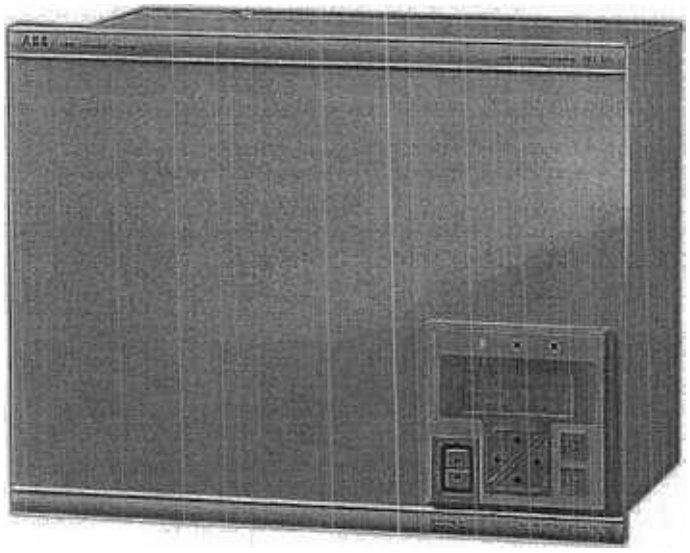
ABB Network Partner

REL 521 * 1.2
Line distance protection terminal

1MRK 506 003-BEN

November 1997
Changed since October 1997
Data subject to change without notice



(SE 95 02 16)

Features

- Simultaneous measurement of the phase-phase and phase-earth loop impedances within the numerical measuring elements that are individual for each type of fault and each distance zone ensures fast and reliable fault detection
- The minimum operating time is 13 ms
- The multiprocessor-based design guarantees high availability together with excellent possibilities for extensive combination of different optional functions
- Numerical filtering and measuring technique ensures a correct performance during CT saturation and CVT transients
- Versatile local man machine communication (MMC) from the relay front panel, together with the two optionally built-in serial ports, brings REL 521 close to the user, whether he be located in a substation, control centre or office
- Extensive self-supervision with fault diagnostics presented on an MMI unit
- Detailed disturbance reporting for the last ten disturbances with up to 150 time-tagged events for each reported disturbance
- The basic version of REL 521 includes:
  - three distance protection zones with individual setting of the directionality and reach in reactive and resistive direction
  - instantaneous overcurrent protection
  - switch-onto-fault protection facilities
  - programmable communication schemes with a built-in unblocking function, weak end infeed logic and current reversal logic
  - three-phase tripping
  - presentation of the measured mean values of the line current, voltage, active power, reactive power and frequency, together with the actual statuses of all input and internal binary signals
  - extensive configuration possibilities by use of built-in logical gates, timers and user configurable connections between different functions, binary inputs and binary outputs

- The following functions are available optionally, independent of each other:
  - up to five I/O printed circuit boards, each of them with eight binary inputs and twelve output relay contacts
  - two additional distance measuring zones with programmable directionality and settings
  - phase-selective single-phase tripping
  - power swing detection element with a programmable effect on different zones
  - disturbance recorder with a recording time of at least 10 s
  - fuse failure supervision function and CT-supervision function
  - single or three-phase autoreclosing
  - synchronism check and energizing check function
  - time delayed under and overvoltage protection
  - supervision of the protected power line
  - stub protection
  - directional or non-directional earth fault overcurrent protection
  - 4-step earth fault overcurrent protection
  - accurate fault locator based on well proven measuring algorithms
  - on-line control function
  - simulation logic

Application

The REL 521 line protection terminal represents the basic unit of the transmission and sub-transmission line protection terminals that form a part of a PYRAMID system. The PYRAMID system includes a complete range of the complex object terminals, a functional station monitoring, and a station control system. The blocks in PYRAMID are available as stand-alone protection units or as building blocks in a complete Station Monitoring System (SMS), Station Control System (SCS) and/or Relay Testing System (RTS).

Basic functions

The basic protection function in REL 521 is a full scheme distance protection with the individual measuring elements for the different types of faults that belong to the various impedance zones. The protection includes basically three impedance measuring zones with programmable directionality.

The quadrilateral characteristic of each impedance zone with an individual and independent setting of the reach in reactive and resistive direction, ensures an optimized application for all line lengths on single lines as well as on lines within the complex network configurations. Automatic adaptation of the earth return compensation contributes additionally to the adaptability of a terminal. The quadrilateral characteristic ensures a maximum resistive coverage for all faults and a maximum limitation of load influence. The load compensated reactance characteristic of zone 1 makes REL 521 applicable for the protection of heavy loaded long transmission lines.

The full scheme distance relay's ability to cover the evolving faults, faults between different circuits on the multi-circuit lines, and simultaneous faults, makes the selective clearing of these faults feasible for the sub-transmission lines as well.

The phase selective instantaneous overcurrent protection function serves as a complement to the basic underimpedance function. This in order to reduce the tripping time for faults characterized by very high fault currents, which can critically influence the stability of the system.

The basic version of REL 521 provides three-phase tripping. Single-phase tripping for the single-phase-to-earth faults is available as an option.

The acceleration of an overreaching zone, as conditioned by the readiness of the autoreclosing function and the corresponding circuit breaker itself, is available. The so-called "loss-of-load" function is also included.

REL 521 has a built-in, special user-programmable logic that enables the implementation of practically any communication scheme. It covers most of the needs of existing communication schemes based on zone extension, permissive overreach and underreach transfer tripping, as well as on the blocking principle. In addition to this, unblocking logic in two different modes is available within the permissive schemes. A separate current reversal logic is available to prevent the unnecessary tripping of healthy systems on the multi-circuit lines and within the complex network configurations. A built-in weak infeed logic is programmable so as to operate in echo mode only, or in both echo and tripping mode. When a single-phase autoreclosing is used for the single-phase faults, the tripping of a circuit breaker caused by the weak end infeed function can also be phase-selective.

A built-in switch-onto-fault function provides instantaneous three-phase tripping for the whole line section if a circuit breaker accidentally is closed on to a fault. The function operates in a conventional way (by means of an external binary signal from a CB control switch), or by the activation of the built-in optional logic.

Four independent groups of setting parameters are available within the REL 521. The user can change an active group as well as different parameters within any of them locally by the aid of the user-friendly man machine communication unit, or by means of a personal computer (PC). It is also possible to change an active setting group by activating one of the four programmable binary inputs.

Connections between different functional inputs and outputs, binary inputs and binary outputs are user configurable. The user can configure all built-in functions according to his needs. A high number of different logical gates and timers with individual settable time delays extends additionally the total flexibility of terminals.

The MMI serves as an information unit, presenting in a logical order starting and tripping signals that have appeared during each of the last ten recorded disturbances.

Furthermore, each of the two local MMC possibilities takes over the functionality of the measuring instruments such as the A-meter, V-meter, VAr-meter, W-meter and Hz-meter. The actual statuses of all binary input signals and internal logical signals are available too. Directional tests during commissioning become a routine by using the REL 521 and its man machine communication possibilities.

Up to 150 time-tagged events for each of the last ten recorded disturbances are available via SMS, SCS or the PC-connection on the front. Time synchronization is possible by means of the minute pulses wired to a separate binary input as well as via the optionally built-in communication ports for remote communication.

Optional functions

Additional impedance measuring zones

As an option, two additional impedance measuring zones are available in REL 521 without changing its basic hardware configuration. Thus, a full scheme distance protection with totally five impedance measuring zones and characteristics as presented in Fig. 1 represents the basic protection function within the REL 521.

Their directionality is programmable either in the forward or reverse direction, and they are independent of each other. Each of the additional zones can also be used as non-directional impedance protection.

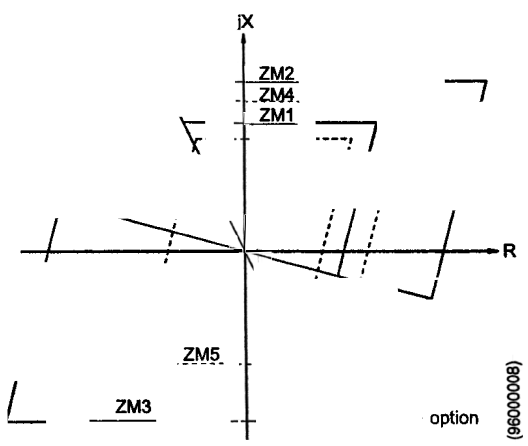


Fig. 1 Operating characteristic of the distance protection function of REL 521

Phase selection and single-phase tripping

The single-phase tripping of a circuit breaker for single-phase-to-earth faults is possible with a separate phase selection measuring element and a single-pole tripping logic. The separate and independent setting of the reach in reactive and resistive direction makes the phase selection in REL 521 independent of the heavy load currents on long transmission lines.

Power swing blocking

The power swing detection function has an independent setting of the reach in resistive and reactive direction. Its measuring principle is based on a well proven measurement of the transient impedance transition time between two concentric impedance polygons. The final effect of power swinging on the operation of a distance protection is programmable for each distance zone separately.

Fuse failure supervision function and CT-supervision function

The operation of the built-in fuse failure supervision function is based on the detection of a zero-sequence voltage without the presence of a zero-sequence current.

The CT-supervision function is based on comparison between the zero sequence current calculated from the phase currents and a reference current. The reference current is taken from the zero sequence current from another core. This core can either be of measuring transformer type or a relay transformer type. The CT-supervision function provides an alarm signal as an output.

Automatic switch-onto-fault logic

As an option, REL 521 has a built-in logic that determines the dead line conditions necessary for the operation of the switch-onto-fault function. This logic can replace the auxiliary contact of the circuit breaker control switch and the corresponding wiring.

Earth fault overcurrent protection

Complementary non-directional or directional earth fault overcurrent protection functions are available optionally.

Both versions have selectable time delay characteristics, four of them current-dependent, and one independent. The current-dependent time characteristics also include the possibility of setting the minimum operating current and time.

Directional overcurrent earth fault protection uses two directional measuring elements; one directed in forward and one in reverse direction. This makes it useful both in the permissive overreach and the blocking communication schemes with the protection on a remote line end. In REL 521, the separate optional communication circuits for directional earth fault protection are completely independent of the communication circuits for the distance protection. Furthermore, similar logical circuits as those for the distance protection are also available for the directional earth fault protection (switch-onto-fault, current reversal, weak end infeed echo and tripping).

In addition an optional 4-step earth fault protection is available. The 4-step earth fault protection is intended for solidly earthed systems where there is a need for selectivity both for low and high zero sequence currents.
The 4-step earth fault protection have three steps with definite time function and one step with combined definite and inverse time function.

The 4-step earth fault protection measures zero sequence current (3IO) and zero sequence voltage (3UO). The directional function has an characteristic angle of 65 degrees i.e. maximum sensitivity is achieved when the zero sequence current follows the polarized voltage (-3UO) by 65 degrees. All four steps can be made directional or non-directional.

In order to avoid influences on the directional measurement by harmonics in the voltage the 4-step earth fault protection is equipped with an harmonic filter. The inverse-time function step is always blocked if the second harmonic exceeds the set value (20 or 32% of the zero sequence current). The definite time functions can be set individually with or without second harmonic blocking.

The operation is stabilized against second harmonics. This allows settings for high sensitivity without unwanted tripping due to residual inrush currents in the transformer.

Fault locator
An optional fault locator is an essential complement to the distance protection, since it measures distance to the fault with great accuracy.

The option provides a fault location together with the information on the actual primary and secondary phasors of the voltages and currents in a relay point. The pre-fault and fault values of currents and voltages in a relay point, recorded together with their phase relations for the last ten recorded disturbances, are also available.

A calculation algorithm compensates the effect of the load currents and the apparent fault resistance.

Disturbance recorder
The disturbance recording function is an important part of a station monitoring system, which enables the evaluation of different events within the power system.

The optional disturbance recorder with a high performance is one of the building blocks within the REL 521. It can memorize up to 10 analogue and 48 binary signals (input binary signals or internal signals) that are available within the terminal. The minimum total recording time is 10 seconds.

Any of the recorded analogue and binary signals is programmable to start a recording. Furthermore, analogue signals are programmable for overfunctions and underfunctions, and binary signals can start recording with a transition from a logical 0 to a logical 1 and vice versa.

The time base is synchronized with an internal clock and via the synchronizing facilities further on to the system. Pre-fault time, post-fault time and limit time are settable in wide ranges.

The disturbance recorder option can be selected as a disturbance recorder with extended memory.

It is possible to locally collect disturbance records by means of a PC used for local man machine communication, as well as remotely within the SMS. The disturbance evaluating PC-based program type REVAL, operating in MS Windows, is also available.

Autoreclosing
The autoreclosing option consists of a single and/or three-phase one or multi-shot autoreclosing.

The reclosing function can be selected to perform single-phase and/or three phase reclosing from eight single shot to multiple shot reclosing programs. The three-phase autoreclose open time can be selected to give either high speed autoreclosing or delayed autoreclosing.

Three phase autoreclosing can be performed with or without the use of an optional synchronism check or energizing check function.

Extensive information on the operation of a reclosing function is available to the user at any time.

Synchronism and energizing check function
The built-in synchronism check function has all the characteristic operating parameters settable in wide ranges. The energizing check function makes possible energizing of dead line as well as energizing of dead busbar or energizing in both directions.

Breaker failure protection
The optional breaker failure protection as built into REL 521 measures the current flowing through a corresponding line circuit breaker.

Two timers are available, one independent on the other: timer T1 for a repeated tripping of its own circuit breaker, and timer T2 that operates the corresponding output relays, connected into the breaker failure tripping logic.

Any one of the internal tripping functions will start the operation of the breaker failure protection. It is also possible to program the corresponding binary inputs for the purpose of starting the breaker failure protection.

Under/Overvoltage protection
Optional voltage measuring functions are available in the REL 521 terminals. Operating values of the overvoltage and undervoltage measuring elements are settable in wide ranges, independent one of another. Each of them has built in an independent time delayed element with wide setting range.

System supervision functions and stub protection
Different supervision functions that supervise a protected power line, as well as the near vicinity of REL 521, are available as an option among the supervision functions of the system.

Their functionality is based on a measurement of the line current (overload protection) and a difference in the phase currents (broken conductor protection). A loss-of-voltage function with its tripping logic is useful in systems with a built-in automatic restoration function.

The overload protection will change to a stub protection by energizing the corresponding binary input in REL 521. It can thus be effectively used in switchyards with $1^1/_2$ circuit breaker configuration when VTs are installed on the line side of the circuit breakers.

On-line control functions
Optionally built-in function block makes possible on line remote control of up to ten binary signals. On this way the on line control of the circuit breakers as well as different built in functions is possible remotely via the SCS and SMS.

Simulation logic
The optional simulation logic makes possible to the user to program an appearance and time sequence of different internal logical signals and on this way test the operation of different built-in disturbance reporting functions, event handling within the SMS and SCS and exercise the signal flow within the substation.

Optional input/output facilities
The basic version of REL 521 comprises four binary inputs and five output relay contacts. One of them is a normally closed contact, used for the signalization of a continuous self-supervision function. Between one and five additional printed circuit boards, each of them comprising eight binary inputs and twelve independent output relay contacts, are available as an option. All the binary inputs are freely programmable for any of the built-in functions to assure the greatest possible flexibility. All of the REL 521 internal logical signals can control one or more of the output relays.

All the output relays are freely programmable to any of the internal logical signals.

Optional remote serial communication
Optionally, the corresponding software and one or two serial communication ports are available with the REL 521. They are installed independent of each other on the back plane of the terminal. Remote communication with REL 521 uses the optical fibres to eliminate the influence of the electromagnetic interferences. This enables the REL 521 to be a part of the SMS and/or the SCS at the same time.

Design

The REL 521 line protection terminal is supplied in a closed case of common ABB look, which is $^3/_4$ of 19" rack wide and 6U (10") high. A motherboard is mounted under the front cover of the terminal. All other units are of plug-in type and thus easily removable. Screw connection terminals, mounted on the back plane of the terminal, serve for the electrical connections to the external circuits. Optional optical connectors of type SPA-ZC 21 that serve for remote communication purposes within the SCS and SMS are located on the back plane too.

The basic configuration of REL 521 consists of the following units:

- Transformer unit with five voltage and five current input transformers
- A/D conversion unit for 10 analogue signals, operating with a sampling frequency of 2000 Hz
- Multiprocessor-based central processing unit that performs all the REL 521 measuring functions
- Power supply unit, which comprises a regulated DC/DC converter that provides stabilized auxiliary voltage to all static circuits. Four binary input circuits together with the five output relays are installed in the same unit.
- Man machine interface unit is installed on the front plane of REL 521 and serves as a local communication facility between the user and the equipment.

The following hardware units are available optionally:

- up to five input/output units, each of them consisting of eight binary inputs and twelve relay output contacts.
- one or two serial interface units of type SPA ZC 2, intended for remote communication purposes.

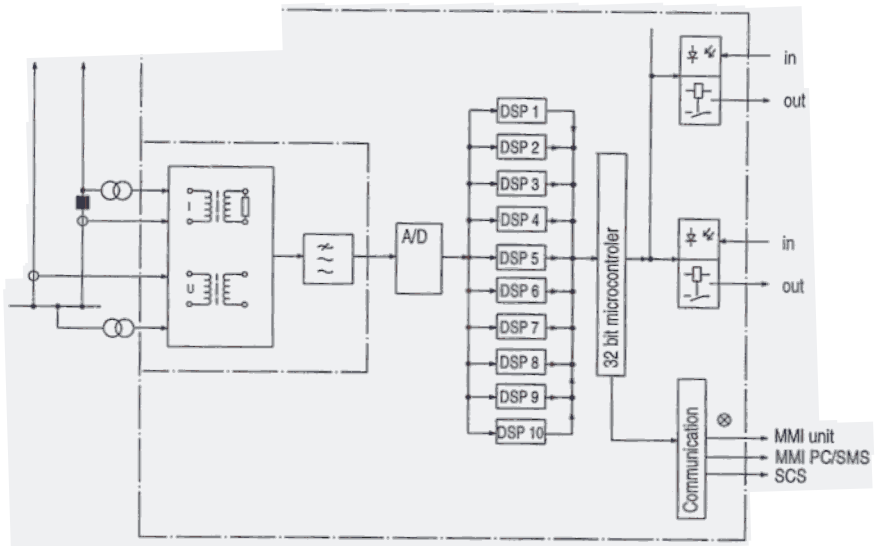


Fig. 2 REL 521 basic block diagram

Basic version

The measuring technique used in the REL 521 terminal is based on pure numerical methods. The measuring signal processors operate with numerical signals derived from the analogue-to-digital converter (see Fig. 2).

The self-supervision function operates continuously and includes:

- normal microprocessor watchdog function
- checking of digitized measuring signals
- checksum verification of PROM contents
- checksum verification of all types of signal communication
- read-write-read-write cycling of the memory cells and internal registers

Transformer unit

Totally ten analogue input quantities are processed in a transformer unit:

- three currents as phase currents of a protected line
- residual current ($3I_0$) of a protected line
- residual current ($3I_0$) of a parallel operating line when used (for an optional fault location function only)
- three phase-to-earth voltages of a protected line
- open delta voltage of a protected line (for an optional directional earth fault protection function, when used)
- one phase-to-earth voltage from the busbar side of a circuit breaker (for an optional synchro check /energizing check function, when used)

A/D conversion unit

Anti-aliasing low pass analogue filters filter the analogue signals before they enter the multiplexer and an analogue-to-digital converter. A separate signal processor in an A/D conversion unit performs digital low-pass filtering. The total bandwidth of the filtered signals will then be suitable for protection purposes.

The information is then converted from parallel to serial mode and transmitted to the measuring unit (central processing unit).

Measuring unit (central processing unit)

REL 521 is based on a multiprocessor design with a 32 bit microcontroller and a number of digital signal processors (DSP). Encoded serial information from the A/D converter unit is decoded and changed back to the parallel information in the measuring unit. Band pass numerical filtering of the corresponding current and voltage signals is performed as well.

Three DSPs perform a basic impedance measuring function. They calculate the impedance as seen for the different fault loops on the basis of the complex values of the measured voltages, currents, and changes in the currents. The resulting impedance is compared with the reactance and resistance limits determined by the relay settings for each fault loop and each distance zone separately for each millisecond.

In order to measure the same operational impedance for all fault loops, an earth fault compensation has been applied for measurement in the phase-to-earth fault loops. It influences the measurement in a reactive direction only. The compensation will be automatically adapted to line positive and zero sequence parameters, for each distance zone separately.

The resistive reach is adjustable separately for the earth fault measuring loops, and for the phase-to-phase fault measuring loops. It is settable for the different distance zones, independently of each other.

To maintain a definite directional measurement for the faults close to the relay point a loop voltage signal is used in conjunction with a phase locked positive sequence memory voltage that lasts for approximately 100 ms.

A 32 bit microcontroller directs the information flow over the CAN bus with the different signal processors, input/output units and also performs some different logical functions, built into the REL 521 line terminal. It also controls the following three communication ports:

- to the man machine communication unit and connected PC, if any, for local man machine communication
- to the station monitoring system SMS (option)
- to the substation control system SCS (option)

Power supply unit
The power supply unit comprises a regulated DC/DC converter that provides a stabilized auxiliary voltage to all static circuits within the REL 521 as well as to all output relays. Four binary input circuits together with the five output relays are installed in the same unit.

Man machine interface (MMI) unit
The MMI unit has a common ABB look and is installed on the front plane of REL 521. It is used for local communication with the personnel on site. The following most important functions are unified in the MMI unit:

- settings: Four groups of setting parameters are settable or readable only by menu-structured, self-explanatory MMI software. Different parameters are changeable within the different setting groups. The selection of an active setting group is also possible.
- information handling: The most important information on the last ten disturbances, including the time of disturbance, its duration, together with the starting and tripping signals, is stored in REL 521 and available to the user at any time via the MMI unit. Information about the actual line current, voltage, active and reactive power together with frequency is also available. The same is valid for the statuses of all important internal logical signals. If the optional fault location is included in REL 521, the information on distance to fault, together with the phasors of the pre-fault and fault currents and voltages, is available for the last ten disturbances as well.
- fault tracing: The faulty part of a REL 521 as detected by the built-in continuous self supervision will be presented by the corresponding code on the MMI unit.
- simplified testing of different functions and wiring during commissioning or any other testing activities, not only within REL 521, but also in the external circuits, is feasible by using the possibility of setting any of the most important REL 521 internal logical signals at the logical value 1, 0, or at the actual logical value. Complete signalling, tripping and logical circuits within the line bay can be tested this way.The use of optional simulation logic makes these activities even more comfortable.

Two connection points (transmitting and receiving), for the connection of the optical fibres, are available in the MMI unit. Thus, disturbance-free local serial communication with the personal computer is also available.

The use of a personal computer simplifies the communication with REL 521 to a great extent, and gives the user additional functionality which, due to the lack of space, is not available in the MMI unit itself:

- up to 150 time-tagged events are available for each of the last ten recorded disturbances
- disturbance records can be collected by a personal computer and corresponding software.

Options
The REL 521 line protection terminal is easily adaptable to the requirements for the protection of any transmission power line, thanks to its modular design and multiprocessor-based configuration. This way, the additional hardware modules and/or additional software functions, can be added to the basic version.

Input/Output units
As an option, up to five input/output units, each of them consisting of eight binary inputs and twelve relay output contacts are available to the user of REL 521.

Binary inputs are freely programmable as the input logical signals to any of the built-in functions, including the disturbance recording and event recording facilities.

This enables the extensive monitoring and evaluation of operation for the terminal itself as well as that of all associated external circuits.

More than 300 internal signals are available for signalling purposes and all of them are freely programmable to operate any of the additional output relays.

Remote serial communication
One or two serial interface units of type SPA-ZC 21, intended for remote communication purposes, make it possible for the REL 521 terminal to be included at the same time both in the SCS and SMS or in only one of them. The units are optional and they are located on the back plane of REL 521.

Plastic optical fibres up to the single length of 30 meters, and glass fibres up to the single length of 500 meters can be used as a communication media.

Technical data

Table 1: Energizing quantities, rated values and limits

Quantity	Rated value	Nominal range
Current Operative range Burden	I_r = 1 or 5 A (0,2-4) × I_r cont. (0,2-100) × I_r for 1 s *) < 0,25 VA at I_r	(0,2-30) x I_r
Ac voltage Ph-Ph Operative range Burden	U_r = 100/110/115/120 V 1,5 × U_r cont. 2,5 × U_r for 1 s < 0,2 VA at U_r	
Frequency	f_r = 50/60 Hz	
Auxiliary dc voltage EL power consumption basic terminal each I/O-board each output relay	U_r = (48/60) V ≤ 14 W ≤ 1 W ≤ 0,1 W	
Binary input circuits dc voltage RL power consumption U_r = (24/30)V U_r = (48/60)V U_r = (110/125)V U_r = (220/250)V	 U_r = (24/30) V U_r = (48/60) V U_r = (110/125) V U_r = (220/250) V max. 0,05 W/input max. 0,1 W/input max. 0,2 W/input max. 0,4 W/input	 ± 20% ± 20% ± 20% ± 20%
Ambient temperature	20° C	-5° C to +55° C
Ripple in dc auxiliary voltage	max. 2%	
Relative humidity	(10-90)%	(10-90)%

*) max. 350 A for 1 s when COMBIFLEX test switch included together with the product

Table 2: Influencing factors, Permissible influence

Dependence on:	Within nominal range	Within operative range
Ambient temperature	0,01% / °C	Correct function
Ripple in auxiliary dc voltage	Negligible	Correct function
Interruption in auxiliary dc voltage without resetting correct function restart time	 < 50 ms 0 - ∞ < 45 s	 < 50 ms 0 - ∞ < 45 s

Table 3: Electromagnetic compatibility tests

Test	Type test values	Reference standards
1 MHz burst disturbance	2,5 kV	IEC 255-22-1, Class III
Electrostatic discharge	8 kV	IEC 255-22-2, Class III
Fast transient disturbance	4 kV	IEC 255-22-4, Class IV
Radiated electromagnetic field disturbance	10 V/m, (25-1000) MHz	IEC 255-22-3, Class III Draft IEEE/ANSI C37.90.2

Table 4: Insulation tests (reference standard: IEC 255-5)

Test	Type test values
Dielectric test	2,0 kV ac, 1 min
Impulse voltage test	5 kV, 1,2/50 µs, 0,5 J
Insulation resistance	>100 MΩ at 500 V dc

Table 5: Mechanical tests

Test	Type test values	Reference standards
Vibration	Class I	IEC 255-21-1
Shock and bump	Class I	IEC 255-21-2
Seismic	Class I	IEC 255-21-3

Table 6: Contact data (reference standard: IEC 255)

Function or quantity	Trip and Signal relays	Fast signal relays
Max system voltage	250 V ac, dc	250 V ac, dc
Test voltage across open contact, 1 min	1000 V rms	800 V dc
Current carrying capacity continuous 1 s	 8 A 10 A	 8 A 10 A
Making capacity at inductive load with L/R>10 ms 0,2 s 1,0 s	 30 A 10 A	 0,4 A 0,4 A
Breaking capacity for ac, cos φ>0,4	250 V/8,0 A	250 V/8,0 A
Breaking capacity for dc with L/R<40 ms		
Maximum capacitive load	-	

Table 7: Additional General Data

Weight approx.	11 kg
Dimensions width height depth	 336 mm 267 mm 245 mm
Storage temperature	-40° C to +70° C

Table 8: Mean values

Function	Nominal range
Frequency	(0,95-1,05) x f_r
Voltage	(0,1-1,5) x U_r
Current	(0,2-4) x I_r
Active power Reactive power	at $\lvert\cos\varphi\rvert \geq 0,9$ at $\lvert\cos\varphi\rvert \leq 0,8$

Table 9: Event recording

Function	Value
Time tagging resolution	1 ms
Event buffering capacity	
Max. number of events/disturbance report	150
Max. number of disturbance reports	10
Time tagging error with synchronisation once/1s	± 1,5 ms
Time tagging error with synchronisation once/10s	± 1,5 ms
Time tagging error with synchronisation once/60s (minute pulse synchronisation)	± 1,5 ms
Time tagging error without synchronisation	± 3 ms/min

Table 10: Remote serial communication

Function	Value
Protocol	SPA
Communication speed	300, 1200, 2400, 4800 or 9600 bit/s
Slave number	1 to 899
Remote change of active group allowed	yes/no
Remote changed of settings allowed	yes/no
Connectors and optical fibres	glass or plastic

Table 11: Disturbance recorder

Function	Setting range
Number of binary signals	0 - 48
Number of analogue signals	0 - 10
Sampling rate	2 kHz
Recording bandwidth	(5-250) Hz
Overcurrent triggering	(0 - 5000)% of I_r in steps of 1%
Undercurrent triggering	(0 - 200)% of I_r in steps of 1%
	(0 - 200)% of $U_r / \sqrt{3}$ in steps of 1% at 100 V sec
	(0 - 110)% of $U_r / \sqrt{3}$ in steps of 1%
	(50 - 300) ms in steps of 10 ms
	(100 - 3000) ms in steps of 100 ms
	(500 - 4000) ms in steps of 100 ms
Number of recorded disturbances	Max 10 disturbances
Function	**Value**
	(0,01-2,0) x $U_r / \sqrt{3}$ at 100 V sec. 0,1% of $U_r / \sqrt{3}$
	(0,01-110) x I_r (0,01-60) x I_r 0,5% of I_r
Total recording time with 10 analogue and 48 binary signals *) recorded	typical 15 s maximum 40 s with extended memory
Built-in calendar	for 30 years with leap years

*) The amount of harmonics can affect the maximum storage time

Table 12: Zone impedance measuring elements

Function	Value
Operate time typical	 28 ms
Min. operate current	
Resetting ratio	
	three phase or single and three phase
	included in the measuring accuracy
	3, direction selectable 2, direction selectable
Impedance setting range at I_r = 1 A reactive reach positive sequence reactance X1 zero sequence reactance Xo resistive reach positive sequence resistance R1 zero sequence resistance Ro fault resistance for phase - phase faults for phase - earth-faults	 (0,1-150) Ω in steps of 0,01 Ω (0,1-1200) Ω in steps of 0,01 Ω (0,1-150) Ω in steps of 0,01 Ω (0,1-1200) Ω in steps of 0,01 Ω (0,1-150) Ω in steps of 0,01 Ω (0,1-150) Ω in steps of 0,01 Ω
Setting range of timers for impedance zones	 (0 -10) s in steps of 0,001 s

Table 13: Phase selection

Function	Value
Impedance setting range at I_r = 1 A reactive reach positive seq. reactance X_1 zero seq. reactance X_0 resistive reach for phase-phase faults for phase-earth-faults	 (0,1 - 150) Ω in steps of 0,01 Ω (0,1 - 1200) Ω in steps of 0,01 Ω (0,1 - 150) Ω in steps of 0,01 Ω (0,1 - 150) Ω in steps of 0,01 Ω

Table 14: Distance protection: Accuracy data at reference conditions

Type	Voltage range	Current range	SIR	Accuracy
Static accuracy at 0° and 85°	(0,1 - 1,1) x U_r	(0,5 - 30) x I_r	-	± 5%
Static angular accuracy at 0° and 85°	(0,1 - 1,1) x U_r	(0,2 - 30) x I_r	-	± 5°
Max. dynamic overreach at 85° measured with CVTs	-	-	0,5 < SIR < 30	+ 5%

Table 15: Power swing detection element

Function	Setting range
reactive reach at I_r = 1 A resistive reach at I_r = 1 A impedance transition time	(0,1-150) Ω in steps of 0,01 Ω (0,1-150) Ω in steps of 0,01 Ω 40 ms

Table 16: Scheme communication logic with current reversal and weak end infeed logic

Function	Setting range
Coordination timers	
tCoord. timer	(0-100) ms in steps of 1 ms
tSendmin timer	(0-150) ms in steps of 1 ms
Weak end infeed trip and echo function	
voltage check U< *)	(20-80)% $U_r / \sqrt{3}$ in steps of 1%
duration of ECHO signal	200 ms
Unblocking logic	
unblocking timer	(0-100) ms in steps of 1 ms
duration of window timer	150 ms
restart check timer	200 ms
Current reversal logic	
activation time delay	(0-100) ms in steps of 1 ms
time delay of CR, CS	(0-150) ms in steps of 1 ms

*) Voltage check function and corresponding setting is common for the following functions:
- weak end infeed trip and echo
- automatic switch-onto-fault logic
- loss of voltage within the power system supervision function
- undervoltage protection

Table 17: Automatic switch onto fault function

Function	Setting range
Automatic switch onto fault function	
voltage check *)	(20-80)% of $U_r / \sqrt{3}$ in steps of 1%
current check	<10% of I_r
Minimum duration for dead line condition	200 ms

*) Voltage check function and corresponding setting is common for the following functions:
- weak end infeed trip and echo
- automatic switch-onto-fault logic
- loss of voltage within the power system supervision function
- undervoltage protection

Table 18: System supervision functions and stub protection

Function	Setting range
Stub protection I> **)	(20 - 300)% of I_r
Power system supervision	
overload I> **)	(20-300)% of I_r in steps of 1%
time delay	(0-60) s in steps of 1 s
broken conductor	
min. phase current I_{bc}	10% of I_r
min. unsymmetry	20% of max. phase current
time delay	(0-50) s in step of 1 s
loss of voltage function *)	(20-80)% of $U_r / \sqrt{3}$ in steps of 1%
time delay	/ s

*) Voltage check function and corresponding setting is common for the following functions:
- weak end infeed trip and echo
- automatic switch-onto-fault logic
- loss of voltage function
- undervoltage protection

**) Current check function and corresponding setting is common for the following functions:
- stub protection
- overload I >

Table 19: Fuse failure supervision function

Function	Setting range
Zero sequence quantities:	
operating voltage $3U_0$	(10 - 50)% of $U_r / \sqrt{3}$ in steps of 1%
operating current $3I_0$	(10 - 50)% of I_r in steps of 1%

Table 20: CT supervision

Function	Setting range
Operating current I>	(5 - 100)% of I_r in steps of 1%

Table 21: Fault locator

Function	Setting range
Distance to fault locator	
reach for I_r =1 A in	
resistive direction	(0 - 1500) Ω
reactive direction	(0 - 1500) Ω
min measuring cycle	1,75 or 1,25 cycle
phase selection	internal

Table 22: Instantaneous overcurrent protection

	Setting range	Operate time
Operate current	(50-2000)% of I_r in steps of 1%	-
Dynamic overreach at τ < 100 ms	-	-
Minimum operate time at I > 10 x I_{set}		max 15 ms

Table 23: Under- and overvoltage protection

Function	Setting range
Operating voltage	
undervoltage *)	(20-80)% of $U_r / \sqrt{3}$ in steps of 1%
overvoltage	(80-200)% of $U_r / \sqrt{3}$ in steps of 1%
Time delay	
undervoltage	(0 - 5) s in steps of 0,1 s
overvoltage	(0 - 5) s in steps of 0,1 s

*) Voltage check function and corresponding setting is common for the following functions:
- automatic switch-onto-fault logic
- loss of voltage function
- undervoltage protection
- weak end infeed echo and trip

Table 24: Autoreclosing - Single- and/or three-phase

Function	Setting range
Number of autoreclosing shots	1 - 4
Number of autoreclosing programs	8
Auto-reclosing open time: 1-phase shot 1 - t1s 3-phase shot 1 - t1 3-phase shot 2 - t2 3-phase shot 3 - t3 3-phase shot 4 - t4	 (0,2-5,0) s in steps of 0,01 s (0,2-60) s in steps of 0,01 s (1,0-300) s in steps of 1 s (1,0-300) s in steps of 1 s (1,0-300) s in steps of 1 s
Reclaim time - tReclaim	(10-300) s in steps of 1 s
Inhibit reclosing, reset time -tInhibit	(5-30) s in steps of 1 s
Duration of reclosing pulse - tPulse	(0,1-1,0) s in steps of 0,01 s
SC/DL time limit - tSync	(0,5-10,0) s in steps of 0,1 s
Breaker closed before start - tCB	5 s
Resetting of "AR Started" after reclosing - tTrip	(0,2-1,0) s in steps of 0,1 s

Table 25: Synchro-check and energizing check function

Function	Setting range
Synchro check frequency difference limit voltage difference limit phase difference limit	 (50-300) mHz in steps of 10 mHz (5-50)% of $U_r / \sqrt{3}$ in steps of 1% (5-75)° in steps of 1°
Energizing voltage level high voltage level low energizing time	 (70-100)% of $U_r / \sqrt{3}$ in steps of 1% (10-80)% of $U_r / \sqrt{3}$ in steps of 1% (0-1) s in steps of 0,01 s
Operating time	**Value**
For synchro check function For energizing check function	typical 190 ms typical 80 ms

Table 26: Non-directional earth-fault overcurrent protection

Function	Setting range	Accuracy
Basic current for inverse time delay $3I_0$	(5-300)% of I_r in steps of 1%	
Independent time delay	(0-6,0) s in steps of 0,01 s	± 0,5% ± 10 ms
Normal inverse characteristic	k = (0,05-1,1) in steps of 0,01	IEC 255-3 class 5 ± 60 ms
Very inverse characteristic	k = (0,05-1,1) in steps of 0,01	IEC 255-3 class 7,5 ± 60 ms
Extremely inverse characteristic	k = (0,05-1,1) in steps of 0,01	IEC 255-3 class 7,5 ± 60 ms
Logarithmic characteristic $t = 5,8 - 1,35 \times \ln \frac{I}{3I_0}$		± 5% of t at I = (1,3-29) x $3I_0$
tMin for dependent characteristic	(0,05-6,0) s in steps of 0,01 s	
Min. operate current for dependent characteristic IMin	(100-400)% of $3I_0$ in steps of 1%	
Operating time	**Value**	
Resetting time	< 70 ms	

Table 27: Directional earth-fault overcurrent protection

Function		Accuracy
Basic current for inverse time delay: $3I_0$		
Operating value for directional current measurement forward $3I_0$ at $\varphi = 65°$ reverse	(5-35)% of I_r in steps of 1% 60% of the setting for forward operation	
Characteristic angle	65° lagging	
Independent time delay	(0-6,0) s in steps of 0,01 s	± 0,5% ± 10 ms
Normal inverse characteristic	k = (0,05-1,1) in steps of 0,01	IEC 255-3 class 5 ± 60 ms
Very inverse characteristic	k = (0,05-1,1) in steps of 0,01	IEC 255-3 class 7,5 ± 60 ms
Extremely inverse characteristic	k = (0,05-1,1) in steps of 0,01	IEC 255-3 class 7,5 ± 60 ms
Logarithmic characteristic $t = 5,8 - 1,35 \times \ln \frac{I}{3I_0}$		± 5% of t at I = (1,3-29) x $3I_0$
tMin for dependent charact.	(0,05-6,0) s in steps of 0.01 s	
Min. operate current for dependent characteristic IMin	(100-400)% of $3I_0$ in steps of 1%	
Rated voltage	110/√3 V	
Minimum polarising voltage	1% of 110/ √3	
Communication scheme	None, Permissive, Blocking	
Coordination timer tCoord	(0-150) ms in steps of 1 ms	
Weak end infeed voltage check $3U_0$	(5-70)% of 110/ √3 in steps of 1%	
Operating time	**Value**	
Resetting time	< 70 ms	

Table 28: 4 Step earth-fault overcurrent protection

Function	Setting range	
Current level for step 1	(50 - 2500)% of I_r in steps of 1%	
Definite time delay for step 1	(0 - 10,0) s in steps of 0,01	
Current level for step 2	(20 - 1500)% of I_r in steps of 1%	
Definite time delay for step 2	(0 - 10,0) s in steps of 0,01	
Current level for step 3	(20 - 1500)% of I_r in steps of 1%	
Definite time delay for step 3	(0 - 10,0) s in steps of 0,01	
Current level for step 4 definite time delay or minimum operate current for inverse time delay	(4 - 440)% of I_r in steps of 1%	
Definite time delay for step 4 or inverse time additional delay	(0 - 10,0) s in steps of 0,01	
Basic current for inverse time delay	(4 - 110)% of I_r in steps of 1%	
Time multiplier for inverse time delay	(0,05 - 1,10) s in steps of 0,01	
Inverse time minimum delay	(0,00 - 10,00) s in steps of 0,01	
Operating value for directional current measurement forward $3I_0$ at $\varphi = 65°$ reverse	 (5 - 40)% of I_r in steps of 1% 60% of the setting for forward operation	
Level for harmonic restrain	(20 or 32)% of fundamental level	
Weak end infeed voltage check $3U_0$	 (5-70)% of 110 / √3 in steps of 1%	
Coordination timer tCoord	(0 - 150) ms in steps of 1	
Characteristic angle	65° lagging	
Normal inverse characteristic	k = (0,05-1,1) in steps of 0,01	IEC 255-3 class 5 ± 60 ms
Very inverse characteristic	k = (0,05-1,1) in steps of 0,01	IEC 255-3 class 7,5 ± 60 ms
Extremely inverse characteristic	k = (0,05-1,1) in steps of 0,01	IEC 255-3 class 7,5 ± 60 ms
Logarithmic characteristic $t = 5,8 - 1,35 \times \ln\frac{I}{3I_0}$		± 5% of t at I = (1,3-29) x $3I_0$
Rated voltage	110 / √3 V	

Table 29: Breaker failure protection

Function	Setting range
Operating current (one measuring element per phase)	(10-200)% of I_r in steps of 1%
Retrip time delay t1	(0-150) ms in steps of 1 ms
Back-up trip time delay t2	(50-400) ms in steps of 1 ms
	Value
Trip operate time	max 18 ms
Operate time for current detection	max 10 ms

Ordering

The basic version of REL 521 is a phase-to-phase and phase-to-ground line distance protection terminal with three impedance measuring zones and scheme communication logic including current reversal and weak end infeed. High set instantaneous phase overcurrent protection and event recorder are also included in the basic version.

Ordering Number: 1MRK 000 494-AA **Quantity:** ☐

Basic data:

Frequency, f_r	50/60 Hz
Ac voltage, U_r	100/110/115/120 V
Dc voltage, EL	48/60/110/125/220/25 V

Basic data to specify:

Rated current, I_r	☐ 1A	☐ 5A		
Interface dc voltage, RL 1	☐ 24/30 V	☐ 48/60 V	☐ 110/125 V	☐ 220/250 V

Options:

Binary in/out module, 8 inputs and 12 output relays.
Totally 5 I/O modules can be selected.

Quantity (specify interface dc voltage RL2 below) 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Interface dc voltage, RL2:

☐ 24/30 V	☐ 48/60 V	☐ 110/125 V	☐ 220/250 V
1MRK 000 173-GA	1MRK 000 173-AB	1MRK 000 173-BB	1MRK 000 173-CB

Two additional zones	☐ 1MRK 000 251-AA
Single phase tripping	☐ 1MRK 000 252-AA
Automatic switch onto fault logic	☐ 1MRK 000 253-AA
Fuse failure (zero sequence quantities) and CT supervision function	☐ 1MRK 000 254-AB
Power swing blocking	☐ 1MRK 000 255-AA
Autorecloser, single- and/or three-phase	☐ 1MRK 000 257-AA
Synchrocheck and energizing check	☐ 1MRK 000 265-AA
Breaker failure protection	☐ 1MRK 000 258-AA
Earth-fault overcurrent protection (only one alternative can be selected):	
Non-directional	☐ 1MRK 000 259-AA
Directional comparison or non-directional	☐ 1MRK 000 260-AA
4-step earth fault overcurrent protection	☐ 1MRK 000 209-AA
Under/Overvoltage protection	☐ 1MRK 000 256-AA
System supervision functions	☐ 1MRK 000 261-AA
Fault locator	☐ 1MRK 000 262-AA
Disturbance recorder (only one alternative can be selected):	
Disturbance recorder	☐ 1MRK 000 263-AA
Disturbance recorder with extended memory	☐ 1MRK 001 376-AA
On-line control function (10 signals)	☐ 1MRK 000 266-AA
Simulation logic	☐ 1MRK 000 267-AA
Remote communication (SMS/SCS)	☐ 1MRK 000 264-AA

Bus connection unit for remote communication, type SPA-ZC21 (one for each port if used):

Transmitter	Receiver	Quantity:		
Plastic	Plastic	1 ☐	2 ☐	1MRK 000 194-AA
Plastic	Glass	1 ☐	2 ☐	1MRK 000 194-BA
Glass	Plastic	1 ☐	2 ☐	1MRK 000 194-CA
Glass	Glass	1 ☐	2 ☐	1MRK 000 194-DA

COMBITEST test switch module RTXP 24 mounted with the terminal in RHGS6 case with window door ☐ 1MRK 000 371-CA

☐ Internal earthing ☐ External earthing

On/Off switch for the dc-supply ☐ RK795 017-AA

Mounting details with IP40 degree of protection from the front:

19" rack	☐ 1MRK 000 020-BR
Wall mounting	☐ 1MRK 000 020-DA
Flush mounting	☐ 1MRK 000 020-Y
additional for IP54 (protection terminal only)	☐ 1MKC 980 001-2
Semi-flush mounting	☐ 1MRK 000 020-BS
additional for IP54 (protection terminal only)	☐ 1MKC 980 001-2
No mounting details	☐

Accessories:

User's Guide for REL 521 * 1.2	**Quantity:** ☐	1MRK 506 003-UEN
Front connection cable for PC (Opto/9-pol D-sub)	**Quantity:** ☐	1MKC 950 001-1
SMS-BASE, version 2.0, Basic program for SMS and PC front connection	**Quantity:** ☐	RS 881 007-AA
SM/REL 521 SMS Program module for REL 521 * 1.2	**Quantity:** ☐	1MRK 000 314-CB
RECOM Disturbance collection program, version 1.3	**Quantity:** ☐	1MRK 000 077-DB
REVAL Disturbance evaluation program, english version	**Quantity:** ☐	1MRK 000 078-AA
CAP 531 - Graphical configuration tool	**Quantity:** ☐	1MRK 000 876-KA
CAP/REL 521, CAP program module for REL 521 * 1.2 [1]	**Quantity:** ☐	1MRK 000 876-CA

[1] SMS-BASE and SM/REL 521 is required

For our reference and statistics we would be pleased if we are provided with the following application data:

Country: End user:

Station name: Voltage level: kV

Sample specification

Line protection terminal with full scheme distance protection as a main protection function, and a directional or non-directional earth fault overcurrent protection function as an optional complement. The fault location function, included as an option, should have an accuracy higher than 2%, and should not depend on fault resistance, load current, nor supply of a fault from the different sources. The design should be microprocessor-based with at least one microprocessor for each basic protection function.

Remote communication with the line protection terminal should be possible from two different locations and independent on one another.

A distance protection function should contain five independent impedance measuring zones with quadrilateral characteristics and independent settings of the reach in reactive and resistive direction, separately for phase-to-earth and for multiphase faults. The directionality of all zones, independent one another, should be programmable. An earth return compensation should be settable independently for each impedance zone.

The line protection terminal should also be appropriate for the protection of lines within complex network configurations. The full scheme design must assure reliable operation for simultaneous and intersystem faults on multi-circuit lines as well as for the different evolving faults.

The minimum operating time of a protection must not be more than 13 ms. The maximum operating time of distance protection Zone 1, specified for a SIR <10 and faults within 50% of a set reach, must not exceed 40 ms and must be given in the isochronical diagrams measured for the protection terminal connected to capacitive voltage transformers. The characteristic of distance zone 1 in reactive direction must be compensated for a load current. The memory voltage for the proper directional discrimination at close-in three-phase faults should be based on a positive sequence voltage.

It must be possible to select between the directional and non-directional version, when choosing the earth fault overcurrent protection function. Its operation should be based on a measurement of the zero-sequence quantities on the protected line. Time delay should be selectable between independent and all standardized dependent time characteristics.

A wide range of permissive tripping and blocking scheme communication logics should be available for the distance protection as well as for the directional earth fault overcurrent protection function. Scheme communication logics should be independent for both protection schemes with independent communication facilities. Standard logics such as current reversal, weak end infeed echo and trip should be provided for both protection functions. Logics operating without separate reverse directed measuring elements are not acceptable.

Local man machine communication should be based on a user-friendly, menu-structured program, and performed by the use of a permanently installed man machine interface unit, type tested together with a line protection terminal.

The pre-fault and fault values of currents and voltages must be available for fault analyzing purposes. Remote communication should be possible via a local fibre optical network and the standard CCITT telephone network. Corresponding computer programs must be available. The remote setting of the different setting parameters within at least four groups of setting parameters must be possible.

The monitoring and controlling of all input and output logical signals as well as tripping signals must be possible both locally and remotely. Continuous self supervision function with self diagnostic possibilities must be included in a line protection terminal.

References

Series RE 500 Mechanical design mounting accessories	1MRK 514 003-BEN
User´s Guide REL 521 * 1.2	1MRK 506 003-UEN
Reference List REL 521	1MRK 506 003-REN
SPA-ZC 21	34 SPACOM 22 EN1 A
SMS 010	1MRK 511 014-BEN
CAP 531	1MRK 511 034-BEN