entails different sensitivity of the protection system for different fault types. You can influence the sensitivity by performing the connection mode which is optimally matched to the system conditions. Refer also to the following explanations concerning the normal and increased earth fault sensitivity.

In the version with summation current transformers, increased restraint may be produced by load currents in the phases not involved in the fault current path. But this is of less importance since the fault currents exceed normally clearly the tripping characteristic.

5.2.1 Summation current transformer methode

The following sections deal with circuit examples for the version with summation current transformers.

The input current transformer (“summation current transformer”) has several primary windings and one secondary winding. The primary windings have different numbers of turns, which allows to connect the three phase currents with a ratio of e.g. 2 : 1 : 3.

Depending on the station operating conditions and the requirements that the protection must meet, there are two different circuits for connecting the summation current transformer to the main transformers.

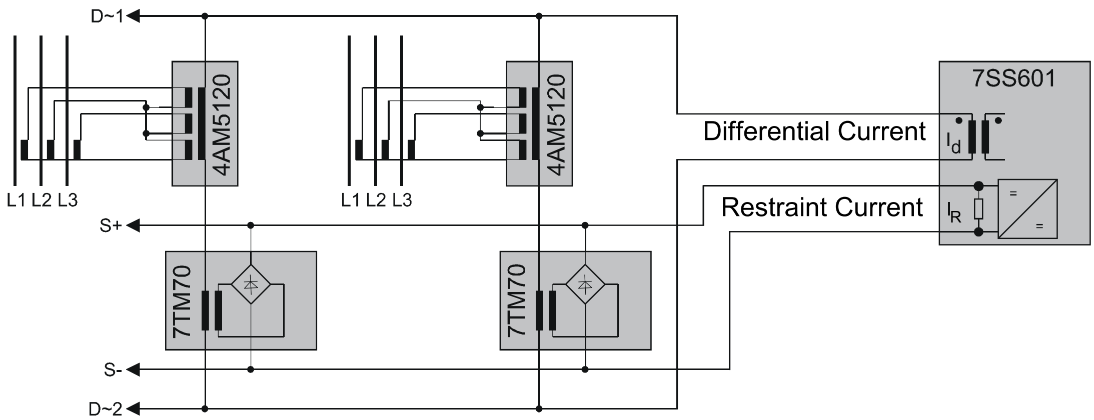


Figure 5-5 Block diagram of the 7SS60 system with summation current transformers

5.2.1.1 Normal earth current sensitivity

Figure 5-6 shows the connection circuit for normal earth current sensitivity. It should be considered for power systems with low-resistant or solid earthing of the starpoints where due to the transformer design sufficiently high short-circuit currents can be expected in case of 1-phase earth faults.

One of its characteristics is that the fault detection thresholds for 2-phase short-circuits have a ratio of 1 : 2. With any other winding ratio than 1 : 2 between the windings in the phases, the fault detection thresholds would differ by more than the ratio 1 : 2. This ratio is thus an optimum. In comparison with the fault-free, symmetrical 3-phase current, the ratio is $2 / \sqrt{3} = 1.15$.

For the connection shown in Figure 5-6, we obtain the winding factors W and their ratio to the three-phase symmetrical fault according to table 5-1 for the different fault types. Additionally, the primary currents I_1 required for the secondary current I_M = 100 mA are indicated. To obtain the actual pickup value, the current setting values have to be multiplied with these factors.

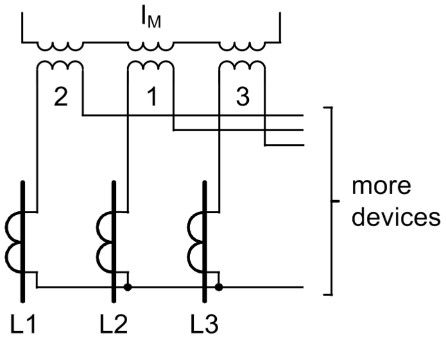


Figure 5-6 Connection circuit of the summation current transformer for normal earth short-circuit sensitivity

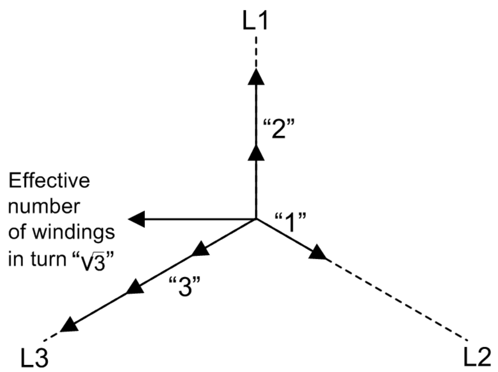


Figure 5-7 Vector diagram for 3-phase faults

Table 5-1 Fault types and winding factors for connection L1-L2-L3

Fault	W	$W / \sqrt{3}$	I_1 for I_M = 100 mA
L1-L2-L3 (sym.)	$\sqrt{3}$	1.00	1.00 * I_N
L1-L2	1	0.58	1.73 * I_N
L2-L3	2	1.15	0.87 * I_N
L3-L1	1	0.58	1.73 * I_N
L1-N	2	1.15	0.87 * I_N
L2-N	1	0.58	1.73 * I_N
L3-N	3	1.73	0.58 * I_N

The values stated for 1-phase earth faults apply in the first place for power systems that have starpoints with solid or low-resistant earthing. They apply also to double earth faults in isolated-neutral systems and systems with earth fault neutralizing if the considered busbar is fed from one side only and the second fault is located outside the protected zone, between the power source and the busbar equipped with a differential protection.

If the starpoints of the transformers that are fed by the protected busbar have a solid or low-resistant earthing but all supply transformers have an isolated starpoint, an earth fault in phase L2 within the protected zone, with the connection circuit shown in Figure 5-10, would lead to a lower fault characteristic than shown.

For a better understanding of this, Figure 5-12 shows the distribution of the currents between the three phase conductors and the earth conductor on the line from the supply transformer to the earth-faulted busbar and on the line between the busbar and an earthed transformer. The currents are shown as arrows.

Figure 5-13 shows the electric loading of the summation current transformer. Depending on the phase that is involved in the earth fault, the electric loading will vary on the supply side. On the busbar side towards the earthed transformer, the current distribution is independent of the affected phase.

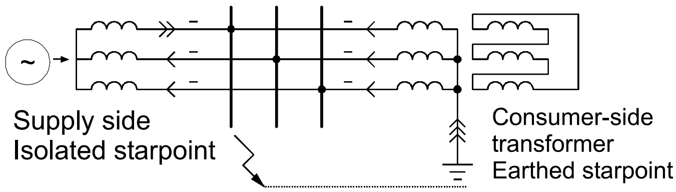


Figure 5-8 Current distribution during a 1-pole earth fault in a power system with earthing only on the consumer side

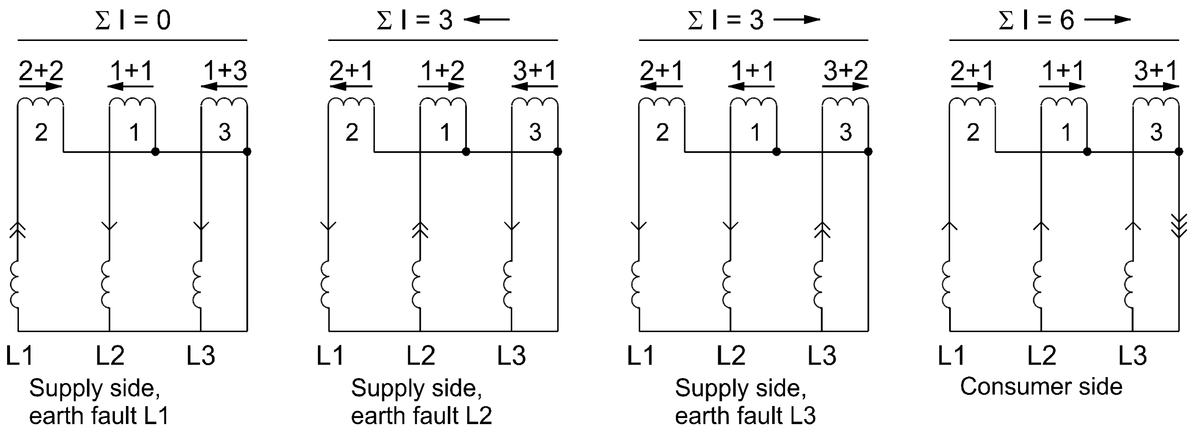


Figure 5-9 Summation transformer currents in a 1-pole earth fault in a power system with earthing only on the consumer side; connection as per 5-6

This circuit yields the following conditions in the differential measuring circuit for power systems with earthing only on the consumer side:

Phase	**Trip value** I_d	**Restraint value** I_s	I_d / I_s
L1	0 + 6	0 + 6	6/6 = 1.0
L2	–3 + 6	3 + 6	3/9 = 0.33
L3	3 + 6	3 + 6	9/9 = 1.0

If an earth fault occurs in phase L2 within the protected zone, the fault characteristic has thus only a slope of 0.33 instead of 1.

This circuit is thus not suitable for power systems with earthing only on the consumer side.

5.2.1.2 Increased earth current sensitivity

Figure 5-10 shows that the windings with the ratio of turns 2 (ratio-2 winding) and 1 (ratio-1 winding) are each connected to one of the three phase currents, and the third winding (ratio-3 winding) is connected to the neutral conductor.

This circuit is used in power systems where system faults involving earth currents are likely to induce relatively small fault currents.

One of its characteristics is that the fault detection thresholds for 2-phase short-circuits have a ratio of 1 : 2. With any other winding ratio than 1 : 2 between the windings in the phases, the fault detection thresholds would differ by more than the ratio 1 : 2. This ratio is thus an optimum. In comparison with the fault-free, symmetrical 3-phase current, the ratio is $2 / \sqrt{3} = 1.15$.

A second characteristic of this connection circuit is its increased sensitivity to earth faults, which is due to the connection of the **ratio-3 winding** to the earth current path.

For the connection shown in Figure 5-10, we obtain the winding factors W and their ratio to the three-phase symmetrical fault according to table 5-2 for the different fault possibilities. Additionally, the primary currents I_1 required for the secondary current I_M = 100 mA are indicated. To obtain the actual pickup value, we multiply the current setting values these factors.

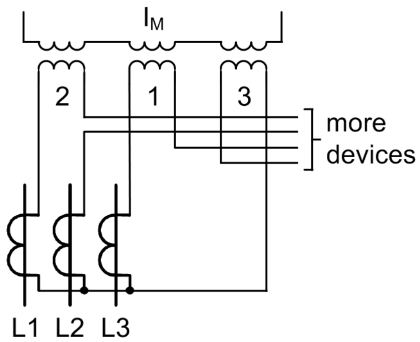


Figure 5-10 Connection circuit of the summation current transformer for increased earth current sensitivity

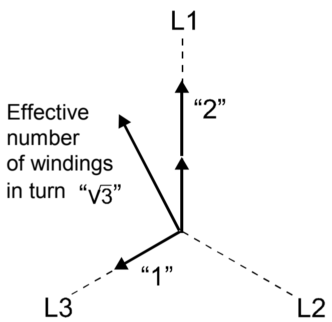


Figure 5-11 Vector diagram for 3-phase faults

Table 5-2 Fault types and winding factors for connection L1-L3-N

Fault	W	W / $\sqrt{3}$	I_1 for I_M = 100 mA
L1-L2-L3 (sym.)	$\sqrt{3}$	1.00	1.00 * I_N
L1-L2	2	1.15	0.87 * I_N
L2-L3	1	0.58	1.73 * I_N
L3-L1	1	0.58	1.73 * I_N
L1-N	5	2.89	0.35 * I_N
L2-N	3	1.73	0.58 * I_N
L3-N	4	2.31	0.43 * I_N

The values stated for 1-phase earth faults apply in the first place for power systems that have starpoints with solid or low-resistant earthing. They apply also to double earth faults in isolated-neutral systems and systems with earth fault neutralizing if the considered busbar is fed from one side only and the second fault is located outside the protected zone, between the power source and the busbar equipped with a differential protection.

If the starpoints of the transformers that are fed by the protected busbar have a solid or low-resistant earthing but all supply transformers have an isolated starpoint, an earth fault in phase L2 within the protected zone, with the connection circuit shown in Figure 5-10, would lead to a lower fault characteristic than shown.

For a better understanding of this, Figure 5-12 shows the distribution of the currents between the three phase conductors and the earth conductor on the line from the supply transformer to the earth-faulted busbar and on the line between the busbar and an earthed transformer. The currents are shown as arrows.

Figure 5-13 shows the electric loading of the summation current transformer. Depending on the phase that is involved in the earth fault, the electric loading will vary on the supply side. On the busbar side towards the earthed transformer, the current distribution is independent of the affected phase.

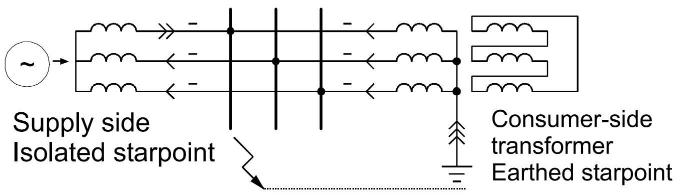


Figure 5-12 Current distribution during a 1-pole earth fault in a power system with earthing only on the consumer side

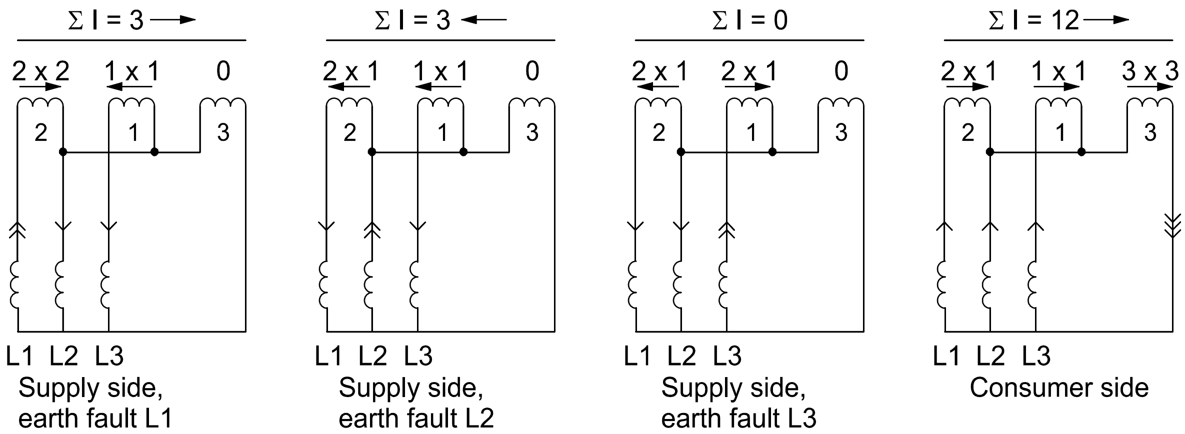


Figure 5-13 Summation transformer currents in a 1-pole earth fault in a power system with earthing only on the consumer side; connection as per Figure 5-10

For the three possible cases, the following conditions apply:

Phase	**Trip value** I_d	**Restraint value** I_s	I_d / I_s
L1	3 + 12	3 + 12	15/15 = 1.0
L2	–3 + 12	3 + 12	9/15 = 0.6
L3	0 + 12	0 + 12	12/12 = 1.0

If an earth fault occurs in phase L2 within the protected zone, the fault characteristic has thus only a slope of 0.6 instead of 1. With such unfavourable conditions, a lower restraint factor should be selected to ensure reliable tripping of the protection in case of internal faults.

5.2.2 Phase-selective measurement

The phase-selective measurement method provides equal sensitivity for all fault types.
The current is measured separately for each phase. To this end, each secondary current of the primary transformer is fed into a matching transformer. If the transformation ratio of the matching transformers has been selected to match the transformation ratio of the primary current transformer, the matching transformer generates a normalized secondary current. If the primary current is 1 * I_{rated}, the secondary current of the matching transformer is 100 mA.

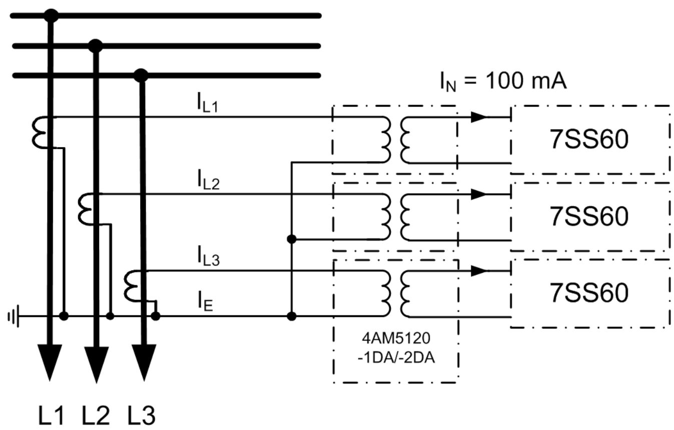


Figure 5-14 Phase-selective measurement

5.2.3 Matching transformers

Summation current matching transformers 4AM5120-3/-4

For current summation, matching transformers of the types **4AM5120-3DA00-0AN2** for connection to transformers with a rated secondary current of 1 A (Figure 5-15) and **4AM5120-4DA00-0AN2** for connection to transformers with a rated secondary current of 5 A (Figure 5-16) are used. These summation current matching transformers have one secondary winding with a rated current of 100 mA, but seven input windings for connection to the main current transformers. The numbers of turns in these windings are such that they allow to compensate by appropriate connection circuits any transformation ratio differences in the main transformers. Otherwise, interposing transformers must be used additionally to prevent mismatching. To ensure the required degree of protection, the summation current matching transformers are usually accommodated in cubicles (Figure 9-3). They can also be installed in the proximity of the main current transformers.

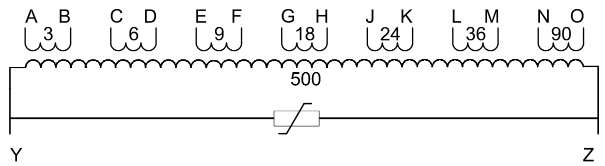


Figure 5-15 Windings of the 4AM5120-3DA00-0AN2 summation current matching transformer

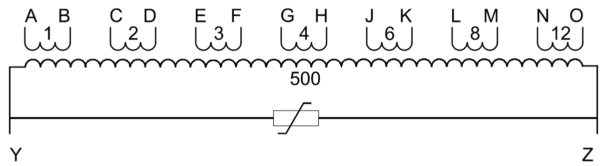


Figure 5-16 Windings of the 4AM5120-4DA00-0AN2 summation current matching transformer

Matching transformers 4AM5120-1/-2

For the phase-selective differential current busbar protection, matching transformers of the types **4AM5120-1DA00-0AN2** (Figure 5-17) for connection to transformers with a rated secondary current of 1 A and **4AM5120-2DA00-0AN2** (Figure 5-18) for connection to transformers with a rated secondary current of 5 A are used. These matching transformers have one secondary winding with a rated current of 100 mA, but 6 or 4 input windings for connection to the main current transformers. The numbers of turns in these windings are such that they allow to compensate, by appropriate protective circuits, any transformation ratio differences in the main transformers. Otherwise, interposing transformers must be used additionally to prevent mismatching. To ensure the required degree of protection, the matching transformers are usually accommodated in cubicles (Figure 9-3). They can also be installed in the proximity of the main current transformers.

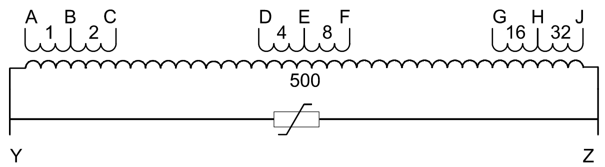


Figure 5-17 Windings of the 4AM5120-1DA00-0AN2 matching transformer

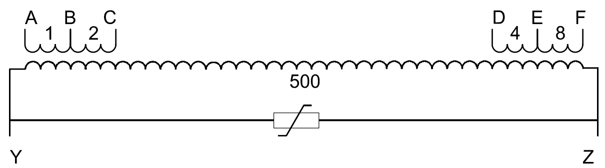


Figure 5-18 Windings of the 4AM5120-2DA00-0AN2 matching transformer

Matching transformers 4AM5272

Matching transformer of type **4AM5272-3AA00-0AN2** are used for each phase if the transformation ratio of the primary current transformer cannot be matched using a **4AM5120** matching transformer. The transformation ratio can be achieved by using an appropriate number of windings.

The auto transformer configuration should be preferred since the losses are smaller and enable more accurate matching.

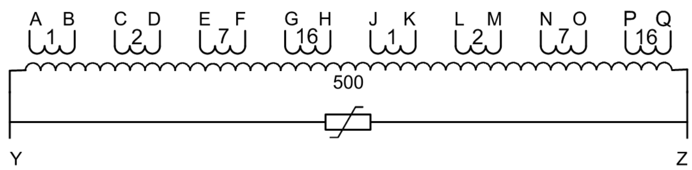


Figure 5-19 Windings of the 4AM5272-3AA00-0AN2 matching transformer

5.3 Power system and switchgear data – Block 01

Note:

If the protection is operated from a personal computer using the DIGSI communication software, the test addresses are identified by a four-digit number. This number will be stated in brackets in the section below.

5.3.1 Function description

The 7SS601 measuring system requires some basic data of the power system and the switchgear so that it can match its functions to these data and to its application. These data are found in block **01 POWER SYST.DAT** and in the switchgear data.

Rated frequency

The parameter **01 FREQ (1101)** is used to set the rated system frequency.

Minimum TRIP command duration

The parameter for the minimum TRIP command duration **01 T-TRP (1134)** ensures that all connected circuit breakers are reliably tripped as required.

The minimum TRIP command duration can also prevent damage to the TRIP command contacts of the protection system, which could occur if these contacts were opened before the auxiliary contacts of the circuit breaker(s) have interrupted the flow of current through the trip coil. With the parameter **01 T-TRIP (1134)** the minimum duration of the TRIP command can be extended long enough to ensure that the flow of current through the trip coil of the circuit breaker is reliably interrupted.

Lockout function

The parameter **01 L.Out (1135)** causes the TRIP command to be memorized until it is manually reset. A TRIP command that is memorized by the lockout function is not even reset by an auxiliary power outage; it drops off, however, for as long as the auxiliary voltage failure persists, as it has no supply voltage.

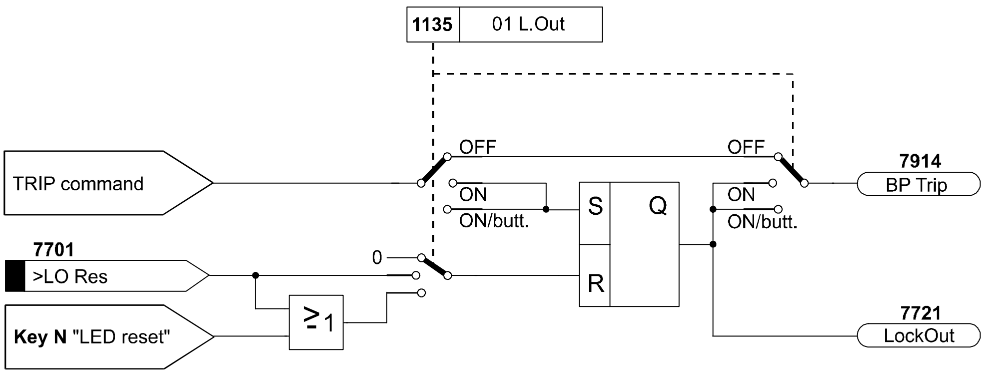


Figure 5-20 Logic diagram of the lockout function

5.3.2 Hints on setting

Rated system frequency

The default setting is **50 Hz**; it needs to be changed only for a system frequency of **60 Hz**.
16.7 Hz are available in a version with separate order no.

Note:

The parameter **01 FREQ (1101)** can only be called up in versions for 50 Hz or 60 Hz. In systems with a rated frequency of 16.7 Hz, the parameter **01 FREQ (1101)** is not displayed at all.

Lockout function

If the Lockout function is set to **ON**, the lockout state can only be reset via a binary input. If **ON/butt.** is set, the lockout can be reset with the **N** key or with a binary input.

5.3.3 Overview of parameters

DIGSI addr.	Parameter	Possible settings	Default setting	Explanation
1101	01 FREQ	50 Hz 60 Hz	50 Hz	Rated frequency of power system
1134	01 T-TRP	0.01 s to 32.00 s	0.15 s	Minimum duration of TRIP command
1135	01 L.Out	OFF ON ON/key	OFF	Lockout function

5.3.4 Annunciations

FNo.	Text on LC display	Logical functions
7721	LockOut	Lockout state

5.4 Busbar protection

5.4.1 Function description

The busbar protection function generates the TRIP command that is then multiplied by means of peripheral modules to enable the output to all tripping circuit breakers. It makes the r.m.s. values of the differential current I_d and of the restraint current I_R available for display, stores events in the form of operational annunciations, fault annunciations or spontaneous annunciations and outputs these via LED indicators or signal relays. Measured values and annunciations are furthermore made available at the RS485 interface for operation by PC using the DIGSI communication software.

The 7SS601 measuring system processes the externally formed sums of the differential current I_d and of the restraint current I_R. By means of these two measured values, the protection function recognizes the presence of a fault in its associated protection zone. Figure 5-21 shows the trip characteristic of the protection. The characteristic is divided into a horizontal portion and a portion with a steadily rising slope. Only value pairs of a differential and a restraint current that are both above the characteristic constitute busbar faults that lead to a TRIP command. The level of the horizontal portion of the characteristic is determined by the parameter **10Id> (1505)**. The slope of the rising portion can be varied by the setting of the parameter **10 K fac (1506)**. The parameter **13ID thr (1802)** constitutes the selectable threshold for the differential current supervision.

The algorithm of the 7SS601 measuring system is optimized for the fastest possible tripping in case of a busbar short-circuit. The stability of the protection against external faults is ensured if the transformer saturation occurs not before 3 ms.

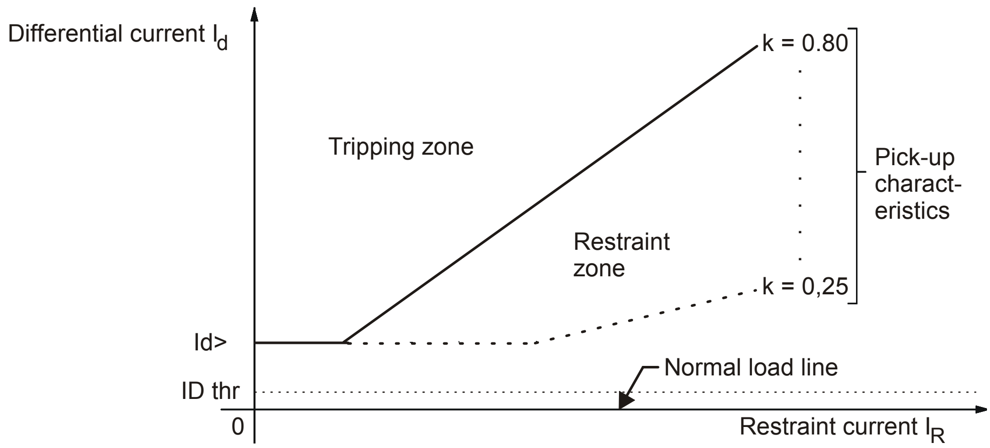


Figure 5-21 Characteristic of the 7SS601 measuring system

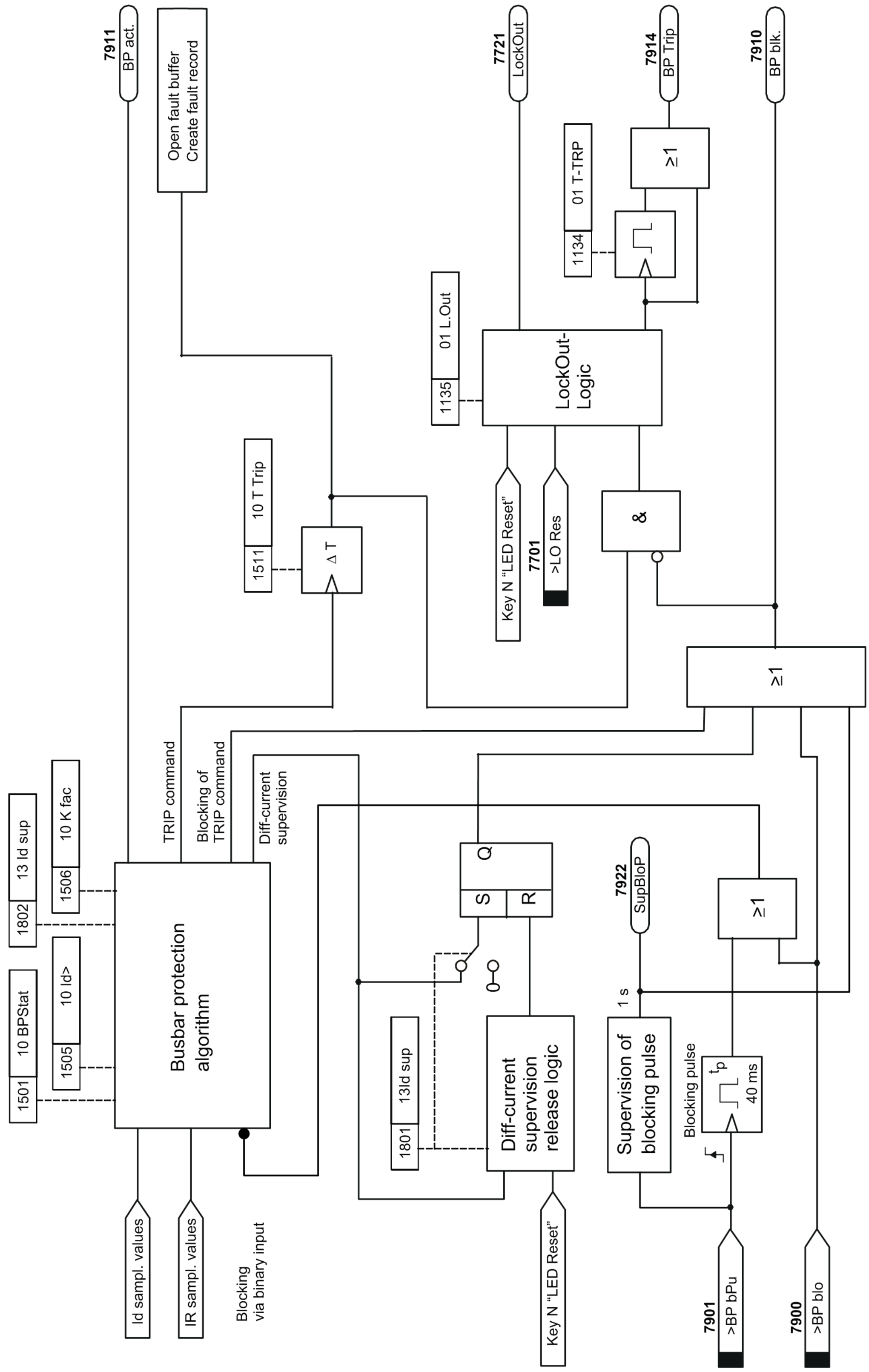


Figure 5-22 Logic diagram of the busbar protection function

5.4.2 Hints on setting

Busbar protection

The parameter **10BPstat (1501)** is used to activate **(ON)** or deactivate **(OFF)** the busbar protection function. It can also be set to block the command and signal relays while the protection function is active **(BLO.TRP)**.

Pick-up value for differential current

For fault detection and tripping the protection only uses the normalized currents I_d and I_R which exceed the threshold set in **10Id> (1505)**. The fault detection is reset when the value drops below the threshold again.

The threshold **10Id> (1505)** has an influence on the sensitivity of the protection for small fault currents. If weak infeed conditions or the type of neutral point grounding only generate ground fault currents in the load range, **10Id> (1505)** may have to be set below the rated value. It must be borne in mind, though, that with a high load the failure of one current transformer might then cause a trip of the busbar. In this case additional criteria must ensure the stability (e.g. additional release via the displacement voltage by means of a feeder protection device).

Delay of the TRIP command

A time delay is implemented between the protection algorithm initiating the tripping and the output of the actual TRIP command. This time step causes the delayed initialization of the TRIP command (if a tripping time other than zero is specified). The TRIP command is only executed if during the entire time step the tripping is issued by the protection algorithm. The time step will be reset prematurely if the protection algorithm assumes the tripping conditions to be no longer fulfilled. The delay time of the TRIP command can be specified as the parameter **10 TrpDly (1511)**. Due to the system configuration the timer accuracy is ± 10 ms.

Restraint factor

The restraint factor **10 K fac (1506)** allows to adapt the stability of the protection to service conditions.

Although a high setting for this factor improves the stability with regard to faults outside the protected zone, it reduces the sensitivity for the detection of busbar faults.

10 K fac (1506) should therefore be chosen as low as possible and as high as necessary.

If the measuring system is to be used for zone-selective protection, which will be the case in most applications, it is advisable to use the default setting of **10 K fac (1506)**.

Where a measuring system is used for protection of the so-called check zone, a lower value for **10 K fac (1506)** is recommended to avoid that the load currents of the non-faulted busbar sections cause an over-restraint.

The recommended settings for **10 K fac (1506)** can be summarized as follows:

Zone-selective protection	
Condition	**Setting of 10 K fac (1506)**
Transformer saturation times ≥ 3 ms (16.7 Hz, 50 Hz, 60 Hz) **Power system time constants** < 300 ms	0.6

Check zone protection	
Condition	**Setting of 10 K fac (1506)**
none	0.3

5.4.3 Overview of parameters

DIGSI addr.	Parameter	Possible settings	Default setting	Explanation
1501	10BUSBAR PROTECT.	ON OFF BLO.TRP	ON	Busbar protection function
1505	10Id>	0.2 I_{no}[1] to 2.50 I_{no}[1]	1.00 I_{no}[1]	Threshold for differential current
1506	10K fac	0.25 to 0.80	0.60	Sensitivity to internal faults
1511	10 TrpDly	0.00 to 10.00	0.00	Time delay of trip

1 I_{no}: normalized rated current; I_{no}=100mA with a symmetrical rated current flowing on the primary side

5.4.4 Annunciations

FNo.	Text on LC display	Logical functions
7721	LockOut	Lock Out state
7911	BP act.	Busbar protection active
7914	BP Trip	Busbar protection: Trip
7915	BP Tdel	Busbar protection: Delay time started
7922	BlPulS.	Supervision of blocking pulse

5.5 Differential current supervision – Block 13

5.5.1 Function description

The 7SS60 also allows to supervise the external transformer circuits. The supervision picks up when the threshold **13Id thr (1802)** is exceeded. This response comes with a delay after the protection function.

The differential current supervision function is available in block **13**. It has the task of detecting malfunctions during operation and blocking so that they do not jeopardize the stability of the system against external faults. This supervision function recognizes transformer failures, e.g. due to phase failures, and sends an alarm. The differential current supervision is able to block the protection if set before.

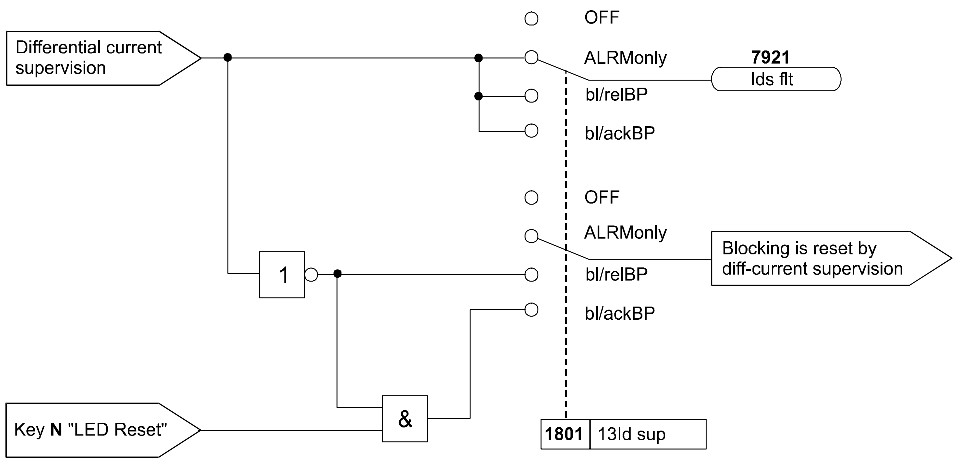


Figure 5-23 Release logic of the differential current supervision

5.5.2 Hints on setting

Differential current supervision

The parameter **13Id sup (1801)** is used to activate and deactivate the differential current supervision function. The following setting options are offered for the differential current supervision: blocking of the busbar protection till the automatic release by **Differential current supervision (bl/relBP)**, blocking till the acknowledgement by pressing the **Key N "LED Reset" (bl/ackBP)**, or only output an alarm **(ALRMonly)**. With **OFF** the function can be deactivated.

Pick-up threshold

In each measuring cycle, i.e. every 0.5 ms, it is checked whether the peak of the differential current exceeds the threshold **13Id thr (1802)** taking into consideration a hysteresis. In this case, the counter is increased by 1. Once the counter has reached a value of 5000, the differential current supervision picks up. If no threshold was exceeded, the counter is reset to zero.

5.5.3 Overview of parameters

DIGSI addr.	Parameter	Possible settings	Default setting	Explanation
1801	13Id Sup	bl/relBP bl/ackBP ALRMonly OFF	bl/relBP	Differential current supervision function
1802	13Id thr	0.10 I_{no}[1] to 1.00 I_{no}[1]	0.15 I_{no}[1]	Threshold of differential current supervision

1 I_{no}: normalized rated current; I_{no}=100 mA with a symmetrical rated current flowing on the primary side

5.5.4 Annunciations

FNo.	Text on LC display	Logical functions
7921	IdS Flt	IDIFF supervision: fault detected

5.6 Fault recording – Block 74

5.6.1 Function description

The 7SS601 protection system has a fault recording function that stores the instantaneous values of the differential and the restraint current in a buffer. This function is available in block **74**.

The instantaneous values of the measured quantities are sampled every 0.5 ms (50, 60 and 16.7 Hz).

In the event of a fault, the data are stored during a settable period. The available buffer has a recording capacity of 7.1 s.

Up to 8 fault events can be stored in this buffer. New fault events are always entered in the fault record buffer. Older records are overwritten by the new data.

The data can be read out to a personal computer via the serial interface, and processed using the DIGSI / SIGRA software. The measured values are prepared for a graphical display. In addition, signals are represented as binary traces, e.g. **Busbar protection: Trip** and **Lock Out state**.

Part of the fault recording memory in the 7SS601 is buffered against voltage failures. The buffered portion has a capacity of 2,5 s. It contains always the most recent fault events.

A fault event starts with tripping by a protection function and ends with the reset of the last tripping by a protection function. Fault records in the 7SS601 always cover this span of time (plus the pre-fault and the post-fault time).

5.6.2 Hints on setting

Times

The actual storage time starts with the pre-fault time **74 T-PRE (7411)** that precedes the reference point and ends when the post-fault time **74 T-POS (7412)** following the disappearance of the storage criterion has elapsed. The maximum permissible total storage time per fault record is set in **74 T-MAX (7410)**. A total of 7.1 s is available for fault recording.

5.6.3 Overview of parameters

DIGSI addr.	Parameter	Possible settings	Default setting	Explanation
7410	74-T MAX	0.20 s to 5.00 s	1.50 s	Maximum time period of a fault recording
7411	74 T-PRE	0.05 s to 1.50 s	0.30 s	Pre-trigger time for fault recording
7412	74 T-POS	0.05 s to 1.50 s	0.20 s	Post-fault time for fault recording

Control in Operation 6

This chapter deals with the control of the SIPROTEC 7SS60 system while it is in operation. It describes how to obtain information from the system, to set the date and time and to check the status of the binary inputs.

Detailed knowledge of the functioning of the system is not required. A prerequisite for control is, however, that the system settings have been made as described in Chapter 4, and especially that the input and output functions have been marshalled.

6.1 Read-out of information

General

The device provides the following information for local readout or for transmission to DIGSI:

- Operational annunciations
- Fault annunciations
- Measured values

The following section describes in detail how this information is called up, and explains the individual items of information.

6.1.1 Output of annunciations and measured values

Annunciations inform the user during operation of measured data, station data and of the status of the device itself. After a fault in the power system, they also provide an overview of important data concerning the fault and the device function, and are used to verify functional procedures during testing and commissioning.

No password is required for reading out events.

Annunciations generated in the device can reach the user in different ways:

- Indication by LEDs on the device front panel
- Activation of binary outputs (output relays) through the device terminals
- Display on a PC monitor through the serial link, using the DIGSI communication software
- Display on the LC display on the front panel

LEDs

The green LED labelled **Service/Betrieb** is continuously on during normal operation.

The red LED labelled **Blocked/Störung** shows that the processor system has detected an internal malfunction. If this LED lights during operation, the device is not operational. Chapter 8 tells you what to do in such a case.

The other LEDs on the front panel indicate the annunciations that have been marshalled to them, refer to Chapter 4.

Those LEDs indicating states will be lit for as long as the status applies.

If the LED indications are memorized (e.g. fault detection by protection system), the memory can be reset with the **N** key. This key is also used for a functional check of the LEDs. When it is pressed, all these LEDs must light up.

LEDs indicating a state are on for as long as the state lasts.

Output relays

Annunciations that have been marshalled to output relays (refer to chapter 4) are transmitted by means of a signal voltage. They are then available for a station control or telecontrol system.

Read-out using the DIGSI communication software

The procedure for reading out the operational and fault annunciation buffer and the measured values using the DIGSI communication software is described in the manual for the communication software.

Readout using the integrated keypad

From the initial state, the block **ANNUNC (5000)** is reached by pressing the ▼ key twice.

The password is not required.

The annunciations are grouped as follows:

- Operational annunciations **81 OPER. ANNUNC (8100)**
  These are annunciations that may be generated during operation of the device: information on device states etc.
- Fault annunciations **82 FAULT ANNUNC. (8200)**
  Here the annunciations of the last eight power system faults can be read out; fault detection, trip commands, chronological sequences etc. According to the definition, a power system fault begins with the first fault detection by a protection function and ends with the reset of the last fault detection.
- Measured values **84 MEAS. VALUES (8400)**
  Display of measured values: differential and restraint current

Note:

A complete list of all annunciation and output functions and their associated function numbers (FNo.) can be found in Appendix A.8.

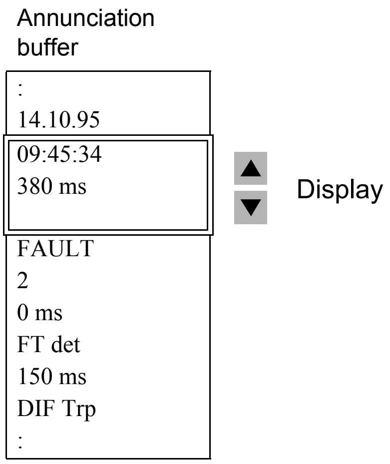
Pressing the ▶ key brings you to the next operation level, where you can call up successively all annunciation blocks using the ▼ and ▲ keys.

Operational annunciations Block 81

Operational annunciations are information that the device generates during operation and that concerns the operation. They are available in block 81. Important events and status changes are listed there in chronological order with the time of their occurrence. Up to 30 operational events are stored. If more events are issued, the oldest are overwritten.

You can move from block **81 OPER. ANNUNC (8100)** to the operational events buffer by pressing the ▶ key.

The events are stored in lists. After selecting the desired block, you can scroll the visible part of the list on the display up and down using the ▼ and ▲ keys, as shown in the following example.



Faults in the primary switchgear are indicated only with “Fault” and a consecutive fault number. Detailed information on the sequence of events during a fault is contained in the block **Fault annunciations**.

Fault annunciations Block 82

Here the annunciations of the last eight faults can be read out. These are sorted from the newest to the oldest in a subordinate level of block 82. When a ninth fault arrives, the system deletes the data of the oldest one. Each of the eight fault buffer can store up to 30 annunciations. If more events are issued, the oldest are overwritten.

As long as the date and time of the device have not been set, the date and time displayed are the relative date and time since the last startup of the processor system. Next, the fault events are displayed in the chronological order of their detection, with a relative time referred to the moment at which the fault started.

Pressing the ▶ key brings you from block **82 FAULT ANNUNC. (8200)** to the fault annunciations, where you can call up successively all fault annunciations using the ▼ and ▲ keys.

To move from the selected fault annunciation to the fault annunciation buffer, press the ▶ key.

Just like the operational annunciations, the fault annunciations are stored in lists. Use the ▼ and ▲ keys to scroll though the lists.

Measured values Block 84

Measured values for the differential and restraint current can be displayed in block 84. Values are shown in percent of the nominal values. A prerequisite for correct display is that the nominal data have been correctly set in block 00.

Pressing the ▶ key brings you from block **84 MEAS. VALUES (8400)** to the measured values, which can now be called up successively using the ▼ and ▲ keys.

The values are updated during the read-out. When scrolling within the block with the ▼ or ▲ key, the updated values are displayed.

6.2 Read out of the date and time

The relevant block is accessed from the initial state of the device. Pressing the ▼ key three times brings you to the block **ADDITION FUNCTION**. Move to the block **TIME SETTING** in the next operation level by pressing the ▶ key. Press the ▶ key again to shift to the level where the date and time can be read out.

The blocks for setting the date and time are called up by scrolling with ▼. This is described in subsection 4.2.5.

6.3 Testing the status of the binary inputs/outputs

The 7SS60 differential protection includes a testing program that allows to check and display the status of the binary inputs and outputs.

If the protection is operated from a personal computer using the DIGSI communication software, the test addresses are identified by a four-digit number. This number will be stated in brackets in the section below.

The block **ADDITION FUNCTION** is accessed from the initial state of the device by pressing three times the ▼ key. Press ▶ to move to the next operation level with the block **TIME SETTING**. Pressing the ▼ key brings you now to the block **TEST AIDS (4000)**.

Move one level higher with the ▶ key to access the block for testing the status of the inputs and outputs **I/O STAT (4100)**.

Testing the binary inputs

Press ▶ once again to move to the address for testing the status of the binary inputs **BI-STAT (4101)**.

After actuating the ENTER key **E** you are asked whether you want to interrogate the status of the binary inputs. If you press the **N** key, the action is aborted, and you can move to the next test item with ▼.

If you actuate **Y/J**, the status of the 3 binary inputs (BI) is shown as a matrix which has the following meaning:

1: BI 1 is activated (energized)
2: BI 2 is activated (energized)
3: BI 3 is activated (energized)
-: The BI is not activated

```
BI-STAT
1 2 -
```

In this example, the binary inputs 1 and 2 are activated, whereas binary input 3 is not energized.

Testing the signal and command relays

Press ▼ to move to the address for testing the status of the signal and command relays **RE-STAT (4102)**.

After actuating the ENTER key **E** you are asked whether you want to interrogate the status of the signal and command relays. If you press the **N** key, the action is aborted, and you can move to the next test item with ▼.

If you actuate **Y/J**, the status of the 2 signal relays (S) and of the 2 command relays (T) is shown as a matrix which has the following meaning:

1: S 1 or T 1 has picked up
2: S 2 or T 2 has picked up
-: The relay has not picked up

```
RE-STAT
S1-- T-2
```

In this example, the signal relay S 1 and the command relay T 2 have picked up.

Testing the LEDs

Press ▼ to move to the address for testing the status of the LEDs **LED STATUS (4103)**.

After actuating the ENTER key **E** you are asked whether you want to interrogate the status of the LEDs. If you press the **N** key, the action is aborted, and you can move to the next test item with▼.

If you actuate **Y/J**, the status of the 4 LEDs is shown as a matrix which has the following meaning:

1: LED 1 is activated
2: LED 2 is activated
3: LED 3 is activated
4: LED 4 is activated
-: The LED is not activated

```
LED STATUS
- 2 - 4
```

In this example, LED 2 and LED 4 are activated.

Installation and Commissioning 7

This section is primarily for personnel who are experienced in installing, testing, and commissioning protective and control systems, and are familiar with applicable safety rules, safety regulations, and the operation of the power system. Some modifications of the hardware to the station data may be necessary. For primary tests, the switchgear must be isolated to perform switching operations.

7.1 Installation and connection

Warning!

Trouble free and safe use of this SIPROTEC device depends on proper transport, storage, installation, and application of the device according to the warnings in this instruction manual.

Of particular importance are the general installation and safety regulations for work in a high-voltage environment (for example, ANSI, IEC, EN, DIN, or other national and international regulations.) These regulations must be observed. Failure to observe these precautions can result in death, personal injury, or severe damage of property.

Prerequisites

The rated data of the device have been checked as described in section 3.2.1, and their conformity with the station data has been verified. Please note also the prerequisites stated in section 9.4.

7.1.1 Measuring system

Panel flush mounting or cubicle mounting

- Slip away the covering caps at the top and bottom of the front panel, making accessible 4 elongated holes.
- Insert the unit into the panel cutout or cubicle mounting frame and fix with four screws (a dimension drawing is shown in Figure 9-1.
- A solid low-resistant and low-inductive operating earth has to be connected to the housing’s rear wall using at least one of the two M4 screws. Earth tapes according to DIN 72333 Form A are suitable for this.
- Make electrical connections via the screw terminals of the housing. Special attention has to paid to the designations of the connection modules, the permissible conductor cross-sections and tightening torque (refer also to chapter 2). Use copper conductors only!
- The shielding of the serial RS485 interface must be earthed.

Auxiliary voltage

Three different ranges of auxiliary voltage can be delivered (refer to chapter 9 and A.4). If, for exceptional reasons, the rated voltage of the supply input is to be changed to adapt it to the station conditions, it must be taken into account that the models for rated auxiliary voltage DC 60/110/125 V and DC 220/250 V differ from each other by different plug jumpers. The assignment of the jumpers to the rated voltage levels, and their location on the p.c.b., is shown in Figure A-5.
The model for DC 220/250 V is suitable for AC 115 V, too. When the device is delivered, all the jumpers are correctly located and matched to the specification given on the rating plate, so that normally none of them need to be altered.

Control voltage for binary inputs

When the device is delivered from the factory, the binary inputs are set to operate with a dc control voltage in the whole operating range between 17 V and 288 V. If the station control voltage has a higher rating (≥ DC 110 V), it may be useful to set a higher pick-up threshold of the binary inputs to increase the static signal-to-noise ratio. This helps to avoid spurious pick-up by interference voltages that may be caused e.g. by earth fault monitoring systems operating in parallel to the device.

To increase the pick-up threshold of a binary input to approx. 74 V, one jumper position per input must be changed. Figure A-5 shows the assignment of the jumpers to the binary inputs, and their location on the p.c.b.

- Slip away the covering caps at the top and bottom of the front panel, making accessible one screw each in the top and bottom center. Unscrew these two screws.

Warning!

Electrostatic discharges via the component connections, the p.c.b. tracks or the connecting pin must be avoided under all circumstances by previously touching an earthed metal surface.

- Pull out the module by taking it at the front cover and place it on a surface which is suited to electrostatically endangered components (EEC).
- Set the jumpers according to Figure A-5.
- Insert the module into the housing.
- Fix the module into the housing by tightening the two fixing screws.
- Re-insert the covers.

7.1.2 Peripheral modules

Panel flush mounting or cubicle mounting

- Slip away the covering caps at the top and bottom of the housing front, making accessible 4 elongated holes.
- Insert the unit into the panel cutout or cubicle mounting frame and fix with four screws (a dimension drawing is shown in Figure 9-2).
- Unscrew the screws next to the fixing screws to remove the front cover.
- A solid low-resistant and low-inductive operating earth has to be connected to the housing’s rear wall using at least one of the two M4 screws. Earth tapes according to DIN 72333 Form A are suitable for this.

The peripheral modules are selected in accordance with the station configuration, refer to section 4.1. It may be necessary to adapt the auxiliary voltage of the modules or the required contact (NC/NO contact) to the particular station conditions.

Warning!

Electrostatic discharges via the component connections, the p.c.b. tracks or the connecting pin must be avoided under all circumstances by previously touching an earthed metal surface.

Auxiliary voltage

Both the 7TM70 restraint/command output module and the 7TS720 command output module have three input voltage ranges for the auxiliary voltage: DC 48/60 V, DC 110/125 V and DC 220/250 V (refer to Chapter 9 and Appendix A.5). The voltage range can be selected by changing the jumper settings on the module. The assignment of the jumpers to the rated voltage levels, and their location on the p.c.b., is shown in figures A-6 and A-8. Before mounting the peripheral module, check whether the selected auxiliary voltage matches the substation conditions.

Relay contacts (NC/NO contacts)

On the 7TR71 preferential treatment/isolator replica module some of the relay contacts can be set either as NC or NO contacts. The relay contacts must be matched to the configurations. The assignment of the jumpers to the respective functions is shown in the block diagram A.3. The physical location of the jumpers on the p.c.b. is shown in Figure A-7.

- ❑ Insert the peripheral modules into their slots and secure them with a screw from the back of the housing. The slots are numbered and color-coded, refer to Figure 2-3.
- ❑ The peripheral modules are identified by a labelling strip on which the current configuration is stated. The configuration information should contain the designation of the peripheral modules in accordance with their mounting position, and their voltage ranges. Each peripheral module housing has a rating sticker that should be placed on the top of the housing after installing the peripheral modules.
- ❑ Make electrical connections via the screw-type connection modules. Special attention has to paid to the designations of the connection modules, the permissible conductor cross-sections and tightening torques (refer also to chapter 2). Use copper conductors only!

Note:

As the plug-on connectors and pins of the different peripheral modules are not coded, the plug-on connectors must be marked to make their allocation to the appropriate pin connectors on the peripheral modules possible. The marking system for this is shown in Figure 2-2. The marking should contain the following information:

- Number of the peripheral module housing
- Slot identification (A, B, C, D) of the module
- Top connector (X1) or bottom connector (X2)
- Terminals on the connector (1-10, 11-20, 21-30, 31-40)

- ❑ Replace the front cover on the housing.
- ❑ Re-insert the covers.

7.2 Commissioning

Warning!

Hazardous voltages are present in this electrical equipment during operation. Non–observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

Particular attention must be drawn to the following:

- The earthing screw of the device must be connected solidly to the protective earth conductor before any other electrical connection is made.
- Hazardous voltages can be present on all circuits and components connected to the supply voltage or to the measuring and test quantities.
- Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).
- After switching of the auxiliary voltage, 10 s should be allowed to elapse before switching the auxiliary voltage on again, in order to ensure defined start-up conditions.

The limit values stated in chapter 9.1 must not be exceeded at all, not even during testing and commissioning.

When performing tests with secondary test equipment, attention must be paid that no other measuring values are applied and that the trip command lines to the circuit breakers are interrupted, unless explicitly stated otherwise.

DANGER!

The CT secondary terminals must be short-circuited on the CTs before the current supply conductors to the device are interrupted!

Where a testing switch is provided which short-circuits the CT secondary lines automatically, it is sufficient to set it to “Test” position, provided that the short-circuiters have been checked previously.

The commissioning procedure requires to perform switching operations. The tests described assume that they can be performed safely. Therefore, they are not suited for checks during operation.

Warning!

Primary test may only be carried out by qualified personnel, who are familiar with the commissioning of protection systems, the operation of the plant and the safety rules and regulations (switching, earthing, etc.).

7.2.1 Checking the connection circuit

The busbar protection is delivered in individual components. The configuration, wiring and testing of the system has to be made specifically to match the station conditions.

Note:

The wiring of the relays on the individual peripheral modules depends on the polarity. Therefore, the wiring must be checked against the block circuit diagrams in Appendix A.3.

In particular, it is recommended to check by a continuity test the status of the connecting leads to the current transformers, to the input or summation current and matching transformers (where required, if the modules are installed outside the cubicle or cubicles), and to the station battery, the circuit breakers, the isolator auxiliary contacts and any connected signalling equipment. The applicable plans for the power system must be observed.

7.2.1.1 Infeed circuits of the protection

Before switching on the station battery, the correctness of the rated voltages and of the polarity must be checked.

Trip circuits

❑ Check the trip circuits for controlling the circuit breakers. Where service conditions do not allow to trip a circuit breaker, you can proceed e.g. by switching off the breaker control voltage and checking the trip function as far as the circuit breaker coil.

Isolator status feedback signals

❑ Check that isolator states are correctly detected. To do so, perform an isolator switching operation and check the feedback signal in OPEN position. If there is no checkback signal (because of wire break or auxiliary power outage), the isolator is assumed to be CLOSED, so that instabilities of the measuring system when a current flows are efficiently counteracted.

Isolator replica

❑ Check the correct allocation of the feeder currents to the measuring system (isolator replica) using load currents or secondary test equipment.

Current transformer circuits

In this context, it must be checked that the busbar protection is “normalized”, i.e. that it provides a uniform transformation ratio in all output circuits. Where current transformers have different transformation ratios, the primary rated current is set to a value between 70 and 100% of the rated maximum primary current of the existing current transformers by means of suitable matching or summation current matching transformers.

For the check of the connection circuits, the currents that are fed by the CTs onto the protection are short-circuited at the terminals of the protection. They are proportional to the respective primary-side currents. The equivalent of the normalized primary rated on the secondary side of the matching or summation current transformers is a current of 100 mA. The correct current ratio must be checked by measurements in each feeder or coupler bay with a primary current that should be at least 20 % of the normalized rated current.

In models with a summation current transformer input, this measurement does not check that the summation current transformer winding that lies in the residual current path is correctly connected. With a symmetrical current and if all devices are correctly connected, the residual current flowing in the neutral conductor is practically zero, so that an interruption or polarity reversal in that circuit is not detected.

Feeders which do not carry a sufficient load current should instead be checked with primary testing equipment.

DANGER!

Manipulations on the measuring current transformers must be performed with the utmost precaution! Short-circuit the current transformers before disconnecting any current supply leads to the device!

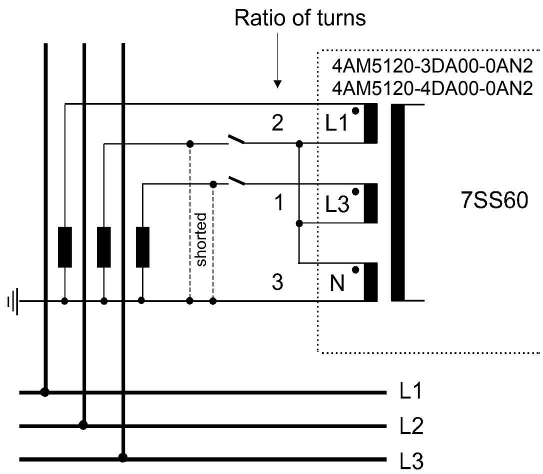


Figure 7-1 Short-circuiting the current transformers

To allow an electrical check of this circuit as well, an artificial asymmetry of the connections is created. This is achieved by short-circuiting in the tested bay successively the secondary windings of either the main current transformers or of the matching transformers in phases L2 and L3, and by disconnecting their outgoing leads, so that the current L1 flows only through the primary winding of L1 and the winding N in the zero current path of the summation current transformers.

In this circuit, the rated current on the primary side of the main current transformer corresponds to a current of approx. 300 mA on the secondary side of the summation current transformer. If the N-winding were connected with reversed polarity, the rated primary current would yield only approx. 60 mA instead of approx. 300 mA. The correct connection of the input windings of the summation current transformers can also be checked by verifying, either visually or with a continuity test, the external connection circuit and then injecting a suitable current, e.g. 1 A or 5 A, directly into the series-connected winding of the L1 and the summation current path. This allows to perform the test without a primary load.

7.2.2 Check of the complete protection system with operating currents

7.2.2.1 Directional check of the input currents

When checking the connection circuits, one prerequisite for a correct comparison of the currents of all feeders was a uniform (normalized) transformation ratio between the primary currents from the main current transformers and the secondary currents from the summation current transformers or matching transformers, which were the basis for the measurement.

Once this prerequisite is fulfilled, the currents must be fed into the protection circuit in the same direction, so that in fault-free load operation of the station the differential current paths of the measuring systems do not carry any currents with wrong polarity which might lead to overfunctioning. Therefore, it must be possible to reverse the polarity of the secondary currents from the summation current and input transformers to match it to the downstream measurement setup.

The directional check of the feeder currents should be performed with operational load currents from the station, with the tripping lines of the busbar protection interrupted or the TRIP command blocked.

Reliable measurements are performed with 20 % of the normalized rated current in each feeder. This can usually be achieved with load current if the power system is switched accordingly.

Where this is not possible, it is recommended to feed into the busbar from any feeder a testing current that is sufficiently high for a reliable measurement. In that case a three-pole short-circuit is generated successively into each feeder outside the differential protection zone during the test.

The subsequent measuring procedure comprises the measuring system of one busbar only. If the system has several busbar sections with one measuring system allocated to each section, any of these will be selected for starting.

The differential and restraint currents can be output on the display for evaluation. In all tests, the differential currents may differ from zero only by a few percent (approx. 3 to 5 %).

Maintenance and Troubleshooting 8

This chapter describes the maintenance procedures that are necessary and recommended to ensure the continuous reliability of the SIPROTEC 7SS60 protection system. It tells you which components should be checked and/or replaced on a routine basis and what to do in case of malfunctions of the device. The chapter is intended both for personnel in charge of operation and for protection engineers.

8.1 General

7SS601 measuring system

The 7SS601 measuring system requires no special maintenance.

As the 7SS601 measuring system is almost completely self-monitored, hardware and software faults are automatically annunciated. This ensures the high availability of the system.

With detected hardware faults the system blocks itself; drop-off of the “Device ready” NC relay signals the equipment fault. Faults that are detected in external connection circuits lead only to the output of an annunciation or to a blocking, depending on the parameter setting.

Recognized software errors cause the processor to reset and restart. If such a fault is not eliminated by restarting, further restarts are initiated. If the fault is still present after three restart attempts, the protective system will switch itself out of service and indication this condition by the red LED **Blocked/Störung** on the front panel; drop-off of the “Device ready” NC relay signals the equipment fault.

The reactions to faults can be called up in chronological sequence as operational annunciations for fault diagnosis (refer to Section 6.1).

Peripheral modules

The current transformer circuits are permanently monitored by the differential current supervision, which can be set to high sensitivity. Faults in the current transformer circuit are detected under the condition that the feeder current is at least 10 % of the normalized rated current I_{no} (rated current of the transformer with the highest transformation ratio).

8.2 Routine checks

Routine checks of characteristics or pick-up values are not necessary as they are part of the continuously supervised firmware programs. The planned maintenance intervals for checking and maintenance of the plant can be used to perform operational tests of the protection equipment. This maintenance serves mainly for checking the interfaces of the unit, i.e. the coupling with the plant.

The following procedure is recommended. If the result of one or more of the above steps suggests that there is a fault, please proceed as described in chapter 8.4.

8.2.1 7SS601 measuring system

- ❑ Check that the green LED **Service/Betrieb** on the front panel of the 7SS601 measuring system is on and that the red LED **Blocked/Störung** is off.
- ❑ Check whether the LED indications on the front panel show a plausible current status of the measuring system and the station.
- ❑ Press the **N** key. All LEDs (with the exception of the red LED **Blocked/Störung**) light up.
- ❑ Read out the measured values (refer to Section 6.1). The differential current must be low, and the restraint current must be equal to the summated amounts of the currents of all feeders that are connected to the measuring system.
- ❑ Read out the operational annunciations (refer to Section 6.1). Check that they do not contain any entries on faults in the system, in the measured values, or any other kind of implausible information.

8.2.2 Peripheral modules

Trip circuits

- ❑ Check the trip circuits for controlling the circuit breakers. Where service conditions do not allow to trip a circuit breaker, you can proceed e.g. by switching off the breaker control voltage and checking the trip function as far as the circuit breaker coil.

Isolator status feedback signals

- ❑ Check that isolator states are correctly detected. To do so, perform an isolator switching operation and check the feedback signal in OPEN position. If there is no checkback signal (because of wire break or auxiliary power outage), the isolator is assumed to be CLOSED, so that instabilities of the measuring system when a current flows are efficiently counteracted.

Isolator replica

- ❑ Check the correct allocation of the feeder currents to the measuring system (isolator replica) using load currents or secondary test equipment.

Current transformer circuits

The transformer currents of feeders which do not carry a sufficient load current should instead be checked with primary testing equipment.

8.3 Troubleshooting

8.3.1 7SS601 measuring system

If the device indicates a defect, the following procedure is recommended:

If none of the LEDs on the front panel of the device is on, then check:

- Has the module been properly pushed in and locked?
- Is the auxiliary voltage available with the correct polarity and of adequate magnitude, connected to the correct terminals (block circuit diagrams are given in Appendix A.2 and A.3)?
- Has the mini-fuse in the power supply section blown? If required, replace the mini-fuse according to the section “Replacing the mini-fuse” below.

If the red fault indicator LED is on and the green ready LED remains dark, re-initialization could be tried by switching the auxiliary voltage off and on again.

This, however, results in loss of parameter settings in a parameterizing process has not yet been completed. Additionally, date and time must be set again (refer to chapter 4.2.5).

Replacing the mini-fuse

- Select a replacement fuse 5 x 20 mm (refer to Section A.4). Ensure that the rated value, time lag (slow) and code letters are correct.
- Prepare the area of work: provide a conductive surface for the module.
- Slip away the covering caps at the top and bottom of the housing, making accessible one screw each in the top and bottom center. Unscrew these two screws.

Warning!

Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).

- Pull out the module by taking it at the front panel and place it on the conductive surface.

Warning!

Electrostatic discharges via the component connections, the p.c.b. tracks or the connecting pin must be avoided under all circumstances by previously touching an earthed metal surface.

- Remove the blown fuse from the holder.
- Fit the new fuse into the holder.
- Insert the module in the housing.
- Fix the module in the housing by tightening the two fixing screws.

Switch the device on again. If a power supply failure is still signalled, a fault or short-circuit is present in the internal power supply. The device should be returned to the factory (refer to chapter 8.4).

8.3.2 Peripheral modules

A general detailed testing specification cannot be given.

Please observe the plans for the switchgear and the block diagrams of the peripheral modules given in Appendix A.3.

8.4 Repair/Return

It is recommended to refrain strictly from repairing units or modules, because they contain especially selected components, which must be handled according to the regulations for EED (**e**lectrostatic **e**ndangered **d**evices). In the first place, special techniques are required for working with the printed circuit boards, so that the flow-soldered boards and sensitive components are not damaged.

Therefore, if a defect cannot be eliminated by the operations described in chapter 6, it is recommended to send the complete device or individual peripheral modules back to the manufacturer. Use the original transport packaging for return. If alternative packaging is used, this must provide the degree of protection against mechanical shock as laid down in IEC 255-21-1 Class 2 and IEC 255-21-2 Class 1.

Note:

Before returning the device, all configuration and setting parameters should be read out and stored. If the location of jumpers on the p.c.b.s has been changed, the changed setting should be noted as well.

When a device is returned to you after a successful repair, all jumpers on the p.c.b. are in the initial state defined by the ordering code (MLFB). The configuration and setting parameters are also reset to the initial delivery state.

In case it is unavoidable to replace single modules, the EED-regulations have to be followed (handling of **e**lectrostatic **e**ndangered **d**evices).

Before you extract the peripheral modules from the housing, pull off the plug-on connectors and unscrew the securing screw on the rear.

Warning!

Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).

Caution!

Electrostatic discharges via the component connections, the p.c.b. tracks or the connecting pin must be avoided under all circumstances by previously touching an earthed metal surface. This applies equally for the replacement of removable components, such as EPROM or EEPROM chips. For transport and returning of individual modules, electrostatic protective packing material must be used.

Modules fitted in the unit are not endangered.

Technical Data 9

This chapter describes the technical specifications of the SIPROTEC 7SS60 protection system and of its functions, including limits that may on no account be exceeded. The electrical and functional data for the maximum scope of functions are followed by the mechanical data and the dimension drawings.

9.1 General data

9.1.1 7SS601 measuring system

Measuring input I_d	Rated current	100 mA
	Rated frequency	50/60 Hz can be set, 16.7 Hz
	Dynamic overload capability (pulse current)	250 x I_N one half cycle
	Thermal overload capability (rms) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous
	Isolating voltage	2.5 kV (rms)
	Measuring range for operational measured values	0 to 240 %
	Measuring dynamics	100 x I_N without offset 50 x I_N with full offset
Measuring input I_R	Rated current	1.9 mA
	Dynamic overload capability (pulse current)	250 x I_N for 10 ms
	Thermal overload capability (rms) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous
	Isolating voltage	2.5 kV (rms)
	Measuring dynamics	0 to 200 x I_N
Auxiliary voltage	via integrated dc/dc converter Rated auxiliary voltage U_H (permissible variations)	DC 24/48 V (DC 19 to 58 V) DC 60/110/125 V (DC 48 to 150 V) DC 220/250 V (DC 176 to 300 V) AC 115 V (AC 92 V to 133 V)
	Superimposed ac voltage peak to peak	≤ 15 % of rated voltage
	Power consumption quiescent energized	 approx. 3 W approx. 5 W
	Bridging time during failure/short-circuit of auxiliary voltage	≥ 50 ms at U_H ≥ DC 100 V ≥ 20 ms at U_H ≥ DC 48 V

Binary inputs	Number	3 (can be marshalled)
	Operating voltage range	DC 24 to 250 V
	Current consumption when energized	approx. 2.5 mA independent of operating voltage can be changed by setting jumpers
	Pick-up threshold rated aux. voltage DC 48/60 V $U_{pick-up}$ $U_{drop-off}$ rated aux. voltage DC 110/125/220/250 V $U_{pick-up}$ $U_{drop-off}$	 ≥ DC 17 V < DC 8 V ≥ DC 74 V < DC 45 V
	max. voltage	DC 300 V
	Binary input **interlocking pulse** Interlocking duration protection	 approx. 40 ms
Command contacts	Number of relays	1 (2 NO contacts) 1 (1 NO contact)
	Switching capacity MAKE BREAK	 1000 W/VA 30 W/VA
	Switching voltage	AC/DC 250 V
	permissible current continuous 0.5 s	 5 A 30 A
Signal contacts	Number of relays	3 (2 can be marshalled)
	Contacts	2 changeover contacts and 1 NO contact (can be changed to NC by jumper)
	Switching capacity MAKE BREAK	 1000 W/VA 30 W/VA
	Switching voltage	AC/DC 250 V
	permissible current continuous 0.5 s	 5 A 30 A
Serial interface		isolated
	Standard	RS485
	Test voltage	DC 3.5 kV
	Connection	data cable at housing terminals, 2 data lines, for connection of a personal computer or similar. Cables must be screened, and screen must be earthed.
	Transmission rate	as delivered 9 600 Baud min. 1 200 Baud, max. 19 200 Baud

Housing	Housing	7XP20, $^1/_6$ 19"
	Dimensions	see Figure 9-1
	Weight	approx. 4.0 kg
	Degree of protection according to IEC 60529-1 for the device for operator protection	 IP 51 IP 2X
Differential current protection	Setting ranges for pick-up threshold Differential current I_d> Restraint factor	 0.20 to 2.50 I_{no} 0.25 to 0.80
	Tolerance of pick-up value Differential current I_d>	 ± 5 % of setpoint
	Times Minimum fault detection time 50/60 Hz [1)] Typical fault detection time 50/60 Hz [1)] Minimum fault detection time 16.7 Hz [1)] Typical fault detection time 16.7 Hz [1)]	 10 ms 12 ms (rapid measurement) 40 ms (repeated measurement) 12 ms 14 ms (rapid measurement) 40 ms (repeated measurement)
	Reset time [2)]	28 ms at 50 Hz 26 ms at 60 Hz 70 ms at 16.7 Hz
	Minimum duration of trip command	0.01 to 32.00 s (in steps of 0.01s)
	Time delay of trip	0.00 to 10.00 s (in steps of 0.01s)
	Differential current supervision Pick-up threshold	 0.10 to 1.00 I_{no}
	[1)] each additional intermediate relay increases the tripping time by 7 ms [2)] each additional intermediate relay increases the reset time by 8 ms	
Lockout function	Maintain TRIP command	until reset
	Reset	by binary input and/or local operator panel

Additional functions	Operation measured values	
	Operating currents	I_{DIFF}, I_{STAB}
	Measuring range	0 to 240 % I_{no}
	Tolerance	5 % of rated value
	Fault logging	buffered storage of the annunciations of the last 8 faults
	Time stamping	
	Resolution for operational annunc.	1 ms
	Resolution for fault annunc.	1 ms
	Fault recording (max. 8 faults)	buffered against voltage failure (last 2.5 s)
	Recording time (from fault detection)	max. 7.1 s total pre-fault and post-fault time can be set
	max. length per record	0.2 to 5.0 s (in steps of 0.01 s)
	Pre-fault time	0.05 to 1.5 s (in steps of 0.01 s)
	Post-fault time	0.05 to 1.5 s (in steps of 0.01 s)
	Sampling frequency	2 kHz

9.1.2 Peripheral modules

9.1.2.1 7TM700 restraint/command output module

Measuring input I_s	Number of restraint units	5
	Rated current	100 mA
	Rated frequency	16.7 Hz, 50 Hz, 60 Hz
	Dynamic overload capability (pulse current)	250 x I_N one half cycle
	Thermal overload capability (rms) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous
Auxiliary voltage	Rated auxiliary voltage U_H (permitted voltage range)	DC 48/60 V (DC 38 to 72 V) DC 110/125 V (DC 88 to 150 V) DC 220/250 V (DC 176 to 300 V) settable, see Figure A-5 As delivered: DC 220/250 V
Command contacts	Number of relays	5
	Contacts per relay	2 NO contacts
	for short-term operation < 10 s [1)]	
	Pickup time	approx. 7 ms
	Switching capacity MAKE BREAK	 1000 W/VA 30 W/VA
	Switching voltage	AC/DC 250 V
	Permissible currents continuous 0.5 s	 5 A 30 A
Weight		approx. 2.0 kg

[1)] limited by the continuous power dissipation of the device

9.1.2.2 7TR710 isolator replica module/preferential treatment module

Note:

The functions isolator replica or preferential treatment are alternatively available.

Isolator replica	Number of feeders (double busbar)	1
	Number of isolators (per 1 auxiliary contact) per feeder	2
Preferential treatment	Number of preferential treatment circuits	2
	Number of contacts per pref. treatm.	3 changeover contacts
	Switching time	< 20 ms
	Number of auxiliary relays	1
	Contacts of auxiliary relay	2 changeover contacts
Auxiliary voltage	Rated auxiliary voltage U_H (permissible voltage range)	DC 48/60 V (DC 38 to 72 V) DC 110/125 V (DC 88 to 150 V) DC 220/250 V (DC 176 to 300 V) depending on the ordering number, see Chapter A.1
Relay contacts	Switching capacity MAKE BREAK	 1000 W/VA 30 W/VA
	Switching voltage	AC/DC 250 V
	Permissible current continuous 0.5 s	 5 A 10 A
Weight		approx. 0.6 kg

9.1.2.3 7TS720 command output module

Auxiliary voltage	Rated auxiliary voltageU_H (permissible voltage range)	DC 48/60 V (DC 38 to 72 V) DC 110/125 V (DC 88 to 150 V) DC 220/250 V (DC 176 to 300 V) settable, see Figure A-8 as delivered: DC 220/250 V
Command contacts	Number of relays	8
	Contacts per relay	2 NO contacts
	for short-term operation < 10 s [1)]	
	Pickup time	approx. 7 ms
	Switching capacity MAKE BREAK	 1000 W/VA 30 W/VA
	Switching voltage	AC/DC 250 V
	permissible current continuous 0.5 s	 5 A 30 A
Weight		approx. 0.5 kg

[1)] limited by the continuous power dissipation of the device

9.1.3 Peripheral module housing

Design	Housing	7XP204 $^1/_2$ 19"
	Dimensions	see Figure 9-2
	Weight	approx. 3.5 kg
	Degree of protection according to IEC 60529-1 for the device for operator protection	 IP 51 (front) IP 20 (rear) IP 2X (if all connectors and blanking plates are fitted)

9.1.4 Matching transformers 1 A/100 mA, 5 A/100 mA

4AM5120-1DA00-0AN2
for connection to current transformers with a **rated current I_N** of **1 A**

Rated frequency f_N 45-60 Hz

Winding		A-B	B-C	D-E	E-F	G-H	H-J	Y-Z
Number of turns		1	2	4	8	16	32	500
Max. current, continuous	A	6.8	6.8	6.8	6.8	6.8	6.8	0.85
Max. voltage	V	0.4	0.8	1.6	3.2	6.4	12.8	200
Max. burden	VA	1.0						

4AM5120-2DA00-0AN2
for connection to current transformers with a **rated current I_N** of **5 A**

Rated frequency f_N 45-60 Hz

Winding		A-B	B-C	D-E	E-F	Y-Z
Number of turns		1	2	4	8	500
Max. current, continuous	A	26	26	26	26	0,85
Max. voltage	V	0.4	0.8	1.6	3.2	200
Max. burden	VA	1.2				

Weight	approx. 3.7 kg

9.1.5 Summation current matching transformer 1 A/100 mA, 5 A/100 mA

4AM5120-3DA00-0AN2
for connection to current transformers with a **rated current I_N** of **1 A**

Rated frequency f_N 45-60 Hz

Winding		A-B	C-D	E-F	G-H	J-K	L-M	N-O	Y-Z
Number of turns		3	6	9	18	24	36	90	500
Max. current, continuous	A	4	4	4	4	4	4	2	0.85
Max. voltage	V	1.2	2.4	3.6	7.2	9.6	14.4	36	200
Max. burden	VA	1.8							

4AM5120-4DA00-0AN2
for connection to current transformers with a **rated current I_N** of **5 A**

Rated frequency f_N 45-60 Hz

Winding		A-B	C-D	E-F	G-H	J-K	L-M	N-O	Y-Z
Number of turns		1	2	3	4	6	8	12	500
Max. current, continuous	A	17.5	17.5	17.5	17.5	17.5	17.5	8.0	0.85
Max. voltage	V	0.4	0.8	1.2	1.6	2.4	3.2	4.8	200
Max. burden	VA	2.5							

Weight	approx. 3.7 kg

9.1.6 Matching transformer

4AM5272-3AA00-0AN2
Multi-Tap auxiliary current transformer to match different current transformation ratios

Rated frequency f_N 45-60 Hz

Winding		A-B	C-D	E-F	G-H	J-K	L-M	N-O	P-Q
Number of turns		1	2	7	16	1	2	7	16
Max. current, continuous	A	6	6	6	1,2	6	6	6	1,2
Max. voltage	V	4	8	28	64	4	8	28	64
Resistance	Ω	0.018	0.035	0.11	1.05	0.018	0.035	0.11	1.05
Max. burden	VA	2.0							

9.2 Electrical tests

CE conformity, regulations	This product complies with the directive of the Council of the European Communities on the approximation of the laws of the member states relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within certain voltage limits (Low-voltage Directive 73/23/EEC). The product conforms with international standards of series IEC 60255 and the German standard DIN 57 435 /Part 303. This product was developed and manufactured for utilization in industrial installations according to the EMC standards.	This conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 50081 and EN 50082 for EMC directive, and with the standards EN 60255-6 for the low-voltage directive.
Insulation tests Standards: IEC 60255-5; ANSI/IEEE C37.90.0	High voltage test (routine test), measuring input I_d and relay outputs	2.5 kV (rms); 50 Hz
	High voltage test (routine test), auxiliary voltage input and RS485 interface, binary inputs and measuring input I_R	DC 3.5 kV
	Impulse voltage test (type test), all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative pulses in intervals of 5 s
EMC tests against radio disturbances (type tests) IEC 60255-6, IEC 60255-22 (international product standards) EN 50082-2 (technical generic standard) DIN VDE 57435 part 303 (German product standard for protection devices)	High-frequency test IEC 60255-22-1, DIN VDE 0435 part 303; class III	2.5 kV (peak); 1 MHz; t = 15 µs; 400 pulses per s; test duration 2 s
	Discharge of static electricity IEC 60255-22-2; IEC 61000-4-2; Klasse IV	8 kV discharge of contacts; 15 kV discharge into air; both polarities; 150 pF; R_I = 330 Ω
	Exposure to HF field, non-modulated IEC 60255-22-3 (report); class III	10 V/m; 27 to 500 MHz
	Exposure to HF field, amplitude-modulated IEC 61000-4-3; class III	10 V/m; 80 to 1 000 MHz; 80 % AM; 1 kHz
	Exposure to HF field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m; 900 MHz; repetition frequency 200 Hz; ED 50 %
	Fast transient disturbance / burst IEC 60255-22-4; IEC 61000-4-4; class III	4 kHz; 5/50 ns; 5 kHz, burst duration = 15 ms; repetition rate 300 ms; both polarities; R_I = 50 Ω; test duration 1 min

	High-energy pulse (SURGE), IEC 61000-4-5, installation class 3	Auxiliary voltage Longitudinal test 2 kV; 12 Ω; 9 μF Transversal test 1 kV; 2 Ω; 18 μF Measuring inputs, binary inputs and relay outputs: Longitudinal test: 2 kV; 42 Ω; 0.5 μF Transversal test: 1 kV; 42 Ω; 0.5 μF
	HF on lines, amplitude-modulated IEC 61000-4-6; class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
	Power system-frequency magnetic field IEC 61000-4-8; class IV IEC 60255-6	30 A/m; continuous; 300 A/m for 3 s; 50 Hz; 0.5 mT
Further EMC tests against radio disturbances (type tests)	Oscillatory Surge Withstand Capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz; damped wave; 50 pulses per s; duration 2 s; R_i = 150 to 200 Ω
	Fast Transient Surge Withstand Capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 pulses per s; both polarities; duration 2 s; R_i = 80 Ω
	Radiated Electromagnetic Interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
	Damped oscillations IEC 61000-4-12 IEC 60694	2.5 kV (peak, alternating polarity); 100 kHz; 1, 10 and 50 MHz; damped wave; R_i = 50 Ω
EMC tests for radio transmission EN 50081-* (technical generic standard)	Radio disturbance voltage on lines, only auxiliary voltage, EN 55022, DIN VDE 0878 part 22, IEC CISPR 22	150 kHz to 30 MHz, limit value class B
	Disturbance field intensity EN 55011, DIN VDE 0875 part 11, IEC CISPR 11	30 to 1 000 MHz, limit value class A

9.3 Mechanical tests

Vibration and shock during operation IEC 60255-21-1 IEC 60068-2	Vibration IEC 60255-21-1, class II IEC 60068-2-6	sinusoidal 10 to 60 Hz, ±0.075 mm amplitude 60 to 150 Hz; 1 g acceleration sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
	Shock IEC 60255-21-2, class I IEC 60068–2–27	half sinusoidal acceleration 5 g; duration 11 ms 3 shocks in each direction of the 3 orthogonal axes
	Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	sinusoidal
	horizontal axis	1 to 8 Hz: ±3.5 mm amplitude 8 to 35 Hz: 1 g acceleration
	vertical axis	1 to 8 Hz: ±1.5 mm amplitude 8 to 35 Hz: 0.5 g acceleration
		frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
Vibration and shock during transport IEC 60255-21 IEC 60068-2	Vibration IEC 60255-21-1, class II IEC 60068-2-6	sinusoidal 5 to 8 Hz: ±7.5 mm Amplitude 8 to 150 Hz: 2 g acceleration sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
	Shock IEC 60255-21-2, class 1 IEC 60068-2-27	half sinusoidal acceleration 15 g; duration 11 ms 3 shocks in each direction of the 3 orthogonal axes
	Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	half sinusoidal acceleration 10 g; duration 16 ms 1000 shocks in each direction of the 3 orthogonal axes

9.4 Climatic stress test

Climatic stress test EN 60255-6 IEC 60255-6	Permissible ambient temperature in service	 -20 to +45 °C
	for storage	-25 to +55 °C
	during transport	-25 to +70 °C
	Storage and transport with standards works packing	
	Humidity in service	mean value per year ≤ 75 % relative humidity, on 56 days per year 95 % relative humidity; condensation not permissible!

We recommend to install the devices so that they are not subject to direct sunlight and strong fluctuations in temperature which could lead to moisture condensation.

9.5 Service conditions

The relay is designed for use in industrial environment, for installation in standard relay rooms and compartments so that with proper installation electro-magnetic compatibility (EMC) is ensured. the following should also be heeded:

- All contactors and relays which operate in the same cubicle or on the same relay panel as the digital protection equipment should, as a rule, be fitted with suitable spike quenching elements.
- All external connection leads in substations from 100 kV upwards should be screened with a screen capable of carrying power currents and earthed at both sides. No special measures are normally necessary for substations of lower voltages.
- It is not permissible to withdraw or insert individual modules under voltage. In the withdrawn condition., some components are electrostatically endangered; during handling the standards for electrostatically endangered components must be observed. The modules are not endangered when plugged in.

Warning!

The device is not designed for used in residential environment as defined in EN 50081.

9.6 Dimensions

Measuring system

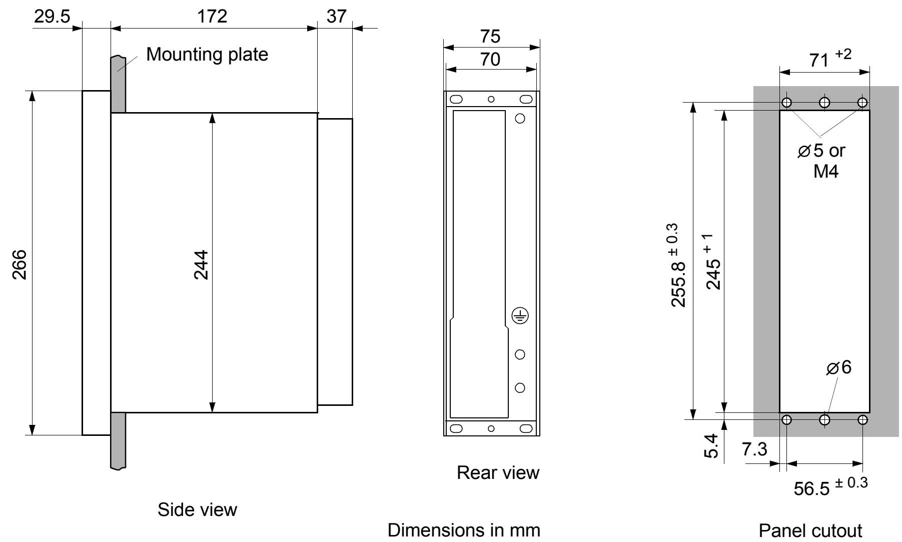


Figure 9-1 Housing 7XP20 of the 7SS601 measuring system for panel or cubicle flush mounting

Peripheral module housing

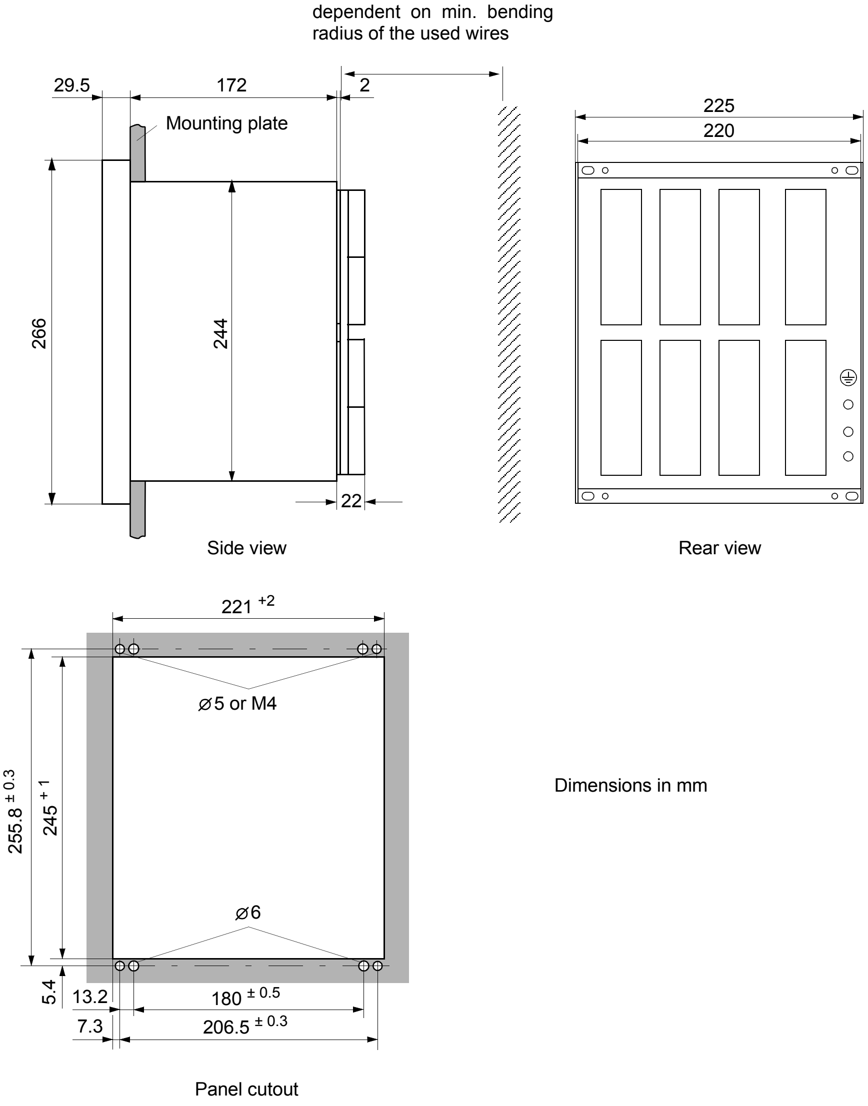


Figure 9-2 Housing 7XP204 of the peripheral modules for panel or cubicle flush mounting

Matching transformer / Summation current matching transformer 4AM5120

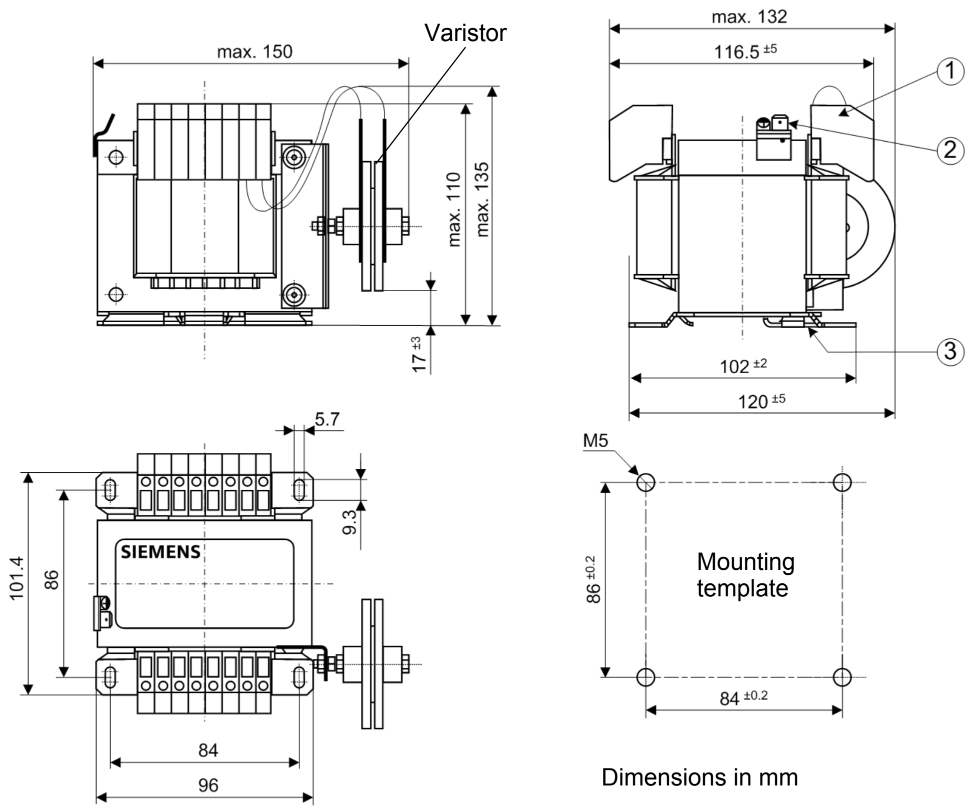


Figure 9-3 Matching transformer and summation current matching transformer 4AM5120

1 Terminal 8WA9200 Siemens
Cross-section: Single-wire 0.5 mm^2 to 6 mm^2
Fine-wire 0.5 mm^2 to 4 mm^2
Current rating: 21 A
Number of terminals depending on design

2 Flat connector DIN46244-A6.3-0.8, Protective-grounding terminal

3 Fixing racket for DIN rail mounting

Matching transformer 4AM5272

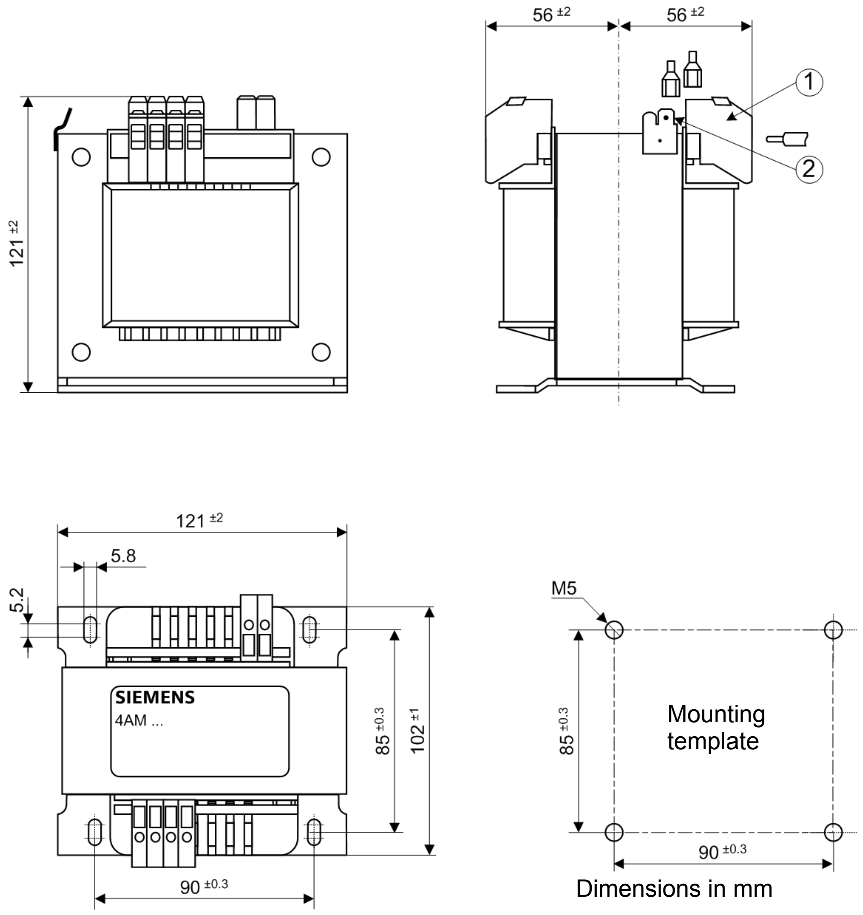


Figure 9-4 Matching transformer 4AM5272

1 Terminal
Cross-section: Single-wire 0.5 mm^2 to 6 mm^2
Fine-wire 0.5 mm^2 to 4 mm^2

2 Flat connector DIN46244-A6.3-0.8, Protective-grounding terminal

Appendix

A

This appendix is mainly a reference for experienced users. It contains ordering information, general diagrams and connection diagrams, and tabular listings of all settings and system data for the full scope of device functions.

A.1 Ordering data and accessories

Table A-1 Selection and ordering data

	Order No.												
Measuring system	**7SS601**	**❑**	**–**	**❑**	**❑**	**A**	**❑**	**0**	**–**	**0**	**A**	**A**	**0**
Rated current/frequency													
100 mA, AC 50, 60 Hz		**0**											
100 mA, AC 16.7 Hz		**6**											
Rated auxiliary voltage of converter													
DC 24 V to DC 48 V				**2**									
DC 60 V to DC 125 V				**4**									
DC 220 V to DC 250 V, AC 115 V				**5**									
Mechanical design													
In 7XP20 1/6 19" housing, for panel or cubicle flush mounting					**E**								
Measuring system													
Standard measuring system							**0**						

	Order No.												
Restraint/ command output module	**7TM700**	**0**	**–**	**0**	**A**	**A**	**0**	**0**	**–**	**0**	**A**	**A**	**0**
Rated auxiliary voltage													
DC 48 V, DC 60 V / DC 110 V, DC 125 V / DC 220 V, DC 250 V settable													

	Order No.												
Preferential treatment/ Isolator replica module	**7TR710**	**0**	**–**	**❑**	**A**	**A**	**0**	**0**	**–**	**0**	**A**	**A**	**0**
Rated auxiliary voltage													
DC 48 V to DC 60 V				**3**									
DC 110 V to DC 125 V				**4**									
DC 220 V to DC 250 V				**5**									

	Order No.												
Command output module	**7TS720**	**0**	**–**	**0**	**A**	**A**	**0**	**0**	**–**	**0**	**A**	**A**	**0**
Rated auxiliary voltage DC 48 V, DC 60 V / DC 110 V, DC 125 V / DC 220 V, DC 250 V settable													

	Order No.												
Housing for peripheral modules	**7XP204**	**1**	**–**	**2**	**M**	**A**	**0**	**0**	**–**	**0**	**A**	**A**	**0**

Accessories	Order No.
Copper cable between PC (9-pin female connector) and converter/protection device	 **7XV5100-2**
RS232 - RS485 converter with power supply unit for AC 230 V with power supply unit for AC 110 V	 **7XV5700-0AA0** **7XV5700-1AA0**
Converter **Full duplex fiber optic cable - RS485** Auxiliary voltage: DC 24 V to 250 V, AC 110/230 V 1 channel FSMA plug ST plug 2 channels FSMA plug ST plug	 **7XV5650-0AA0** **7XV5650-0BA0** **7XV5651-1AA0** **7XV5651-1BA0**
Communication software DIGSI4 (incl. DIGSI 3) English/German/French	 **7XS5400-0AA00**
Graphic evaluation software SIGRA 4 English/German/French	 **7XS5410-0AA00**
Remote control software DIGSI REMOTE 4 English/German/French	 **7XS5440-0AA00**
Summation current/matching transformer 1 A, 50/60 Hz 5 A, 50/60 Hz	 **4AM5120-3DA00-0AN2** **4AM5120-4DA00-0AN2**
Matching transformer 1 A, 50/60 Hz 5 A, 50/60 Hz 1 A, 5 A, 50/60 Hz 1 A, 16.7 Hz 5 A, 16.7 Hz	 **4AM5120-1DA00-0AN2** **4AM5120-2DA00-0AN2** **4AM5272-3AA00-0AN2** **4AM5120-1DB00-0AN2** **4AM5120-7BA00-0AN0**
Test adapter for 7SS60	**7XV6010-0AA00**
connector for peripheral modules (spare part)	**W73078-B9005-A710**
Angle bracket (2 pieces)	**C73165-A63-D200-1**
Extractio tool for connector	**W73078-Z9005-A710**

A.2 Block diagram - Measuring system

7SS601

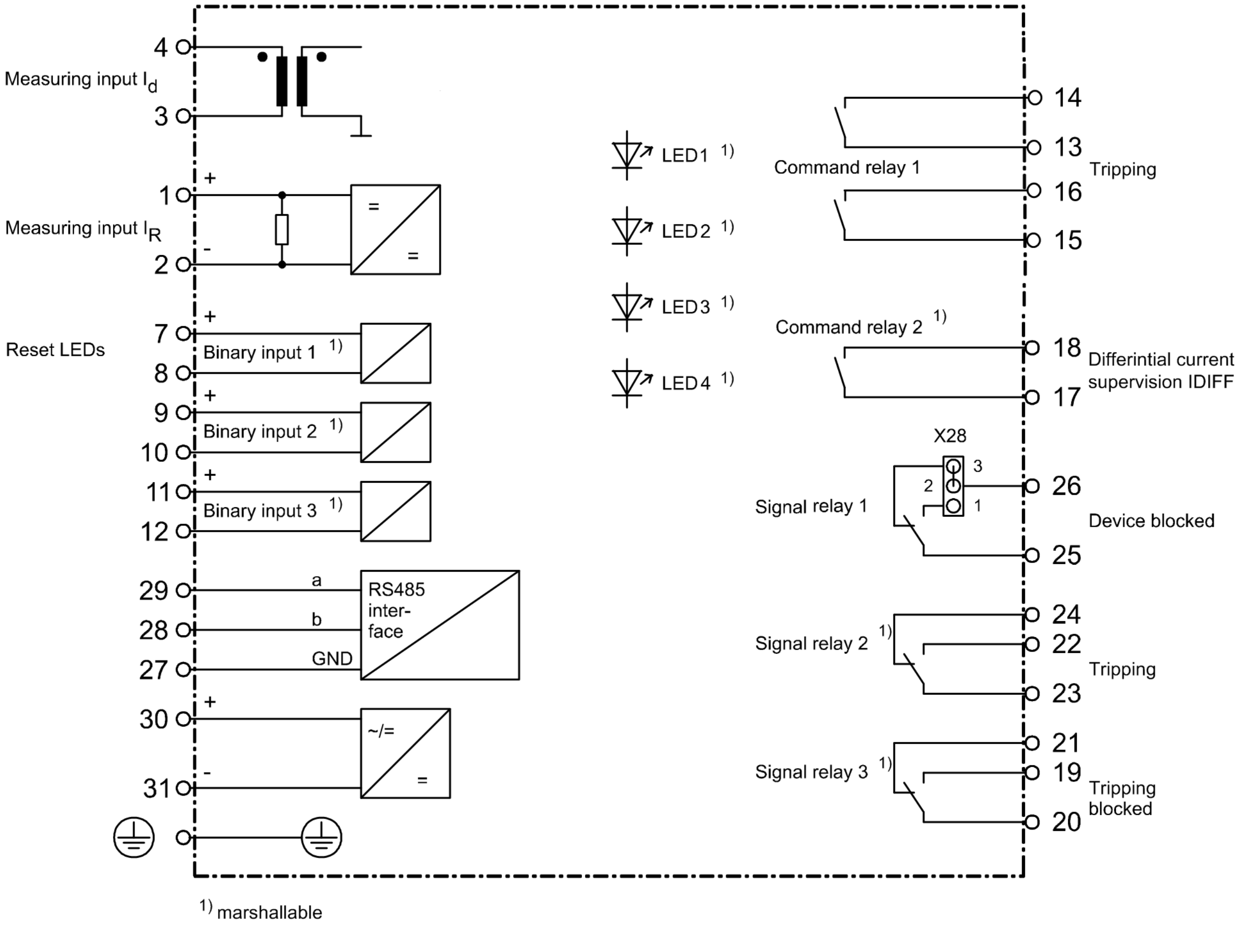


Figure A-1 Block diagram of the 7SS601 measuring system (default setting of binary inputs, command and signal relays as delivered)

A.3 Block diagrams - Peripheral modules

Restraint/ command output module 7TM700

Attention!
All relay coils depend on polarity

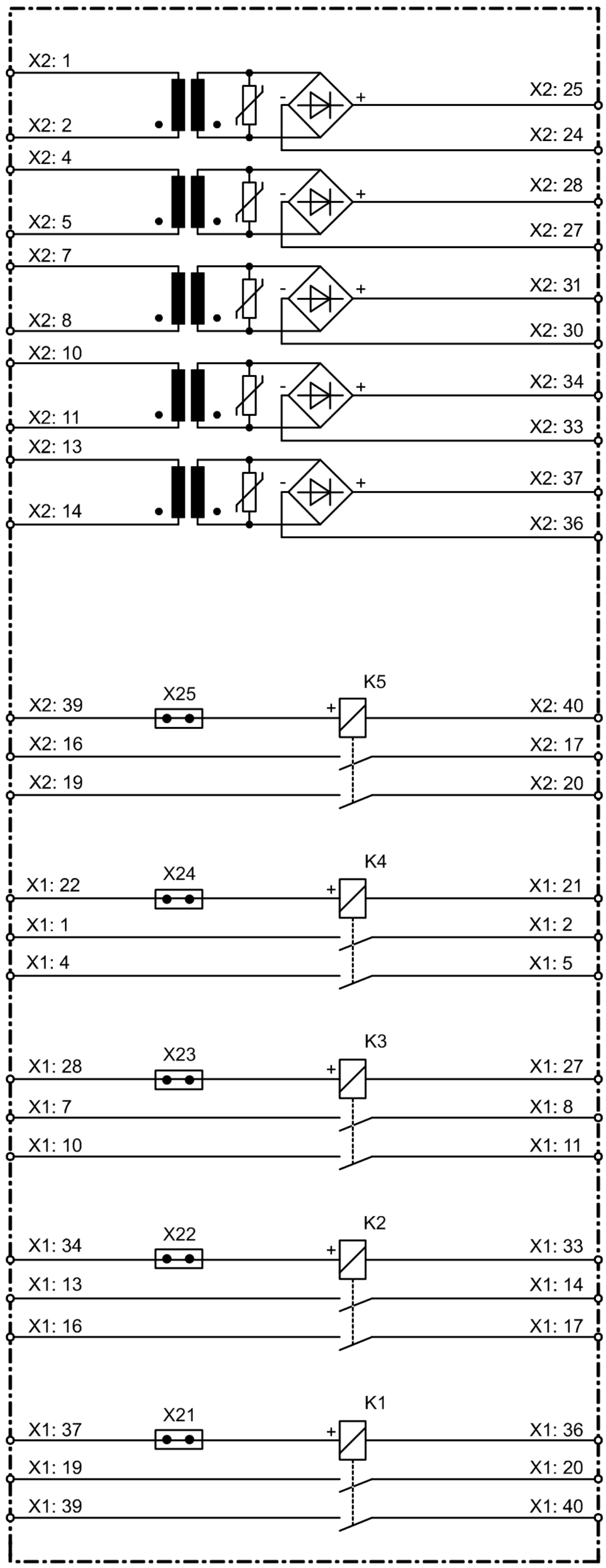


Figure A-2 Block diagram for 7TM700 restraint/command output module

Preferential treatment/ isolator replica module 7TR710

Attention!
All relay coils depend on polarity

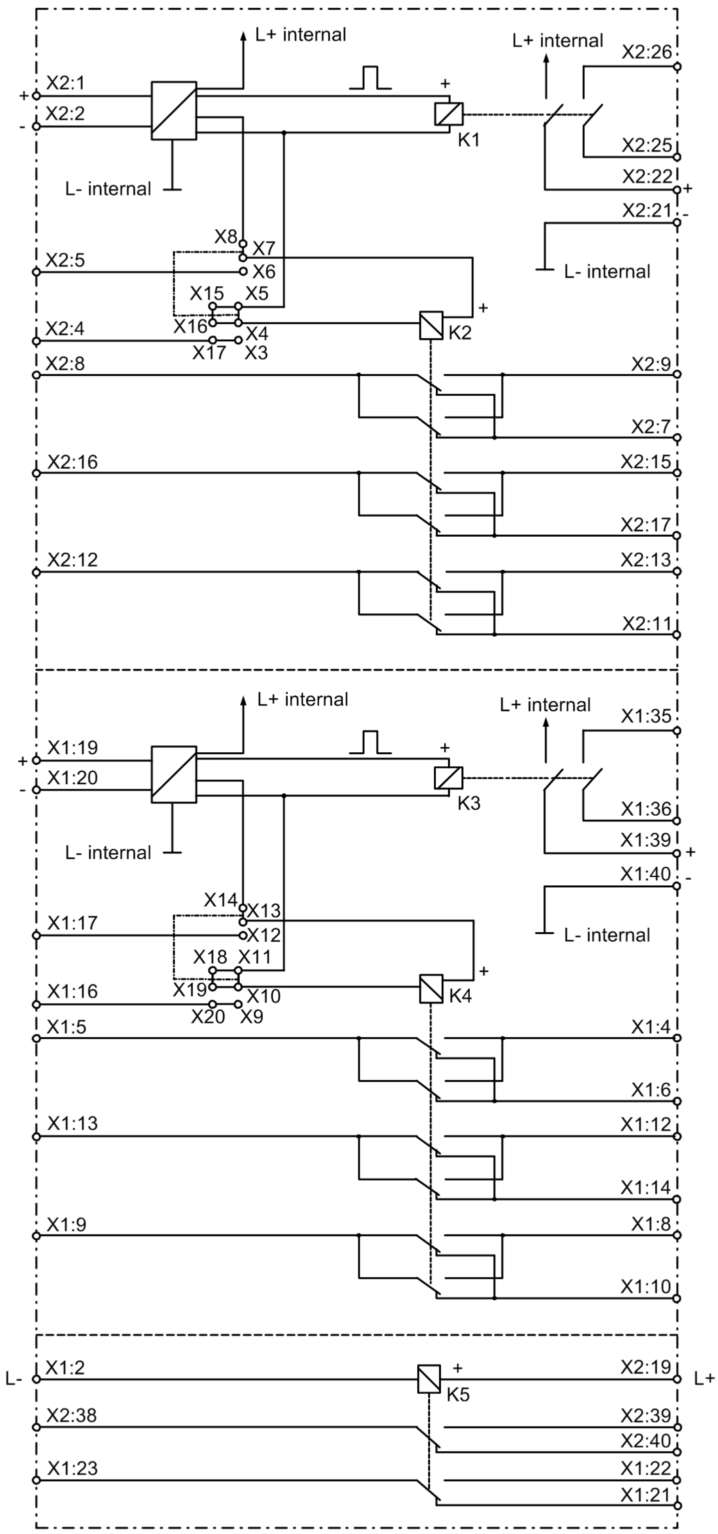


Figure A-3 Block diagram of 7TR710 preferential treatment/isolator replica module

Command output module 7TS720

Attention!
All relay coils depend on polarity

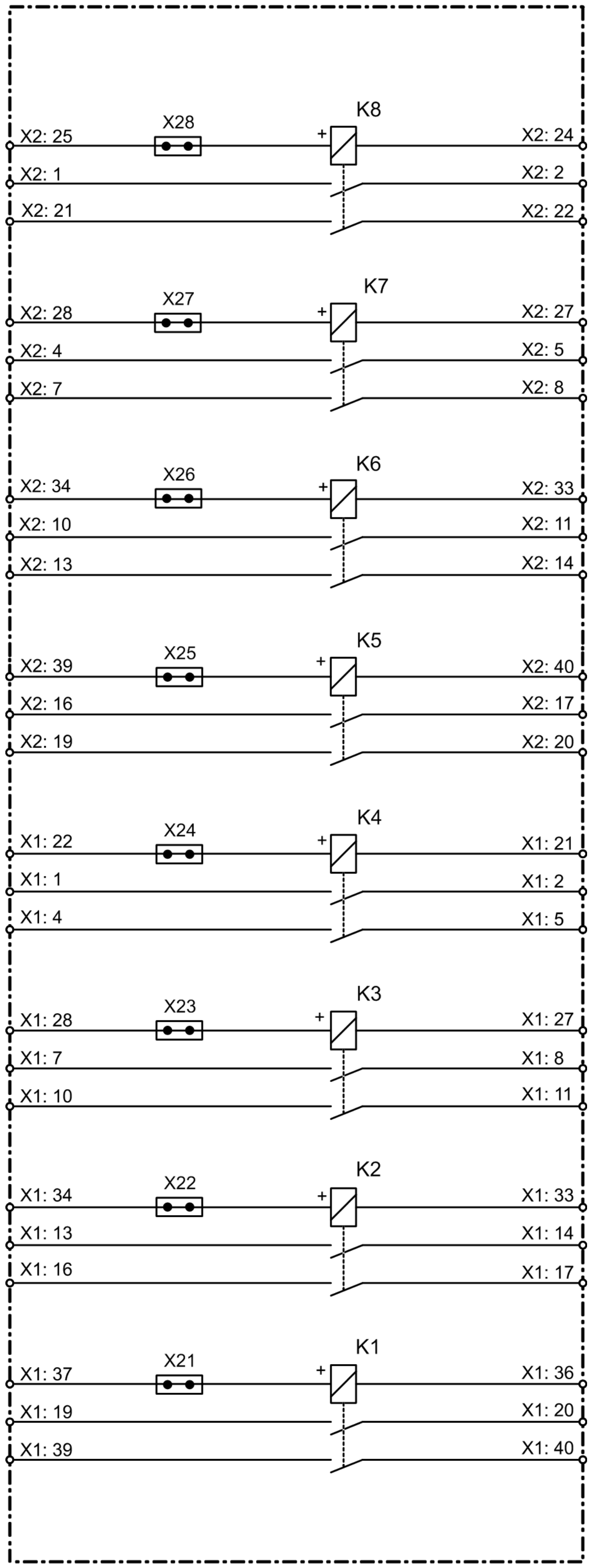


Figure A-4 Block diagram of 7TS720 command output module

A.4 Jumper settings for the measuring system

7SS601

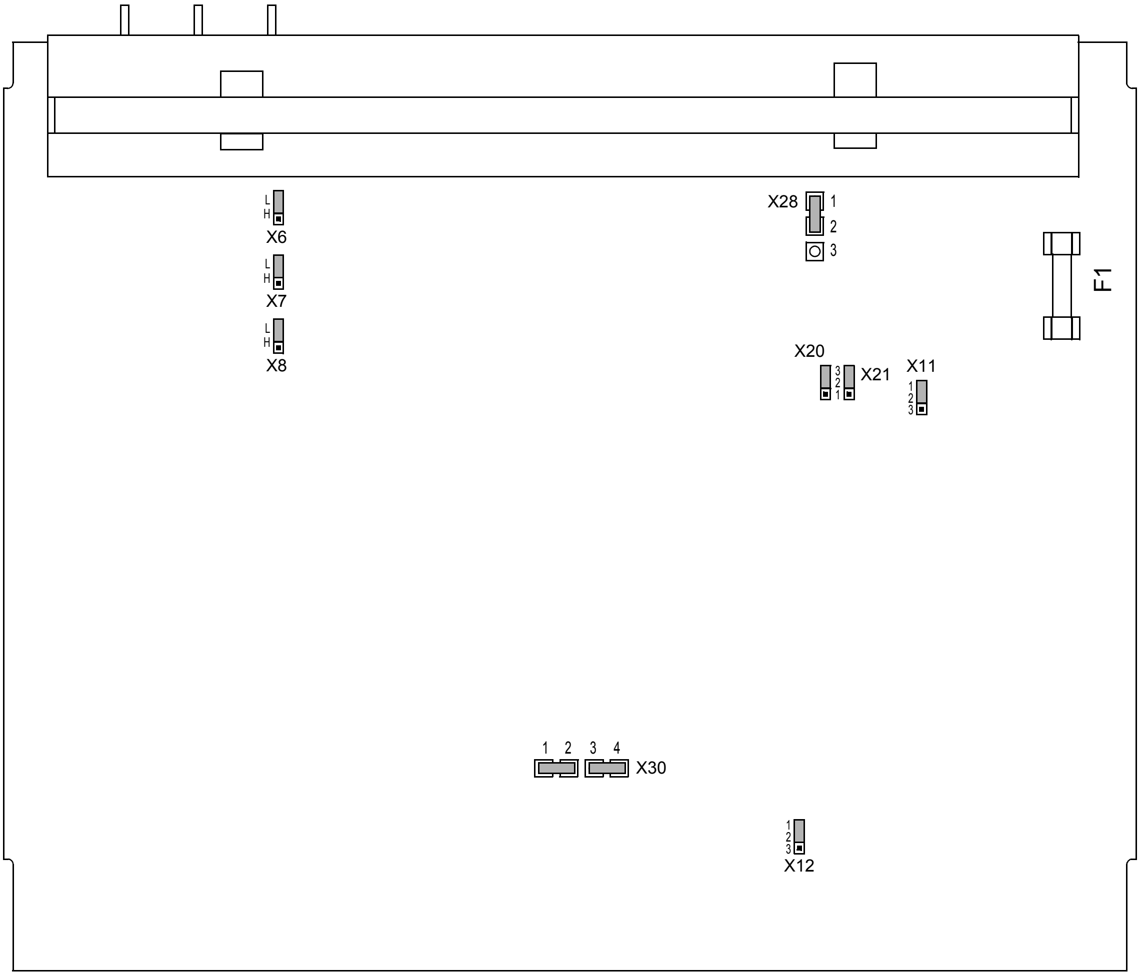


Figure A-5 Location of the jumpers in the 7SS601 measuring system (delivery status)

Jumper	Rated auxiliary voltage		
	DC 24 / 48 V	DC 60 / 110 / 125 V	DC 220 / 250 V DC 115 V
X11	empty	1–2	2–3
X12	2–3	2–3	1–2
X30	empty	1–2, 3–4	2–3

Binary input	Jumper	Pick-up threshold	
		17 V	73 V
1	X6	L	H
2	X7	L	H
3	X8	L	H

Jumper	RS485 interface	
	without terminator	with terminator
X20	1–2	2–3
X21	1–2	2–3

Jumper	Signal relay 1	
	NO contact	NC contact
X28	1–2	2–3

Rated voltage	Fuse F1 acc. to IEC 60127
DC 24/48 V	T1.6H250V
DC 60/110/125 V	T1H250V
DC 220/250 V	T1H250V
AC 115 V	T1H250V

A.5 Jumper settings for the peripheral modules

**Restraint/
command output
module 7TM700**

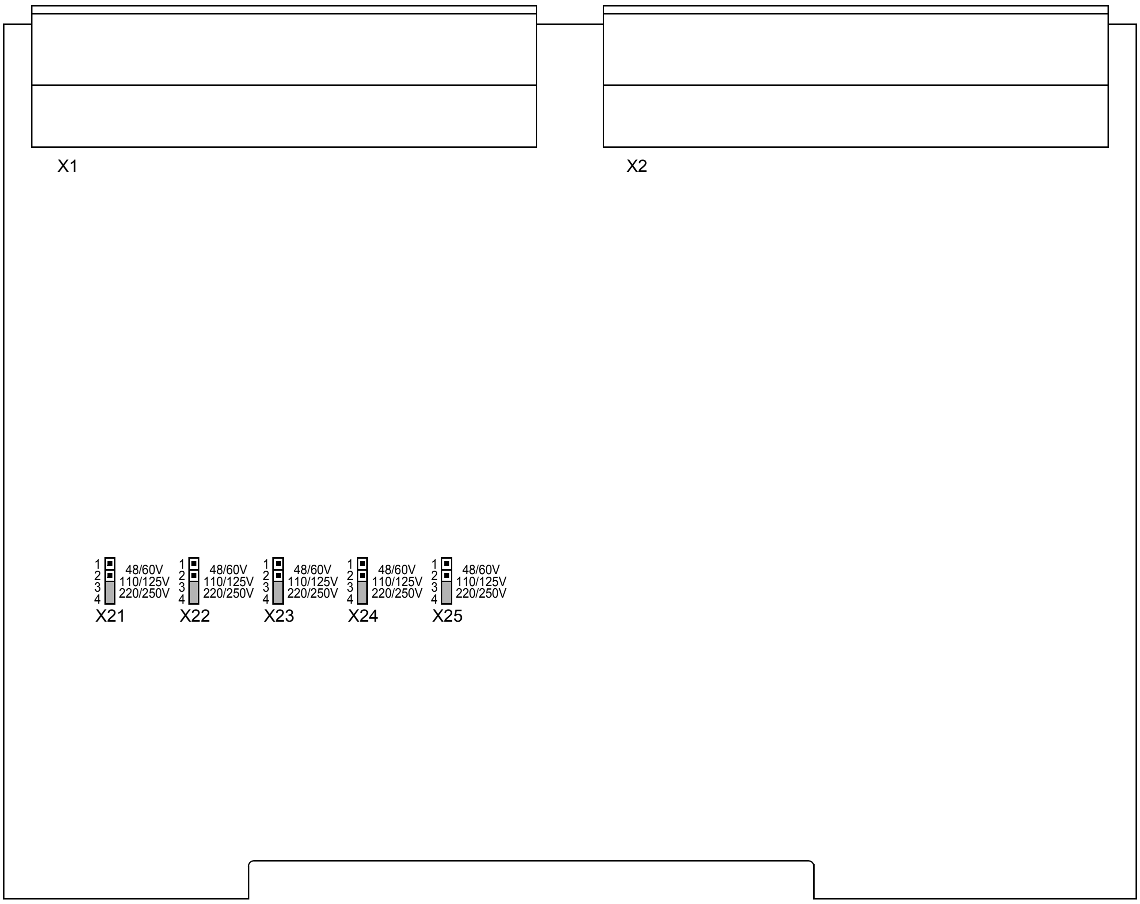


Figure A-6 Location of the jumpers on the 7TM700 restraint/command output module (delivery status)

Relay No.	Jumper	Rated auxiliary voltage		
		DC 24 / 48 V	DC 110 / 125 V	DC 220 / 250 V
K1	X21	1–2	2–3	3–4
K2	X22	1–2	2–3	3–4
K3	X23	1–2	2–3	3–4
K4	X24	1–2	2–3	3–4
K5	X25	1–2	2–3	3–4

Preferential treatment/ isolator replica module 7TR710

Figure A-7 Location of the jumpers on the 7TR710 preferential treatment/isolator replica module (delivery status)

Refer to Figure A-3 for the function of the jumpers. The jumper assignment depends on the configuration.

Command output module 7TS720

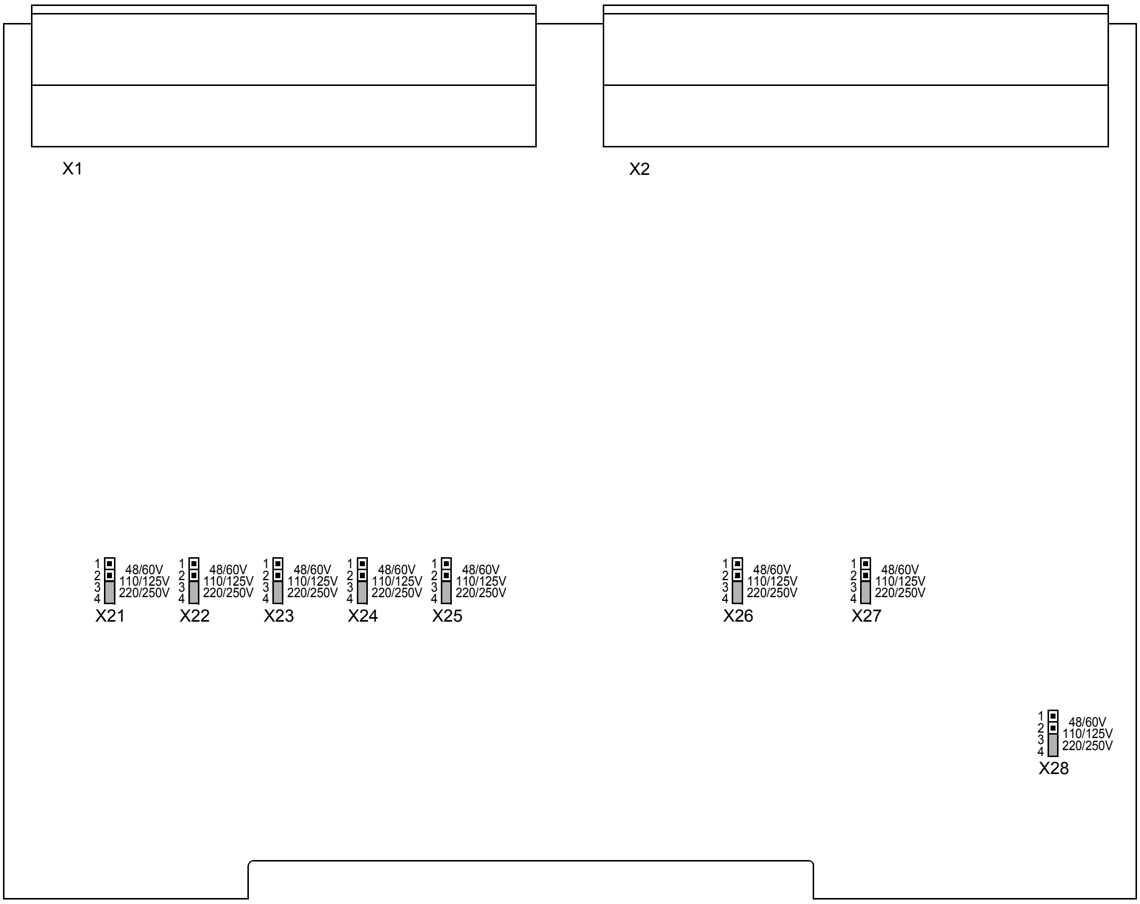


Figure A-8 Location of the jumpers on the 7TS720 command output module (delivery status)

Relay No.	Jumper	Rated auxiliary voltage		
		DC 48 / 60 V	DC 110 / 125 V	DC 220 / 250 V
K1	X21	1–2	2–3	3–4
K2	X22	1–2	2–3	3–4
K3	X23	1–2	2–3	3–4
K4	X24	1–2	2–3	3–4
K5	X25	1–2	2–3	3–4
K6	X26	1–2	2–3	3–4
K7	X27	1–2	2–3	3–4
K8	X28	1–2	2–3	3–4

A.6 Operating tree

The following operating tree gives you an overview of the address blocks and setting parameters of the 7SS601 busbar protection system. It shows the operating sequences that must be followed to make a specific selection.

Table A-2 Operating tree of the 7SS601

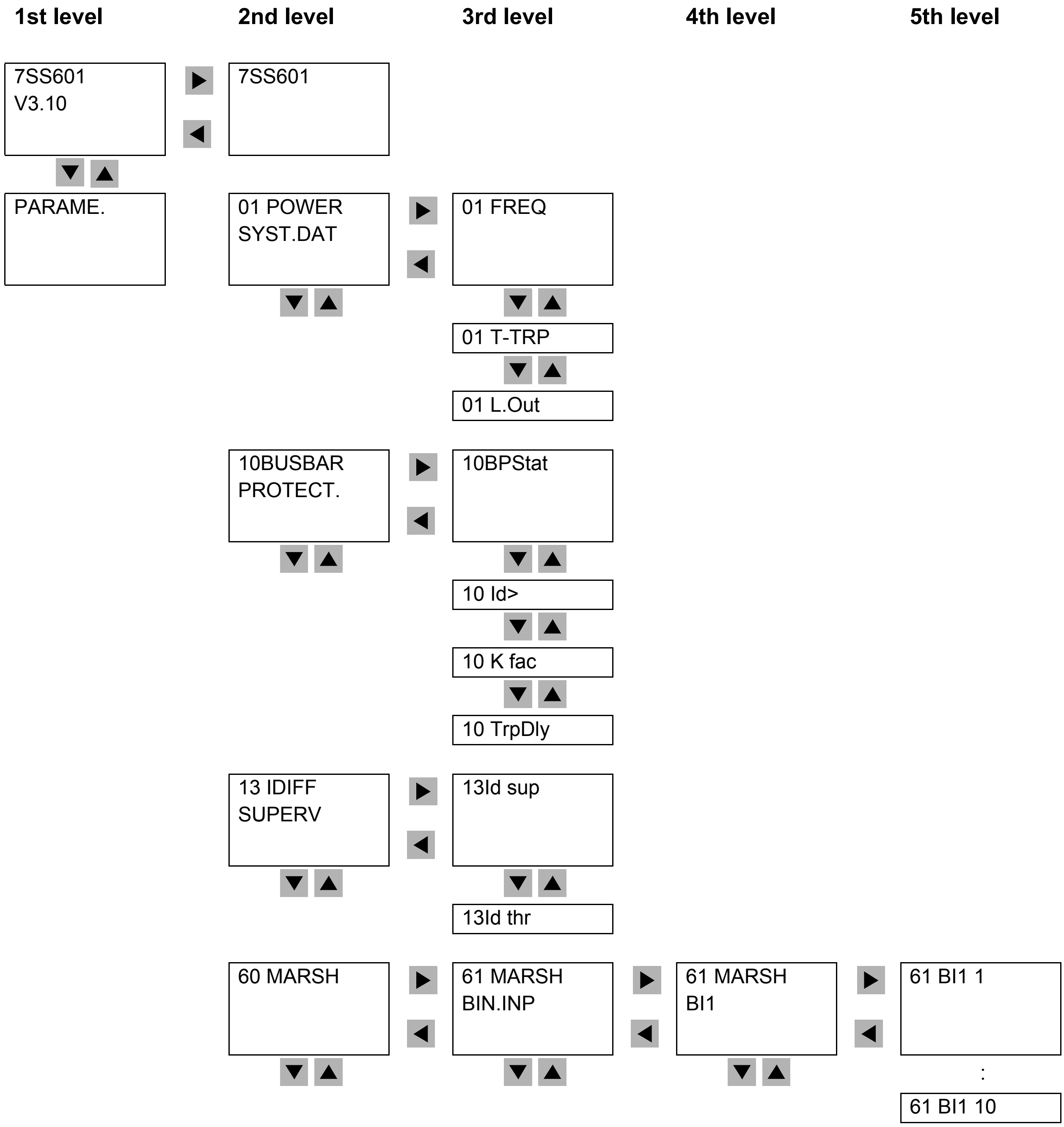


Table A-2 Operating tree of the 7SS601

1st level	2nd level	3rd level	4th level	5th level
			61 MARSH BI2	61 BI2 1 : 61 BI2 10
			61 MARSH BI3	61 BI3 1 : 61 BI3 10
		62 MARSH SIG.REL	62 MARSH SIG.RE 2	62SIG 1 : 62SIG20
			62 MARSH SIG.RE 3	62SIG3 1 : 62SIG320
		63 MARSH LED	63 MARSH LED 1	63LED1 1 : 63LED120
			63 MARSH LED 2	63LED2 1 : 63LED220
			63 MARSH LED 3	63LED3 1 : 63LED320

Table A-2 Operating tree of the 7SS601

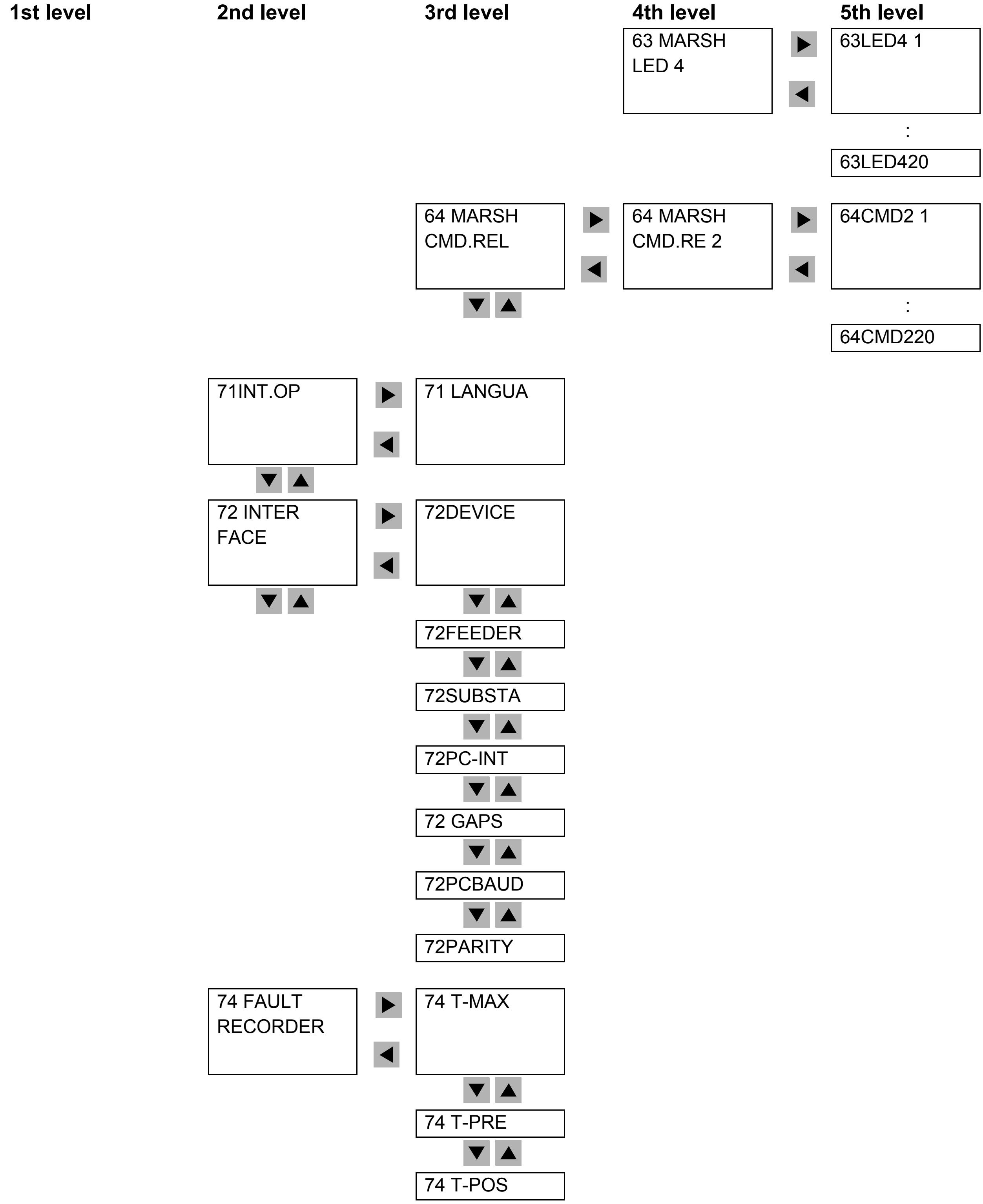


Table A-2 Operating tree of the 7SS601

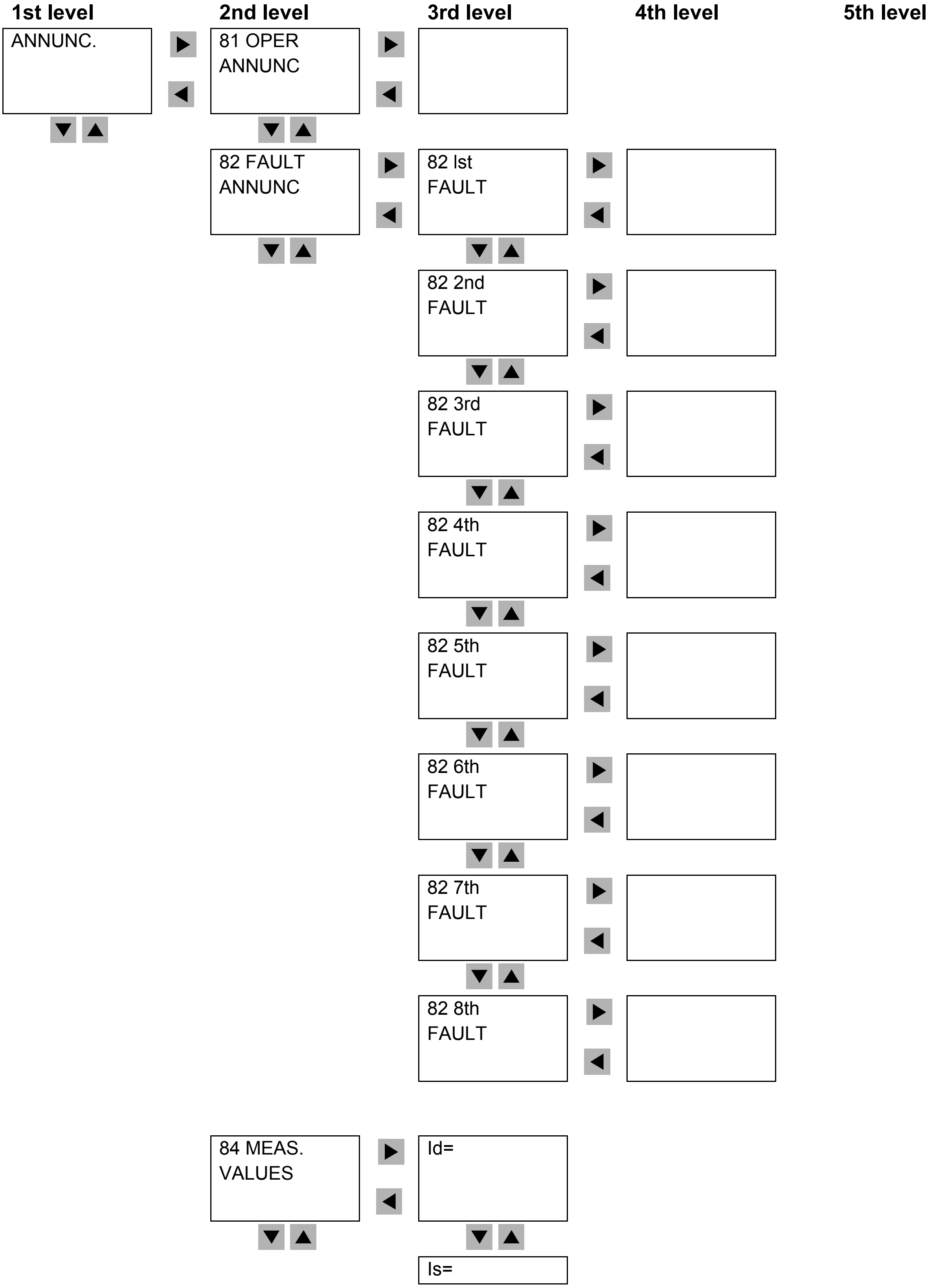
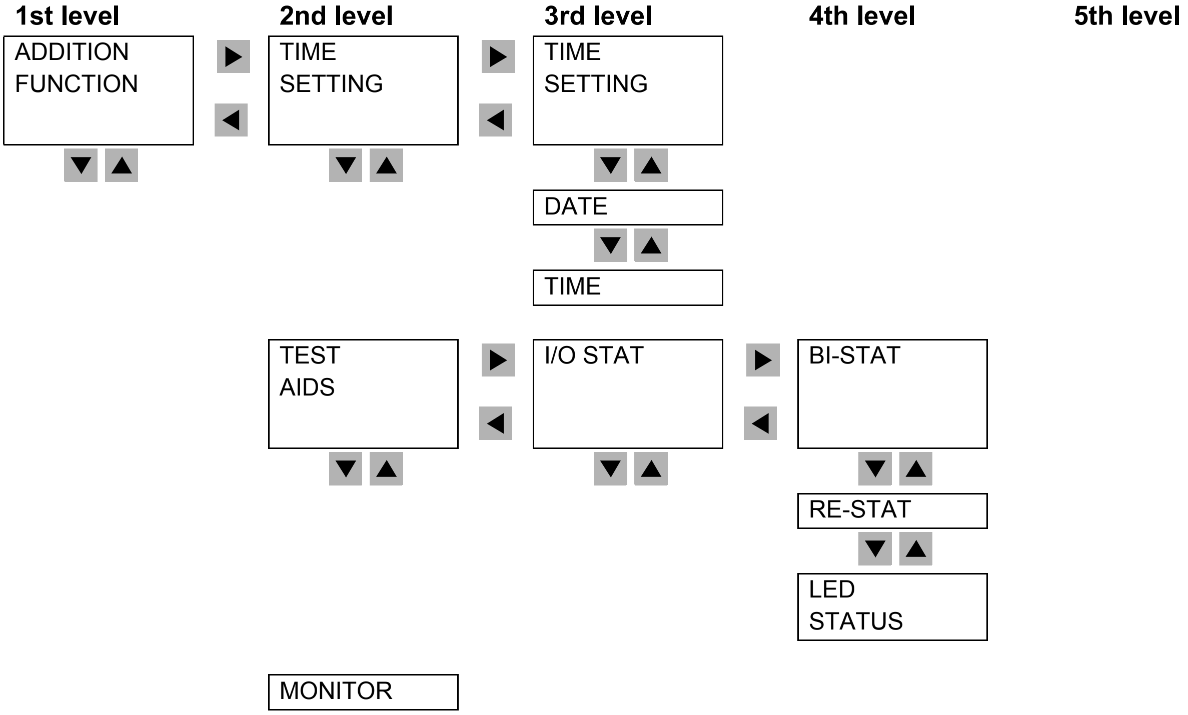


Table A-2 Operating tree of the 7SS601



A.7 Overview of parameters

DIGSI addr.	Parameter	Possible settings	Default setting	Explanation
1101	01 FREQ	50 Hz 60 Hz	50 Hz	Rated frequency of power system
1134	01 T-TRP	0.01s to 32.00 s	0.15 s	Minimum duration of TRIP command
1135	01 L.Out	OFF ON ON/butt.	OFF	Lockout function
1501	10BUSBAR PROTECT.	ON OFF BLO.TRP	ON	Busbar protection function
1505	10Id>	0.20 Ino[1] to 2.50 Ino[1]	1.00 Ino[1]	Minimum threshold for differential current
1506	10K fac	0.25 to 0.80	0.60	Sensitivity to internal faults
1511	10 TrpDly	0.00 to 10.00 s	0.00 s	Time delay of trip
1801	13Id Sup	bl/relBP bl/ackBP ALRMonly OFF	bl/relBP	State of supervision of the differential current function
1802	13Id thr	0.10 Ino[1] to 1.00 Ino[1]	0.15 Ino[1]	Threshold of differential current supervision
7101	71LANGUA	ENGLISH DEUTSCH	ENGLISH	Selection of the operating language
7201	72DEVICE	minimum setting:..........1 maximum setting:.....254	1	ID number of the device within the substation
7202	72FEEDER	minimum setting:..........1 maximum setting:.....254	1	Number of feeder within the substation (feeder address)
7203	72SUBSTA	minimum setting:..........1 maximum setting:.....254	1	ID number of substation, if more than one substation can be addressed
7211	72 PC-INT	DIGSI V3 ASCII	DIGSI V3	Data format for the interface
7214	72 GAPS	minimum setting:.....0.0 s maximum setting:....5.0 s	1.0 s	Maximum permissible transmission gap between telegrams for modem transmission
7215	72PCBAUD	1200 Baud 2400 Baud 4800 Baud 9600 Baud 19200 Baud	9600 Baud	Transmission baud rate for serial PC- interface
7216	72 PARITY	DIGSI V3 8O1 8N2 8N1	DIGSI V3	Parity of transmission telegrams
7410	74-T MAX	0.20 s to 5.00 s	1.50 s	Maximum time period of a fault recording
7411	74 T-PRE	0.05 s to 1.50 s	0.30 s	Pre-trigger time for fault recording
7412	74 T-POS	0.05 s to 1.50 s	0.20 s	Post-fault time for fault recording

1) I_{no}: normalized rated current; I_{no} = 100 mA with a symmetrical rated current flowing at the primary side

A.8 List of information

Abbreviation	Meaning
FNo.	Function number of annunciation
Op/Ft	Operational/fault annunciation
C/CG	Coming/Coming and going annunciation
M	Measurand
I	can be marshalled to binary input
O	can be marshalled to binary output (LED, signal/command relay)
BT	Binary trace for fault recordings
GI	Annunciation for General Interrogation

Table A-3 Annunciations of the 7SS601 busbar protection system

FNo.	Text	Meaning	Op	Ft	I	O	BT	GI
1	not all.	Not allocated			I	O		
5	>LED r.	>Reset LED indicators			I	O		
51	DEv.OK	Device operative/healthy [1]						
52	operat.	Any protection operative				O		
60	LED res	LED reset	C					
110	ANNlost	Annunciations lost (buffer overflow)	C					
111	PCannLT	Annunciations for PC lost	C					
113	TAGlost	Fault tag lost					X	
115	ANNovfl	Fault annunciation buffer overflow		C				
203	REC del	Fault recording data deleted	C					
301	Sys.Flt	Fault in the power system	C	C				
302	FAULT	Fault event with consecutive number	C	C				
608	ID=	Operational meas. differential current in %	M					
609	IR=	Operational meas. restraint current in %	M					
7701	>LO Res	>Lock Out reset	C		I	O	X	
7721	LockOut	Lock Out state	CG			O	X	X
7900	>BP blo	>Block Busbar protection	CG		I	O	X	
7901	>BP bPu	>Busbar protection blocking pulse		C	I	O	X	
7910	BP blk.	Busbar protection blocked	CG	CG		O	X	
7911	BP act.	Busbar protection active	CG			O		X
7914	BP Trip	Busbar protection: Trip [2]		CG		O	X	
7915	BP Tdel	Busbar protection: delay time started		C		O		
7920	IdS act	IDIFF supervision active	CG			O		X
7921	IdS Flt	IDIFF supervision: fault detected	CG			O		
7922	BIPulS.	Supervision of blocking pulse	CG					

1 permanently allocated to signal relay 1
2 permanently allocated to command relay 1

Index