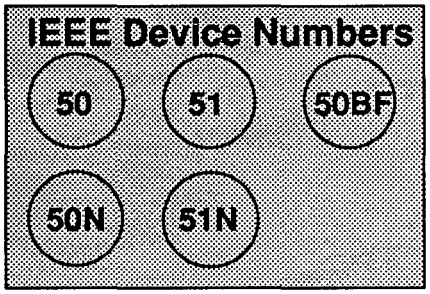
7SJ511 Numerical Overcurrent Protection



Features

- Microprocessor-Based Technology
- Fully Numerical Design
- 3-Phase and Ground Overcurrent Protection
  - Instantaneous (50/50N)
  - Definite Time (51/51N)
  - Inverse Time (51/51N)
- Breaker Failure Protection (50BF)
- Reverse Interlock Bus Protection
- Nonvolatile Memory for Settings, Event Logs, and Targets
- Programmable Binary Inputs, LEDs, Signal and Trip Relays
- Four Independent Setting Groups
- Real Time Clock
- Circuit Breaker Operations Counter
- Accumulated Circuit Breaker Interrupted Current (per pole)
- Circuit Breaker Trip Test
- Two (2) Serial Ports
- IEC 870-5 Communication Standard
- Waveform Capture (20 samples per cycle)
- Target Data
- Operations Event Log
- Current Metering Function (online)
- Isolated DC to DC Power Supply
- Self-Monitoring
- Draw Out Construction

Description

The 7SJ511 is a microprocessor-based, three-phase and ground, overcurrent relay. The user can select definite time or inverse time protection. An additional high-set element can be set as instantaneous or time delayed. Phase and ground settings are independent.

All analog current inputs are isolated with internal transformers. High frequency components are removed by anti-aliasing filters. The inputs are sampled 20 times per cycle and converted to digital signals. Reliable, field-proven, numerical algorithms process the protection functions that include breaker failure protection and reverse interlocking.

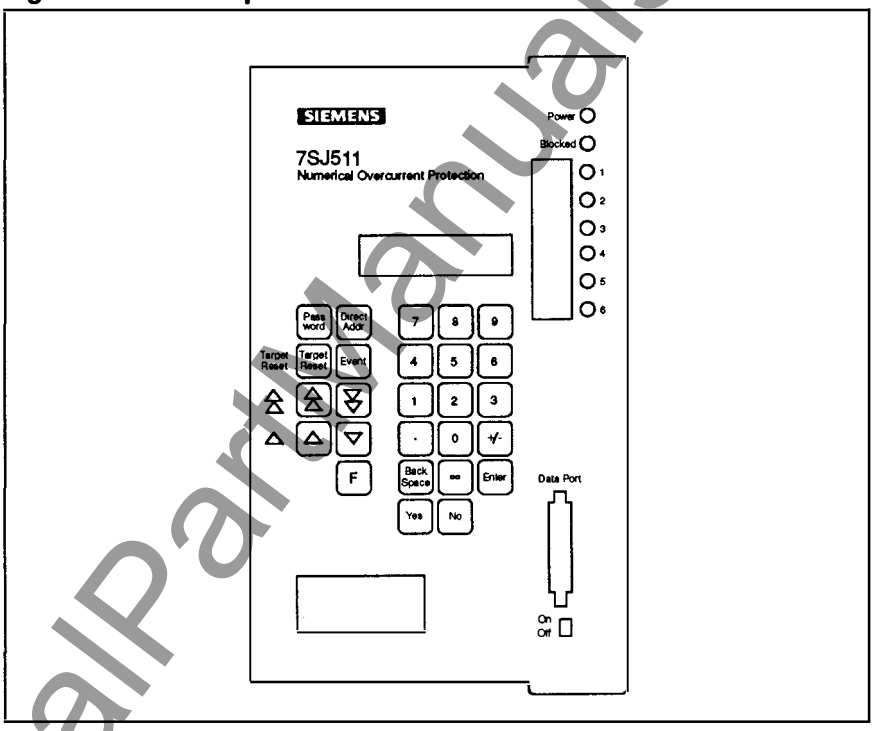
As shown in Figure 1 above, the relays have a built-in numeric key pad and a 32-character liquid crystal display for setting the relay, monitoring measured and calculated values, and readout of various logs. LEDs are provided on the front for quick display of relay status and target indication.

Two serial communication ports are provided: one on the front for local connection of a personal computer for use by an operator, and, optionally, one on the back for connection to a substation control system.

The 7SJ511 has 4 current inputs, 2 optically isolated binary inputs, 2 trip relays, 4 signal relays and 8 LEDs. The ability to program the inputs, outputs and LEDs provides the user flexibility to configure the relay to his specific requirements. Figure 2 shows the 7SJ511 block diagram.

The relays are suitable for either panel or rack mounting and come in either a flush or surface mounting case. External connections are made on the rear for the flush mounting or on the front for the surface mounting. Screw terminals are provided which accept #10 ring lugs for current

Figure 1. 7SJ511 Operator Panel



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circuits and #8 ring lugs for all other circuits.

Draw out construction provides easy removal and replacement of the relay. All CT inputs are automatically shorted and all other circuits are disconnected.

Application

The 7SJ511 relay can be used as primary protection for distribution or subtransmission lines and as backup protection for transmission lines, transformers, and generators.

The 7SJ511 can also be applied as a breaker failure relay initiated by either internal or external trip signals.

For radial distribution substations, bus protection can be implemented using the reverse interlock capability.

Waveform capture can be initiated by trip command, relay pickup, or external command. Up to 150 cycles of data, including 5 prefault cycles, are available. The resolution is 20 samples per cycle (0.83 ms at 60 Hz).

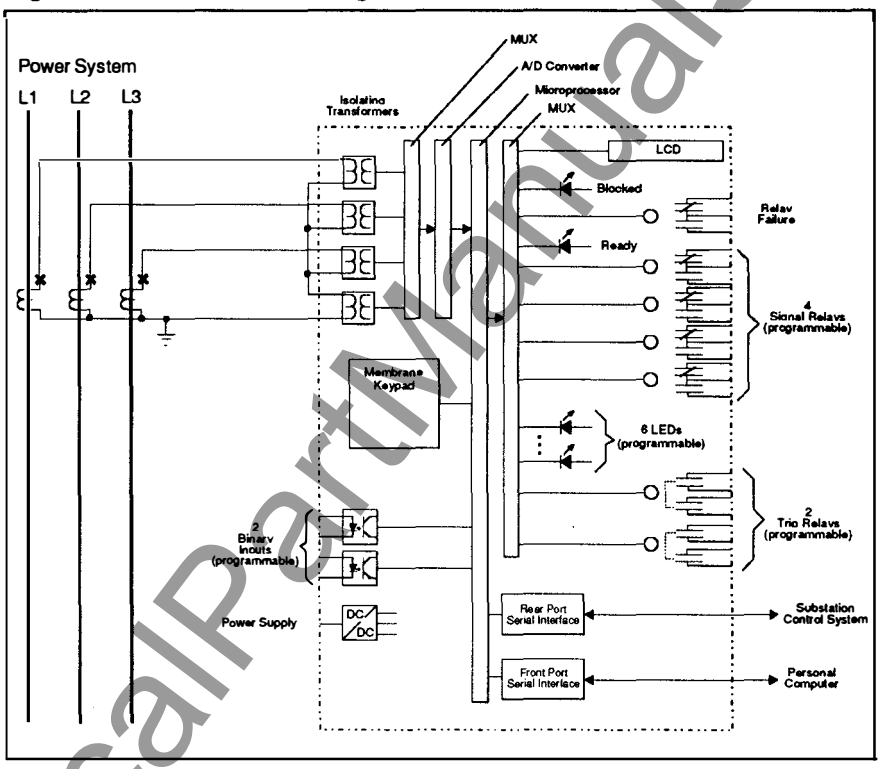
Phase and ground settings are independent. Ground current can be obtained from a separate toroidal CT or from the neutral connection of the three phase CTs.

The 7SJ511 relay stores 4 separate groups of settings. With the Parameter Changeover function, the relay, while not in pick-up, can change its operating settings to another group that accommodates new or changing system conditions. Parameter Changeover can be activated through the operator panel or front serial port, or by a binary input.

Operating Principles

Digitized input values are compared against the programmed protection settings. If the values are above the specified limits, programmed output devices are activated. External control of all protection functions is available through the binary inputs.

Figure 2. 7SJ511 Block Diagram



Overcurrent Protection

The measured values obtained from the current inputs are compared against the programmed overcurrent settings. When the limits are exceeded, a programmed time delay is started. If the fault condition is still present at the expiration of the time delay, the specified trip relays, LEDs, or other output devices are activated. Pick-up values and time delays can be specified separately for phases and ground.

Both definite and inverse time protection elements are provided. The following inverse time characteristics are available:

ANSI Inverse
ANSI Short Inverse
ANSI Long Inverse
ANSI Moderately Inverse
ANSI Very Inverse
ANSI Extremely Inverse
ANSI Slightly Inverse
IEC Normal Inverse
IEC Very Inverse
IEC Extremely Inverse

In addition, an independent high-set overcurrent element for use as an instantaneous or time delayed trip is available.

Breaker Failure Protection

After a circuit breaker has been signalled to trip, the breaker failure protection function can be activated to check for successful operation of

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Figure 3. Connection Diagram

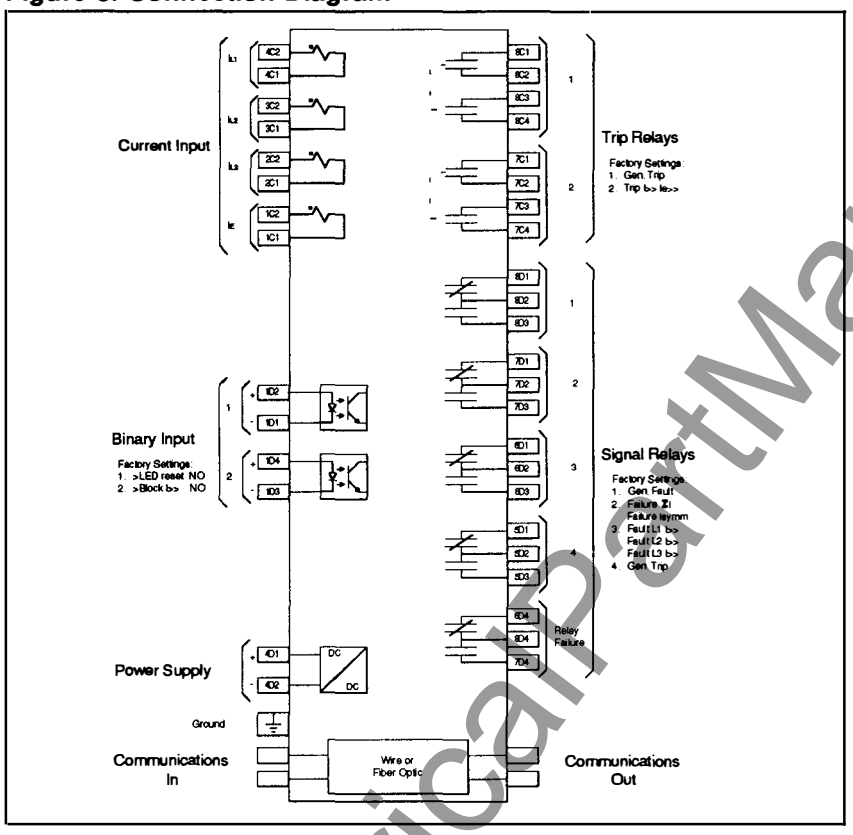
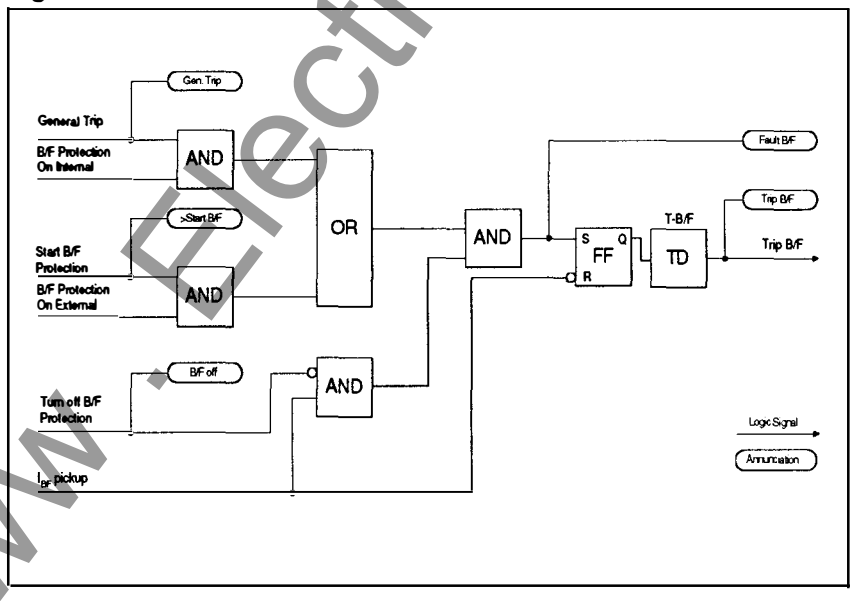


Figure 4. Breaker Failure Protection



the breaker. A timer is started following a trip command, during which the relay checks for removal of the fault current. If the fault current is not removed before the timer expires, the relay can initiate other corrective actions (e.g., retrip, bus clearing). This protective function can also be activated by an external trip command. Figure 4 shows the breaker failure logic.

Reverse Interlocking

The programmability of the 7SJ511 relay allows implementation of reverse interlocking configurations. The principal of reverse interlocking is to block upstream relays by downstream relays so that the relay closest to the fault is the only one that trips. This technique is used for bus protection to prevent the instantaneous element of the relay protecting the supply feeder from tripping on feeder fault (see Figure 5). The time overcurrent element of the supply feeder remains in service at all times for effective local backup.

Programmable Inputs/Outputs

The 7SJ511 relay includes a preprogrammed, integrated trip matrix. The trip and signal relays can be reprogrammed by the user to operate for any internal protection or alarm function, or they can be linked to an external function or command (e.g., block instantaneous trip) via the programmable binary inputs. In addition, the LEDs can be programmed to provide visual indication of trip and alarm functions. These features allow the user to configure the relay to best suit the protection system's requirements and practices.

Programming the relay is accomplished through either the operator panel or the communications feature described below.

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Self-Checking

The 7SJ511 relay incorporates comprehensive monitoring functions which cover both hardware and software. Plausibility checks on the currents monitor the external CT circuits. Detection of a failure will block the relay and provide an alarm contact output. In some cases, an LED indication is available.

Hardware

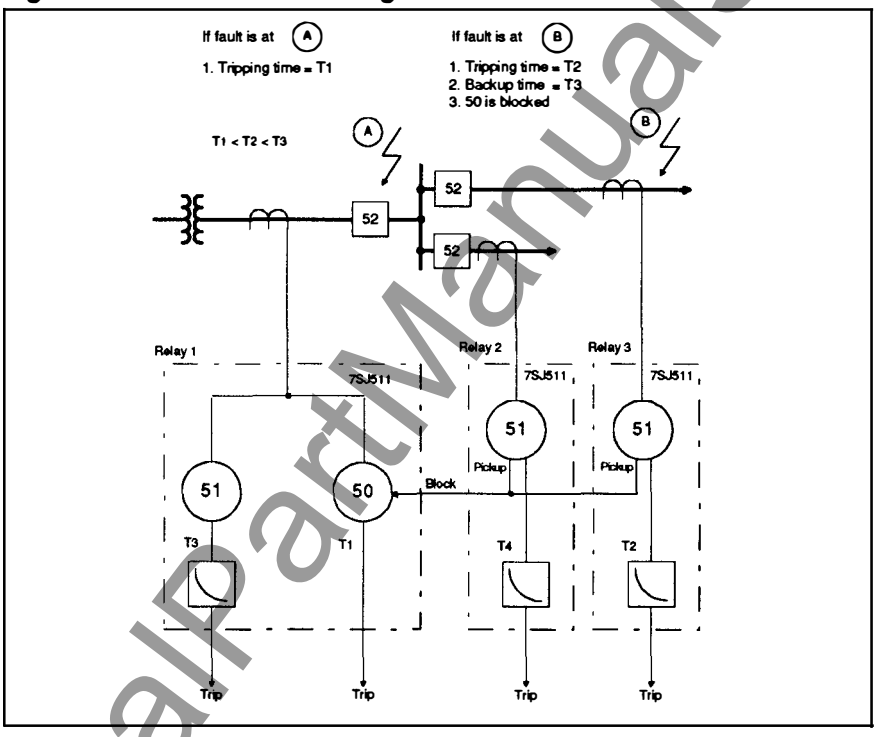
The relay monitors the auxiliary and internal reference voltages, A/D converter, trip circuits and memory modules.

The internal DC voltages are monitored. If the voltages deviate outside the permissible limits, the protection functions are blocked, and an alarm is signaled. The relay can withstand temporary loss of the supply voltage for up to 50 milliseconds with input of 110 volts and above.

The trip relays are controlled by two command channels and one release channel. As long as no protection elements have picked up, the central processor checks the command channels for availability. This is a cyclic check where the channels are excited in sequence and the output signal changes are monitored. If the feedback signal changes to a low level, a fault in a channel or a relay coil is indicated. In this case, the command output is blocked and an alarm is signaled.

The complete current circuit from the CTs to the A/D converters are monitored for problems in any part. The digitized sum of the four converter outputs must always be zero. User settable value for the summation factors provide compensation for for CT performance errors.

Figure 5. Reverse Interlocking



To detect interruptions or short circuits in the external CT circuits (transformers and connections), the system currents are checked for symmetry. During normal operation the currents are approximately symmetrical. If the amount of asymmetry exceeds a user settable threshold, an alarm is signaled. This checking is suspended any time a protection element picks up.

Software

The memory modules are checked through a cyclic checksum process, which is compared to the stored checksum.

A watchdog timer is provided for continuous monitoring of the program sequence. It will reset the processor in the event of a processor failure or if the program falls out of step. Additional plausibility checks are performed to detect faults in the program processing caused by interference. If these faults are not eliminated after three reset attempts, the relay will take itself out of service and activate the alarm contact and LED.

Operational Values

The rms values of phase and neutral currents are available from the front panel LCD or the serial interfaces. Two values may be continuously dislayed on the LCD during normal operation.

Fault Data

The relay stores fault target information for the last three faults. The time that the fault occurred, the element that detected the fault, and the value of the fault current are provided for each record. All of this data is stored in non-volitile memory.

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In addition, the relay can be programmed to display two lines of fault information in the LCD whenever a protection element picks up. LEDs programmed to indicate pickup and/or trip events can be set to retain the indications until acknowledged by an operator.

Waveform Capture

The relay will record the fault waveforms for the last fault. The maximum record length is 150 cycles with a sampling rate of 20 samples per cycle. The record begins 5 cycles before pickup and can extend up to 145 cycles after pickup. An example of the captured data as it can be displayed with appropriate software is shown in Figure 6.

Waveform capture can be initiated three ways: (1) internal fault detection, (2) internal trip, or (3) external command via a binary input.

Communications

An RS-232-C serial interface on the relay's operator panel (see Figure 1) allows you to connect the relay to any personal computer. The Siemens DIGSI® software package, provided with the relay, allows the user to reconfigure the relay, change settings, and retrieve data.

There also is a optional wire (RS-232-C subset) or fiber optic serial interface on the back of the unit, which can be used for online communications with a remote or local substation control or monitoring system.

Figure 6. Waveform Capture

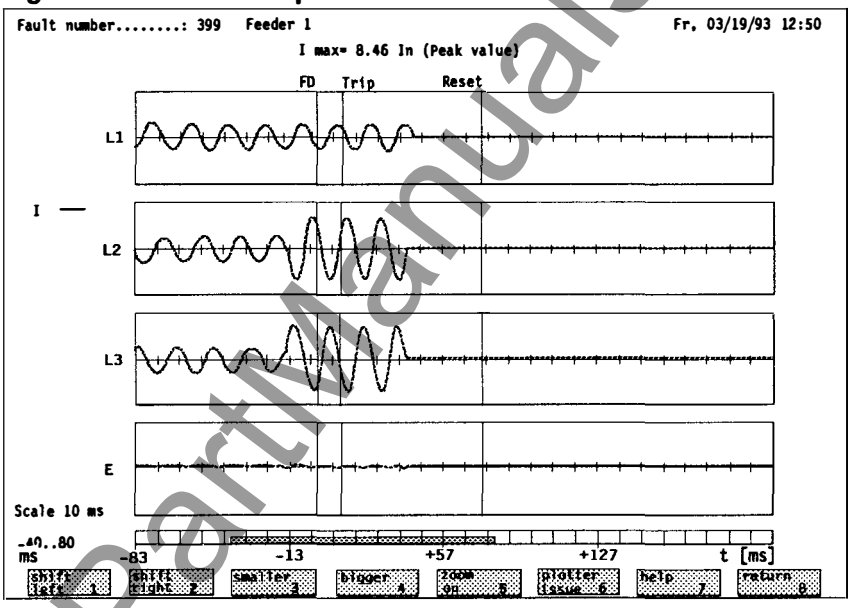

Figure 7. 7SJ511 One Line Diagram

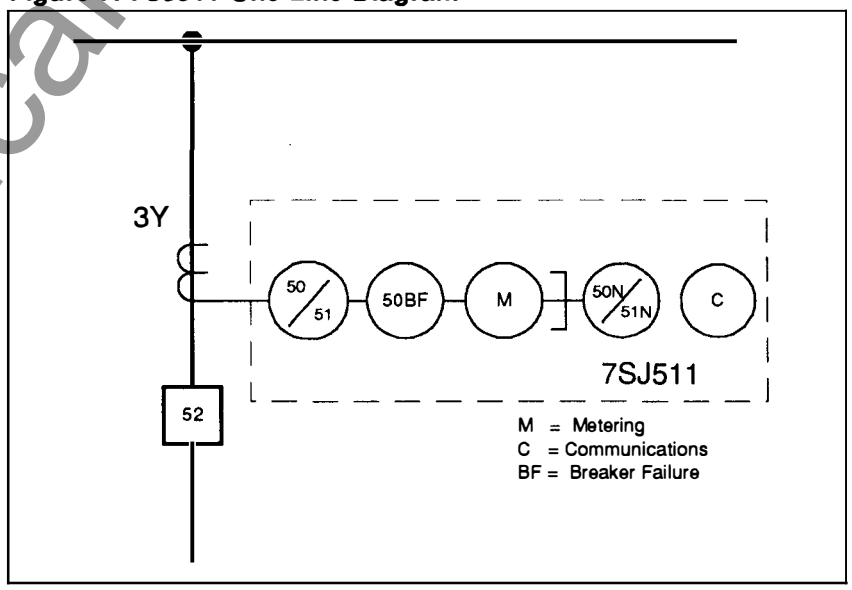

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Figure 8. AC Connections, 3-Phase with Neutral Residual

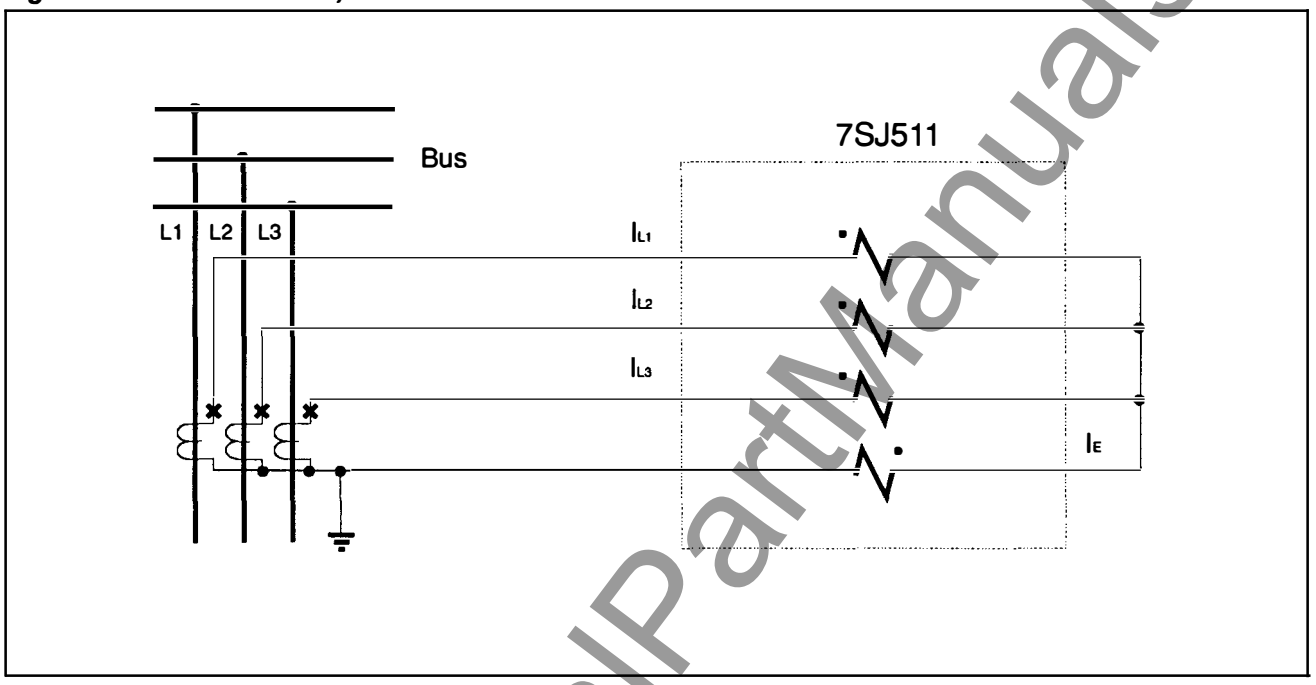
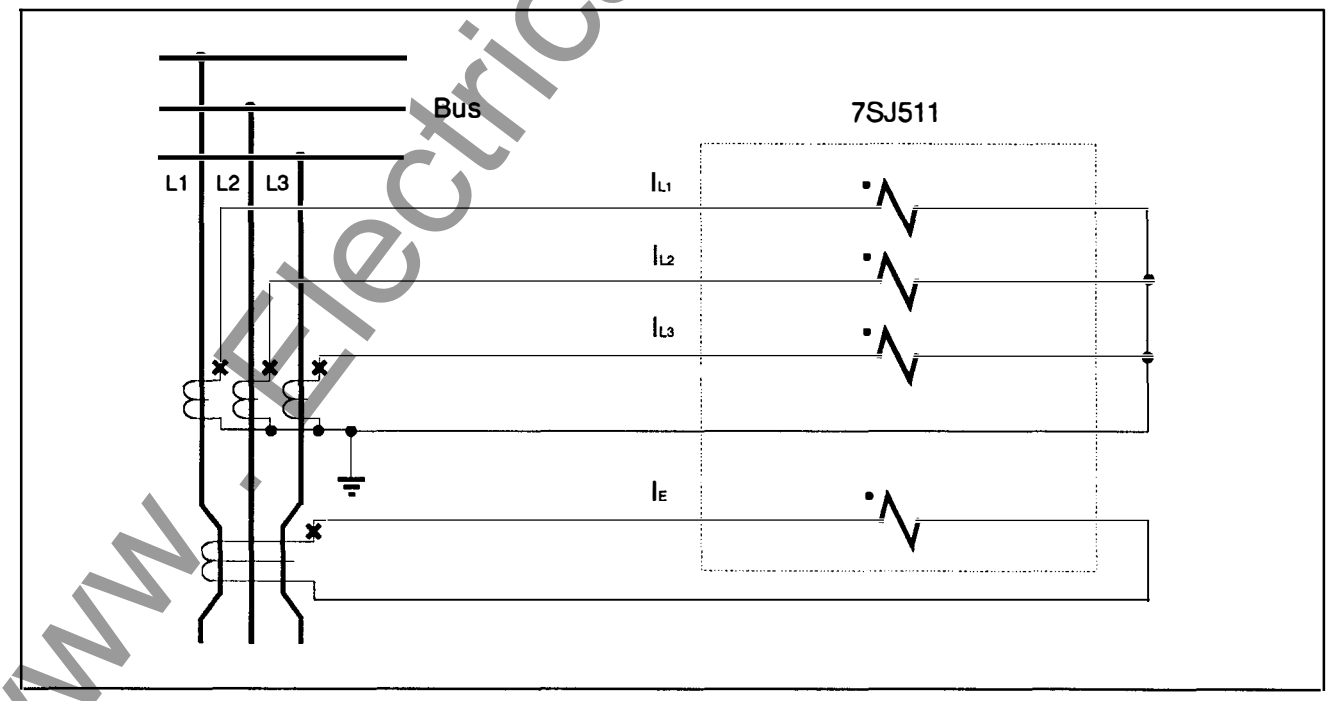


Figure 9. AC Connections, 3-Phase with Toroidal CT



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Technical Data - Relay Specifications

Measuring circuits	Rated current I_N Rated frequency f_N Burden at I_N = 1 A Burden at I_N = 5 A Overload capability: - Thermal (rms) - Dynamic (impulse)	1 A or 5 A 50 Hz/60 Hz (programmable) Approx. 0.1 VA per phase Approx. 0.2 VA per phase 100 x I_N for ≤ 1 s 10 x I_N for ≤ 10 s 4 x I_N continuous 250 x I_N for 1/2 cycle (peak value)
Power system DC power supply via integrated DC/DC converter	Rated voltage V_{HN} (VDC) 24/48 60/110/125 220/250 Ripple, peak-to-peak Power consumption - Quiescent - Energized Loss of DC supply ride-through	Operating range V_H (VDC) 19 to 56 48 to 144 176 to 288 ≤ 12% at rated voltage ≤ 6% at the limits of the voltage ranges Approx. 7 W Approx. 11 W ≥ 50 ms at V_H ≥ 110 VDC
Trip relays	Number of relays Contacts per relay Switching capacity Switching voltage Permissible current	MAKE BREAK	2 2 form A 1000 W/VA 30 W/VA 250 V 5 A continuous, 30 A for 0.5 seconds
Signal/failure relays	Number of signal relays Number of failure relays Contacts per relay Switching capacity Switching voltage Permissible current	MAKE BREAK	4 1 1 form C 20 W/VA 20 W/VA 250 V 1 A
Binary inputs	Number of inputs Operating voltage Current consumption		2 24 VDC to 250 VDC Approx. 2.5 mA, independent of operating voltage
Serial interfaces	Operator interface (front port) - Connection - Transmission speed		Non-isolated 25-pin connector on the front panel, providing an EIA RS-232-C (ISO 2110) interface for connection to a personal computer 1200 bps as delivered max. 38400 bps; min. 1200 bps

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Technical Data - Relay Specifications (cont.)

Serial interfaces (cont.)	Rear port interface - Standards	Isolated Similar to CCITT V.24/V.28, EIA RS-232-C, IEC 870-5 Protocol DIN 19244
	- Transmission speed	9600 bps as delivered max. 19200 bps; min. 4800 bps
	- Hamming distance	d = 4
	- Connection - Wire	At the housing terminals; 2 core pairs, with individual and common shields
	Transmission distance	Max. approx. 0.6 mi (3280 ft) (1000 m)
	Test voltage	2 kV with rated frequency for 1 min
	- Connection - Fiber Optic	Integrated F-SMA connector for direct optical fiber connection, e.g. glass fiber; 62.5/125 µm
	Optical wave length	820nm
	Permissible line attenuation	Max. 8 dB
	Transmission distance	Max. 1.2 mi (2 km)
	Normal signal position	Settable; factory setting: "light off"
Weight	In housing for flush mounting	17.5 lb (8.0 kg)
	In housing for surface mounting	14.5 lb (6.5 kg)

Technical Data - System Specifications (Standards: ANSI C37.90.0, C37.90.1, C37.90.2; IEC 255-5, 255-6)

Insulation tests (ANSI C37.90.0; IEC 255-5)	High voltage test (routine test)	2 kV (rms), 50/60 Hz, 1 min; alt. 2.8 kVDC, 1 min
	Impulse voltage test (type test)	5 kV (peak); 1.2/ 50 µs; 0.5 J; 3 positive and 3 negative shots at intervals of 5 s
Disturbance tests	High frequency test (type test)	2.5 kV (peak); 1 MHz; τ = 15 ms; 400 shots per s for 2 s - ANSI C37.90.1; IEC 255-22-1 class III
	Electrostatic discharge test (type test)	8 kV (peak); 5/30 ns; 10 positive discharges - IEC 255-22-2 class III
	Radiated electromagnetic fields (type test) test with walkie-talkie	68, 151, or 450 MHz - IEC 255-22-3 class III 25 MHz - 1 GHz; 10 V/m - ANSI C37.90.2, C37.90.2
	Fast transients (type test)	2 kV (peak); 5/50 ns; 5 kHz; 4 mJ per shot - IEC 41B (CO) class III 5 kV; 10/150 ns - ANSI C37.90.1
Mechanical stress tests	During operation	10 Hz to 60 Hz: 0.035 mm amplitude 60 Hz to 500 Hz: 0.5 g acceleration
	During transport	5 Hz to 8 Hz: 7.5 mm amplitude 8 Hz to 500 Hz; 2 g acceleration

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Technical Data - System Specifications (cont.)

Climatic tests	Permissible ambient temperature during - Operation - Storage	 -20° C to +55° C (-4° F to +131° F) -25° C to +55° C (-13° F to +131° F)
	Humidity	95% non-condensing

Technical Data - Definite Time Overcurrent Protection (50/50N, 51/51N)

Setting range/steps	Overcurrent pickup setting, I/I_N (phases and neutral)	0.10 to 25.00 (steps 0.01)
	High-set overcurrent pickup setting, I/I_N (phases and neutral)	0.10 to 25.00 (steps 0.01)
	Delay time setting	0.00 s to 60.00 s (steps 0.01 s) or infinite
Times	Pickup time with: 2 x setting value, w/o meas. repetition 2 x setting value, with meas. repetition 5 x setting value, w/o meas. repetition 5 x setting value, with meas. repetition	 Approx. 33 ms Approx. 50 ms Approx. 25 ms Approx. 40 ms
	Reset time	Approx. 50 ms
	Overshot time	Approx. 35 ms
	Reset ratio	Approx. 0.95
Tolerances	Pickup value	± 3% of setting value
	Delay time	± 1% of setting value or 10 ms
Influence variables	Power supply in range: $0.8 \le V_H/V_{HN} \le 1.15$	≤ 1%
	Temperature in range: $0° C \le \Theta_{amb} \le 40° C$	≤ 0.5%/10° C
	Frequency in range: $0.98 \le f/f_N \le 1.02$ $0.95 \le f/f_N \le 1.05$	≤ 1.0% ≤ 2.5%
	Harmonics: Up to 10% of 3rd Up to 10% of 5th	≤1% ≤1%

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Technical Data - Inverse Time Overcurrent Protection (51/51N)

Setting range/steps	Overcurrent pickup setting, $I_p = I/I_N$ (phases and neutral)	0.10 to 4.00 (steps 0.01)
	Time multiplier setting, T_p	0.05 s to 3.20 s (steps 0.01 s) or infinite
Trip Time Characteristics	ANSI - Inverse - Short inverse - Long inverse - Moderately inverse - Very inverse - Extremely inverse - Slightly inverse IEC 255-3 - Normal inverse - Very inverse - Extremely inverse	
	Pickup threshold	1.1 I_p
Tolerances	Pickup value	± 5% of setting value
	Delay time for $2 \le I/I_p \le 20$ if: $T_p = 1$ $T_p \ne 1$	± 5% of setting value Additional ± 2% or at least ± 30 ms
Influence variables	Power supply voltage in range $0.8 \le V_H/V_{HN} \le 1.15$	≤ 1%
	Temperature in range $0° C \le \Theta_{AMB} \le 40° C$	≤ 0.5%/10° C
	Frequency in range $0.95 \le f/f_N \le 1.05$	≤ 8%

Technical Data - Breaker Failure Protection (50BF)

Setting range/steps	Pickup setting, I/I_N (phases and neutral)	0.10 to 4.00 (steps 0.01)
	Delay time setting, T_{BF}	0.06 s to 60.00 s (steps 0.01 s) or infinite
Times	Pickup time with: Internal start External start	 Included in overcurrent time Approx. 50 ms
	Reset time	Approx. 50 ms
Tolerances	Pickup value	± 3% of setting value
	Delay time	± 1% of setting value or at least ± 20 ms

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Technical Data - Ancillary Function Specifications

Operational measured values	Line currents - Measurement range - Tolerance	$I_{L1}, I_{L2}, I_{L3}, I_E$ 0% to 240% of I_N ± 2% of I_N
Measured value plausibility checks	Sum of currents	$I_{L1}, I_{L2}, I_{L3}, I_E$
Steady- state measured value supervision	Current unbalance	I_{max}/I_{min} > symmetry factor as long as $I > I_{limit}$
Waveform capture	Recording time - Front port - Rear port Sampling rate	 5 cycles before fault; up to 145 cycle after fault 3 cycles before fault; up to 30 cycles after fault 20 per cycle
Target log	Fault event data storage - Maximum no. of faults - Maximum no. of events per fault - Sequence/display resolution	 3 most recent 80 1 ms
Event log	Operational data storage - Maximum no. of events - Sequence resolution - Display resolution	 50 most recent 1 ms 1 min
Real time clock	Accuracy Standby power - Type - Life	± 0.01% Internal lithium battery 5 years

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Ordering Information

Model Number 7SJ511☐-☐☐A1☐-0☐

Rated Current (50 or 60 Hz)

1 A	1
5 A	5

Power Supply Input Voltage

24, 48 VDC	2
60, 110, 125 VDC	4
220, 250 VDC	5

Mounting Construction

Surface (projection) mounting	B
Panel flush mounting	C
Panel flush mounting with screw terminals	G

Options

Without real time clock and parameter changeover	0
With real time clock and parameter changeover	1

Serial system interface (rear port)

Without interface	A
With isolated electrical interface	B
With fiber optic interface	C

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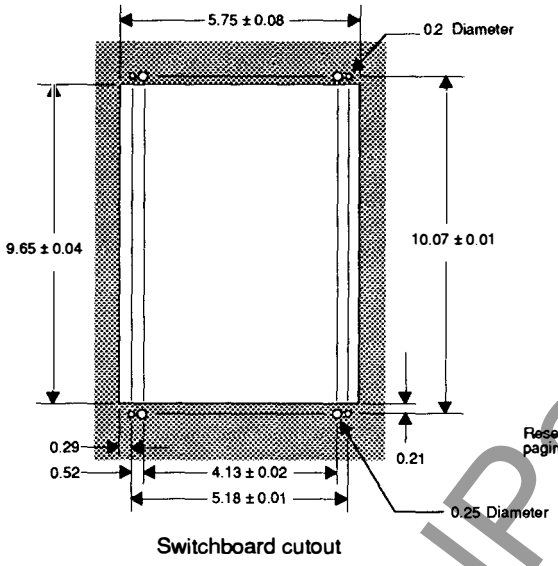
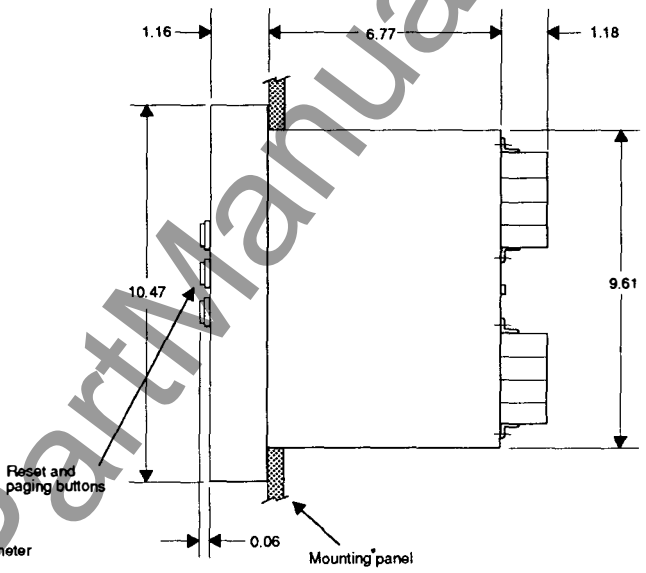
Dimensions - Flush Mounting (inches)

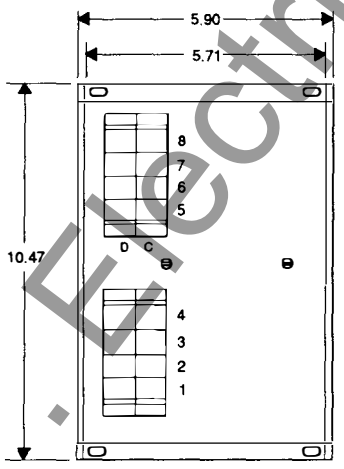


Switchboard cutout

Front view



Side View



Rear View

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Notes:

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Notes:

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