Design Characteristics

- Device Function Numbers
- Differences Among Various Designs:
  - Technology Used (Solid State, VLSI-MOS, Bipolar)
  - Architecture (Single Board, Multi-Processor, Hybrid)
  - Algorithms (All Different)
  - Tripping Characteristics (MHO, Quadrilateral, Selectable)
  - Redundancy (No; Algorithm; Hardware)
  - Novel Features
<table>
<thead>
<tr>
<th>ANSI Numbers (Device Function NO.)</th>
<th>Extract from ANSI/IEEE C37.2-1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Master Element</td>
<td>53 – Field Excitation Relay</td>
</tr>
<tr>
<td>2 - Time Delay Starting or Closing Relay</td>
<td>55 – Power Factor Relay</td>
</tr>
<tr>
<td>3 - Checking or Interlocking Relay</td>
<td>56 – Field Application Relay</td>
</tr>
<tr>
<td>4 - Master Contactor</td>
<td>59 – Overvoltage Relay</td>
</tr>
<tr>
<td>5 - Stopping Device</td>
<td>60 – Voltage or Current Balance Relay</td>
</tr>
<tr>
<td>6 - Starting Circuit Breaker</td>
<td>62 – Time-Delay Stopping or Opening Relay</td>
</tr>
<tr>
<td>7 – Rate of Change Relay</td>
<td>63 – Pressure Switch</td>
</tr>
<tr>
<td>8 - Control Power Disconnecting Device</td>
<td>64 – Ground Detector Relay</td>
</tr>
<tr>
<td>9 - Reversing Device</td>
<td>65 – Governor</td>
</tr>
<tr>
<td>10 - Unit Sequence Switch</td>
<td>66 – Notching or jogging device</td>
</tr>
<tr>
<td>11 – Multifunction Device</td>
<td>67 – AC Directional Overcurrent Relay</td>
</tr>
<tr>
<td>12 - Overspeed Device</td>
<td>68 – Blocking or “out of step” Relay</td>
</tr>
<tr>
<td>13 - Synchronous-speed Device</td>
<td>69 – Permissive Control Device</td>
</tr>
<tr>
<td>14 - Underspeed Device</td>
<td>74 – Alarm Relay</td>
</tr>
<tr>
<td>15 - Speed or Frequency-Matching Device</td>
<td>75 – Position Changing Mechanism</td>
</tr>
<tr>
<td>16 – Data Communications Device</td>
<td>76 – DC Overcurrent Relay</td>
</tr>
<tr>
<td>20 - Elect. operated valve (solenoid valve)</td>
<td>78 – Phase-Angle Measuring Relay</td>
</tr>
<tr>
<td>21 - Distance Relay</td>
<td>79 – AC-Reclosing Relay</td>
</tr>
<tr>
<td>22 – Temperature Control Device</td>
<td>81 – Frequency Relay</td>
</tr>
<tr>
<td>24 – Volts per Hertz Relay</td>
<td>83 – Automatic Selective Control or Transfer Relay</td>
</tr>
<tr>
<td>25 - Synchronizing or Synchronism-Check Device</td>
<td>84 – Operating Mechanism</td>
</tr>
<tr>
<td>26 - Apparatus Thermal Device</td>
<td>85 – Pilot Communications, Carrier or Pilot-Wire Relay</td>
</tr>
<tr>
<td>27 - Undervoltage Relay</td>
<td>86 – Lockout Relay</td>
</tr>
<tr>
<td>30 - Annunciator Relay</td>
<td>87 – Differential Protective Relay</td>
</tr>
<tr>
<td>32 - Directional Power Relay</td>
<td>89 – Line Switch</td>
</tr>
<tr>
<td>36 - Polarity or Polarizing Voltage Devices</td>
<td>90 – Regulating Device</td>
</tr>
<tr>
<td>37 - Undercurrent or Underpower Relay</td>
<td>91 – Voltage Directional Relay</td>
</tr>
<tr>
<td>38 – Bearing Protective Device</td>
<td>92 – Voltage and Power Directional Relay</td>
</tr>
<tr>
<td>39 - Mechanical Conduction Monitor</td>
<td></td>
</tr>
<tr>
<td>40 – Field (over/under excitation) Relay</td>
<td></td>
</tr>
<tr>
<td>41 - Field Circuit Breaker</td>
<td></td>
</tr>
<tr>
<td>42 - Running Circuit Breaker</td>
<td></td>
</tr>
<tr>
<td>43 - Manual Transfer or Selector Device</td>
<td></td>
</tr>
<tr>
<td>46 – Rev. phase or Phase-Bal. Current Relay</td>
<td></td>
</tr>
<tr>
<td>47 - Phase-Seq. or Phase-Bal. Voltage Relay</td>
<td></td>
</tr>
<tr>
<td>48 - Incomplete-Sequence Relay</td>
<td></td>
</tr>
<tr>
<td>49 - Machine or Transformer Thermal Relay</td>
<td></td>
</tr>
<tr>
<td>50 – Instantaneous Overcurrent</td>
<td></td>
</tr>
<tr>
<td>51 - AC Time Overcurrent Relay</td>
<td></td>
</tr>
<tr>
<td>52 - AC Circuit Breaker</td>
<td></td>
</tr>
</tbody>
</table>

**Full List**

**B – Bus**

**F – Field**

**G – Ground or generator**

**N – Neutral**

**T – Transformer**

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Design review

- ABB
  - MDAR (REL-300)
- GE
  - L90
- Schweitzer
  - SEL-121G
  - SEL-411L
- Alstom (Former GEC Alsthom Measurements)
  - QUADRAMHO
  - MiCOM
- Siemens
  - 7SA502
  - 7SA522
  - 7SD80
- Mitsubishi
  - MULTICAP
  - MELPRO-C Series
Numerical Distance Protection MDAR (REL-300) Relaying System (V. 2.71, 1996)

- Multiprocessor Design (16 bit)
- Many Relaying Functions in One Design
- Multiple Communication Interfaces to Other Devices/Systems
- Oscillography Also Available
Features Included in Version V2.71
The following features are **standard** for the Non-Pilot REL300 V2.71:

- 3-Zone phase and ground distance relay, with reversible Zone 3 phase and ground; 4 impedance units per zone: 3 phase-to-ground; 1 phase-to-phase.
- Selectable Zone 1 extension
- Zone 1 timer (0 to 15 cycles)
- Independent timers for phase and ground (T2G, T2P, T3G, T3P)
- Inverse time directional or non-directional (selectable) ground overcurrent backup logic
- Loss of potential supervision (LOP)
- Loss of current monitoring (LOI)
- Overcurrent supervision of phase and ground distance
- Instantaneous forward directional phase and ground highset overcurrent trip (ITP and ITG)
- Close Into Fault Trip (CIFT)
- Stub Bus Protection (89b)
- Unequal-pole-closing load pickup logic
- Selectable Loss-of-Load accelerated trip logic
- Current change fault detector (ΔI)
- Voltage change fault detector (ΔV)
- Line voltage, current and phase angle monitor.
- Last Fault LED now blinks once for a single fault and twice for more than one fault. When the RESET button is depressed, the flashing LED is reset, and the displayed data is returned to the Volts/Amps/Angle...metering mode. REL300 fault data memory cannot be cleared from the front panel. Fault data can be accessed by selecting Last Fault or Previous Fault Display Mode.
- Selectable polarizing for directional O/C ground units (ZSEQ/NSEQ/DUAL)
- Programmable Reclose initiation and reclose block (RB) outputs; Reclose Initiate (RI2) can be enabled with the selection of:
  - 1PR for φG fault
  - 2PR for φG or φφ fault
  - 3PR for φG or φφ fault or 3φ fault
- Numerical (Digital) Processing
- Fault locator
- Self-checking software with Failure Alarm and Displayed error codes
- Input contact status check for input circuits
- Push-to-close test for output contacts
- Software switches for functional tests, e.g., TK (SEND), RS1, RS2 and RS12 (Receivers).
- Trip contact sealed by trip current, with selectable dropout delay timer, 0/50 ms.
- Real-time clock
- 16 fault record storage with selectable capture mode.
- 16 sets of oscillographic data and intermediate target data. Each set includes 7 analog graphic inputs and 24 digital intermediate targets with 8 samples per cycle. Each analog input contains 1 prefault and 7 fault cycles.
- Selectable oscillographic data capture setting trip, Z2PU, Z2Z3 or ΔV/ΔI.
- Selectable Data Capture Setting (FDAT) - TRIP, Z2PU/TRIP, Z2Z3/TRIP.
- Logic for load restrictions
- Selectable phase sequence rotation of ABC or ACB
- 1-way/2-way block logic
Features Included in Version V2.71
The following features are standard for the Pilot REL300 V2.71:

- All features listed as standard for the Non-Pilot REL300 V2.70 are included in the Pilot system
- Independent pilot phase and ground distance units
- Complete Logic and Channel Interface for:
  - Permissive Overreach Transfer Trip (POTT) / Simplified Unblocking
  - Permissive Underreach Transfer Trip (PUTT)
  - Directional Comparison Blocking Scheme (BLK)
  - POTT or Simplified Unblocking Weakfeed
- Instantaneous Forward Directional Overcurrent Function for High Resistance Ground Fault Supplement to Overreach Pilot, with adjustable timer (from 0 to 15) in 1 cycle steps or Block
- Instantaneous Reverse Directional Overcurrent Ground Function
  - Carrier Ground Start on Blocking Scheme
  - Weakfeed System Application
- Reclose Block on Breaker Failure (BF) Squelch
- 3-Terminal Line Application
- Weakfeed Trip

Features Included in Version V2.71
The following features are optional for the Non-Pilot and the Pilot REL300 V2.71:

- Choice of rear communications port options:
  RS232C W/IRIG B PORT/PONI
  RS232C/PONI or INCOM®/PONI
- Optional graphic software program (OSCAR).
- Built-in FT-14 test switches
- Optional Programmable Output Contacts. Eight additional contacts chosen from 30 functions.
- Single-Pole-Trip (SPT) logic and outputs: Consult Factory
4.7 COMMUNICATION INTERFACE

4.7.1 Introduction

Three options are available for interfacing between REL300 and a variety of local and remote communication devices.

- RS-232C - for single point computer communication
- RS-232C (with IRIG-B input) - for single point computer communication and IRIG-B time clock, synchronization input
- INCOM®/PONI1 - for local network communication

An IBM® AT or PC2 compatible computer, with software provided (WRELCOM®), can be used to monitor the settings, 16 fault data, 16 intermediate data, and metering information. For a remote setting, SETR should be set to “YES”; then the settings can be changed (remotely) with a user-defined password. If a user loses his assigned password, a new password can be installed by turning the REL300 relay’s dc power supply “OFF” and then “ON”. REL300 allows a change of password within the next 15 minutes, by using a default “PASSWORD”.

Figure 1-3 INCOM®/PONI Communication Interface Device
4.9 OSCILLOGRAPHIC DATA (Standard)
(Optional Graphic Feature)

Sixteen sets of oscillographic data are stored in REL300. Each set includes seven analog traces ($V_a$, $V_b$, $V_c$, $I_a$, $I_b$, $I_c$, and $I_n$), with one cycle pre-fault and 7-cycle fault information, and 20 sets of digital data based on 8 samples per cycle.

The oscillographic data (OSC) collection can be set for TRIP, Z2TR, Z2/Z3, and $\Delta V\Delta I$. For setting of OSC = TRIP, data are collected for the trip events. The data collection is started from $\Delta V\Delta I$ if the trip occurs within 7 cycles. For OSC = Z2TR, the data collection is triggered by Zone 2 pickup or any types of trip. For OSC = Z2/Z3, the collection is triggered by either Zone 2 or Zone 3 pickup (including the Zone 3 reverse setting) or trip. For OSC = $\Delta V\Delta I$, the data collection is caused by any line disturbance, e.g., a sudden phase current change (by 1 amp) or a ground current change (by 0.5 Amp), or a voltage change ($\Delta V$) greater than 7Vdc.

NOTE: Setting at $\Delta V\Delta I$ is not recommended because a lot of meaningless data will be stored, such as breaker opening or closing, etc.
Line Current Differential System
L90 (V. 6.0X, 2011)

Key Features

- Phase segregated line current differential with adaptive restraint & Ground differential
- Stub bus protection
- Phase Distance (three Zones) with independent compensation settings for in-zone power transformers
- Real time monitoring of remote, local and differential per phase currents
- Oscillography - 64 samples/cycle, up to 64 records
- Event Recorder - 1024 time tagged events, with 0.5ms scan of digital inputs
- Data Logger - Up to 16 channels with user selectable sampling rate
- P & M Class synchrophasors of voltage, current and sequence components – 1 to 120 frames/sec
- Multi-ended fault location consistently providing 2% accuracy
- Ground distance (three zones) with independent self and mutual zero sequence compensation
- Out-of-step tripping and power swing blocking
- Directional overcurrent: Phase, neutral and negative sequence
- Synchronism check for dual breaker applications
Advanced Communications

- Networking interfaces – 100Mbit Fiber Optic Ethernet, RS485, RS232, RS422, G.703, C37.94
- Multiple Protocols – IEC61850, DNP 3.0 Level 2, Modbus RTU, Modbus TCP/IP, IEC60870-5-104, Ethernet Global Data (EGD)
- Direct I/O – secure, high-speed exchange of data between URs for Direct Transfer Trip applications
- Embedded Managed Ethernet Switch with 4 - 100 Mbit Fiber optic ports and 2 copper ports

The L90 supports the most popular industry standard protocols enabling easy, direct integration into monitoring and SCADA systems.

- IEC 61850
- DNP 3.0
- Ethernet Global Data (EGD)

- IEC 60870-5-104
- Modbus RTU, Modbus TCP/IP

Interoperability with Embedded IEC 61850

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SEL-121G Phase Distance Relay, Ground Directional Overcurrent Relay, and Fault Locator 
(Early 1990s)

• Single Processor Design (8 bit) 
• Multi-Function Programmable Design 
• Serial communication 
• Fault Location Available
DATA SHEET

- Three zones of phase distance protection provide complete line coverage
- Multiple residual overcurrent elements give sensitivity for high impedance ground faults
- Three ground directional polarization methods span a variety of system conditions
- Switch-onto-fault logic permits instantaneous tripping for reclosing or line pickup
- Out-of-step blocking of selected zones for power swings
- Programmable three-shot reclosing
- Programmable Mask Logic provides application and testing flexibility
- Load compensating fault locator reduces line patrolling for improved system reliability
- Eleven-cycle event report simplifies fault and system analysis
- Serial communication ports allow local or remote interaction with relay
Table 3: Relay Word Bit Summary

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1ABC</td>
<td>Zone 1 three-phase instantaneous element (includes Z1DP delay) (set by Z1%)</td>
</tr>
<tr>
<td>2ABC</td>
<td>Zone 2 three-phase instantaneous element (set by Z2%)</td>
</tr>
<tr>
<td>3ABC</td>
<td>Zone 3 three-phase instantaneous element (set by Z3%)</td>
</tr>
<tr>
<td>4ABC</td>
<td>Zone 4 three-phase instantaneous element (equal to 1.5 x Z3%)</td>
</tr>
<tr>
<td>LOP</td>
<td>Loss-of-potential condition</td>
</tr>
<tr>
<td>50H</td>
<td>High-level overcurrent element (set by 50H)</td>
</tr>
<tr>
<td>50M</td>
<td>Medium-level overcurrent element (set by 50M)</td>
</tr>
<tr>
<td>50L</td>
<td>Phase fault current supervision (set by 50L)</td>
</tr>
<tr>
<td>51NT</td>
<td>Residual time-overcurrent trip (set by 51NP, 51NTD, and 51NC)</td>
</tr>
<tr>
<td>67N1</td>
<td>Residual instantaneous-overcurrent (includes Z1DG delay) (set by 50N1P)</td>
</tr>
<tr>
<td>67N2</td>
<td>Residual instantaneous-overcurrent (set by 50N2P)</td>
</tr>
<tr>
<td>67N3</td>
<td>Residual instantaneous-overcurrent (set by 50N3P)</td>
</tr>
<tr>
<td>51NP</td>
<td>Residual time-overcurrent pickup</td>
</tr>
<tr>
<td>Z1P</td>
<td>Zone 1 phase-phase element (includes Z1DP delay) (set by Z1%)</td>
</tr>
<tr>
<td>Z2P</td>
<td>Zone 2 phase-phase element (set by Z2%)</td>
</tr>
<tr>
<td>Z3P</td>
<td>Zone 3 phase-phase element (set by Z3%)</td>
</tr>
<tr>
<td>Z2PT</td>
<td>Zone 2 phase-phase or three-phase timeout (set by Z2DP)</td>
</tr>
<tr>
<td>Z3PT</td>
<td>Zone 3 phase-phase or three-phase timeout (set by Z3DP)</td>
</tr>
<tr>
<td>OSB</td>
<td>Out-of-step block</td>
</tr>
<tr>
<td>3P50</td>
<td>Three-phase fault current supervision</td>
</tr>
<tr>
<td>50MF</td>
<td>Asserts a settable delay after LOP and 50M pickup (delay set by 50MFD)</td>
</tr>
<tr>
<td>RC</td>
<td>Reclose cancel</td>
</tr>
<tr>
<td>RI</td>
<td>Reclose initiate</td>
</tr>
<tr>
<td>DF</td>
<td>Direction forward for ground faults</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALRM</td>
<td>System alarm</td>
</tr>
<tr>
<td>TRIP</td>
<td>Trip condition</td>
</tr>
<tr>
<td>TC</td>
<td>Trip (OPEN) Command</td>
</tr>
<tr>
<td>DT</td>
<td>Direct Trip (or other user defined external purposes)</td>
</tr>
<tr>
<td>52BT</td>
<td>Inverted time delayed 52A follower (delay set by 52BT setting)</td>
</tr>
<tr>
<td>52AT</td>
<td>Time-delayed 52A follower (delay set by 52BT setting)</td>
</tr>
<tr>
<td>Z2GT</td>
<td>Zone 2 timeout-ground (set by Z2DG)</td>
</tr>
<tr>
<td>Z3GT</td>
<td>Zone 3 timeout-ground (set by Z3DG)</td>
</tr>
</tbody>
</table>

1 The 50N elements are made directional by enabling any of the directional control methods, i.e., 32QE = Y, or either 32VE = Y or 32IE = Y.
Figure 6: SEL-121G Relay Typical Ac Current and Voltage Connections
• Applies differential and distance protection in one relay (distance as backup when differential is disabled)

• Incorporate IEEE C37.118 synchrophasor measurements into wide-area protection and control systems

• Provides multi-terminal fault location

• Serial or Ethernet communications
Full Scheme and Overcurrent Backup

- Apply differential and distance protection in one relay.
- Enable distance backup when differential protection is disabled.
- Use Mirrored Bits communications permissive signals sent over the same or different paths from the differential communications.
- Apply and coordinate single- and three-pole tripping for improved stability.
Use fiber or electric connections for one or two communications channels. Simple, removable tray and self identification make changing channel types easy.

Communicate using fiber or copper Ethernet for engineering access, SCADA, IEC 61850 GOOSE, or multiterminal differential protection.

Use high-speed contacts for tripping and standard contacts for alarms and interlocking.

Apply six current inputs for double-breaker applications.

Connect six voltage inputs for alternate voltage source or synchronizing.
QUADRAMHO
GEC Static Distance Relay
(1984 or earlier)

Features

- Full scheme 3-zone distance relay with 18 measuring elements.
- Characteristic shapes to suit all line lengths and fault levels.
- Fast operating times over a very wide range of fault conditions.
- Digital synchronous polarising for close-up three phase faults.
- Microprocessor scheme logic with wide range of built-in schemes selected by option switches.
- Ample input/output facilities - 5 optically coupled inputs, 24 output contacts, 10 light emitting diodes.
- Full range of test features for commissioning and routine testing. Interfacing enables automatic field test equipment to be used if required.
- Continuous self monitoring, on-demand and periodic self-testing.
- Built-in voltage transformer supervision.

Models available

Two models are available with the following characteristics:
- Zone 1 and 2
  Shaped partially cross-polarised mho with partially cross-polarised directional line.
  Zone 3
  Offset lens, (adjustable to offset circular mho).
- Zone 1 and 2 ground faults:
  Quadrilateral with partially cross-polarised directional line.
  Zone 1 and 2 phase faults:
  Shaped partially cross-polarised mho with partially cross-polarised directional line.
  Zone 3 ground faults:
  Offset quadrilateral.
  Zone 3 phase faults:
  Offset circular mho.

Application

The QUADRAMHO distance relay has been designed and developed for high speed protection of medium and high voltage transmission, sub-transmission and distribution lines. The full scheme design offers many advantages over switched relays traditionally used in this application. The full scheme arrangement uses 18 comparators eliminating the need for starting relays and switching circuits, thus providing a high degree of reliability and faster operating times.

The relay is suitable for both three pole and single-end-three-pole tripping of the circuit breaker. Either busbar or line voltage transformers may be used and these can be either capacitor VT's or electro-magnetic VT's.

CT requirements are moderate as the relay is highly tolerant of saturated current transformers.

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Figure 11: External connection diagram: Quadramho static distance protection relay. Single and three phase tripping.
Numerical Distance Protection Relays
MiCOM P44X (2011)

- Fault locator
- Display of instantaneous measured and derived values
- Circuit breaker control, status & condition monitoring.
- Trip circuit and coil supervision
- 4 alternative setting groups
- Programmable scheme logic
- Sequence of event recording
- Comprehensive disturbance recording (waveform capture)
- User configurable LEDs
  - Local and remote communication ports
  - Multiple communication protocol and interface options
  - Time synchronisation
  - Fully customisable menu texts
  - Multi level password protection
  - Test facilities
  - Power-up diagnostics and continuous self monitoring of the relay
  - User friendly setting and analysis software (MiCOM S1 Studio)
SCADA Communication
Siemens 7SA502 Distance Protection (1985)

• The First Microprocessor-Based Multi-Function Relays (7SA500 and 7SA502)
• Multi-Processor (16 bit)
• Many Relaying Functions in One Design
• Serial Communication Interface to System Operator and Substation System
• Fault Locator and Oscilloscopy Available
Fig. 6: TSA502, Block Diagramm
Siemens 7SA522
Distance Protection
(V. 4.3, 2004)

Protection functions

- Non-switched distance protection with 6 measuring systems (21/21N)
- High resistance ground (earth)-fault protection for single and three-phase tripping (50N, 51N, 67N)
- Tele (pilot) protection (85)
- Fault locator (FL)
- Power swing detection / tripping (68/68T)
- Phase-overcurrent protection (50/51)
- STUB bus overcurrent protection (50STUB)
- Switch-onto-fault protection (50HS)
- Over/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure (79)
- Synchro-check (25)
- Circuit-breaker failure protection (50BF)

Control functions

- Commands for control of CB and isolators

Monitoring functions

- Trip circuit supervision (74TC)
- Self-supervision of the relay
- Measured-value supervision
- Event logging/fault logging
- Oscillographic fault recording
- Switching statistics

Communication interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
  - IEC 61850 Ethernet
  - IEC 60870-5-103 protocol
  - PROFIBUS-FMS/-DP
  - DNP 3.0
- 2 serial protection data interfaces for tele (pilot) protection
- Rear-side service/modem interface
- Time synchronisation via IRIG B or DCF77 or system interface

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Communication is accomplished via direct optical fibre connections or communication networks. It depends on the distance and the transmission means what media is used. For shorter distances a direct connection via optical fibres with a transmission rate of 512 kBit/s is possible. Otherwise we recommend communication converters. A transmission via modem and communication networks can also be realized. Please take into consideration that the response times of the protection data communication depend on the transmission quality and increase in case of a reduced transmission quality and/or an increased transmission time.
SIEMENS 7SD80 (SIPROTEC Compact Series)

Line Differential Protection (2011)

Suitable for solid, low and high resistance as well as resonance earthed or isolated networks.

**Protection functions**

- Line differential protection phase (87L)
- 310 line differential protection (87N L)
- Ground-fault differential protection for isolated/resonance-earthed networks (87Ns L)
- Definite/inverse time-overcurrent protection (50 TD, 50N TD, 51, 51N)
- Directional definite/inverse time-overcurrent protection (67, 67N)
- Breaker-failure protection (50BF)
- Trip-circuit supervision (74 TC)
- Lockout (86)
- CB intertripping function (85 DT)
- External trip initiation
- Under-/overvoltage protection (27/59)
- Under-/overfrequency protection (81 U/O)

**Control functions/programmable logic**

- Automatic reclosure function (79)
- Flexible protection function for current, voltage, power, cos φ, frequency
- Overload protection (49)
- Control commands for CB, disconnect switches, earth switches
- Control via keyboard, binary inputs, DIGSI 4 or protocol interface
- User-defined PLC logic with CFC (e.g. interlocking)
Communication Interfaces

- System/service interface
  - IEC 61850
  - IEC 60870-5-103
  - Profibus DP
  - DNP 3.0
  - MODBUS RTU
  - DIGSI RS232/RS485

- USB front interface for DIGSI

- Protection Data Interface
  - FO (up to 24 km)
  - Copper Wires (up to 20km)
Multiple Control and Protection Modular System (Multicap) (1986 or earlier)

- Single Processor and Multiprocessor Design (8 and/or 16 bits)
- Most Relaying, Control and Measurement Functions can be Implemented Using Modular Design
- Extensive Local and Remote User Interfaces
- Provides for Implementation of Most of the Substation Functions
<table>
<thead>
<tr>
<th>Type name</th>
<th>Function</th>
<th>Device function No.</th>
<th>µ-P bit</th>
<th>size</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBV</td>
<td>Voltage</td>
<td>27 + 64, 27 + 59, 64</td>
<td>8</td>
<td>U-1</td>
</tr>
<tr>
<td>COC</td>
<td>Overcurrent</td>
<td>50 + 51</td>
<td>8</td>
<td>U-1</td>
</tr>
<tr>
<td>CDO</td>
<td>Directional OC</td>
<td>67, 67+67G</td>
<td>16</td>
<td>U-3</td>
</tr>
<tr>
<td>CDG</td>
<td>Directional ground</td>
<td>67G</td>
<td>8</td>
<td>U-1</td>
</tr>
<tr>
<td>CAV</td>
<td>High impedance</td>
<td>87G</td>
<td>8</td>
<td>U-1</td>
</tr>
<tr>
<td>CAC</td>
<td>Current differential</td>
<td>87</td>
<td>16</td>
<td>U-3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type name</th>
<th>Function</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CSY</td>
<td>Synchronized closing</td>
<td>25</td>
<td>16</td>
<td>U-3</td>
</tr>
<tr>
<td>CFV</td>
<td>Frequency load</td>
<td>81</td>
<td>16</td>
<td>U-3</td>
</tr>
<tr>
<td>CRE</td>
<td>Reclose</td>
<td>79</td>
<td>8</td>
<td>U-1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type name</th>
<th>Function</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CNP</td>
<td>Spot network</td>
<td>Trip ... 51L + 51H + 67</td>
<td>16</td>
<td>U-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Close ... 84 + 78 + 27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CGP</td>
<td>Generator</td>
<td>51 + 46 + 67R + 51G + 64</td>
<td>16</td>
<td>U-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ 59 and A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMP</td>
<td>Motor</td>
<td>49 + 50 + 51 + 51G + 67G</td>
<td>16</td>
<td>U-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPP</td>
<td>Parallel running</td>
<td>67P + 67Q + 37</td>
<td>16</td>
<td>U-3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type name</th>
<th>Function</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CDA</td>
<td>Measuring and data transmission</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**Fig. 5 MULTICAP series configuration**

Note: A: Ammeter
<table>
<thead>
<tr>
<th>No.</th>
<th>Module classification</th>
<th>Example of system application</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Single function module (8 bit)</td>
<td><img src="#" alt="Diagram" /></td>
</tr>
<tr>
<td>2</td>
<td>Control module (16 bit)</td>
<td><img src="#" alt="Diagram" /></td>
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<tr>
<td>3</td>
<td>Multiple function module (16 bit)</td>
<td><img src="#" alt="Diagram" /></td>
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<tr>
<td>4</td>
<td>Single function module (8 bit) Measurement and transmission module (16 bit)</td>
<td><img src="#" alt="Diagram" /></td>
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</tbody>
</table>

**Fig. 8 Example of MULTICAP system configuration**
MELPRO-C Series
Integrated Protection and Control System (2001)

- Integration of protection and control
- Compact Design
- User-friendly computer display
- Programmable and adaptive
- Offers self diagnosis
- Allows for import of new functions as system and technology develop

Table 1 MELPRO-C Series Product Line

<table>
<thead>
<tr>
<th>Application</th>
<th>Scheme</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission lines protection</td>
<td>PCM current differential, Distance relay</td>
<td>MCD-H</td>
</tr>
<tr>
<td>Busbar protection</td>
<td>Current differential, High impedance differential</td>
<td>MBP-H, MBP-H3</td>
</tr>
<tr>
<td>CB failure protection</td>
<td>High speed OC</td>
<td>MBF-H</td>
</tr>
<tr>
<td>Transfer protection</td>
<td>Ratio differential</td>
<td>MTP-H</td>
</tr>
<tr>
<td>Feeder line protection</td>
<td>OC/OCG, UV/OVG directional earth fault</td>
<td>MFP-H</td>
</tr>
<tr>
<td>Feeder line management</td>
<td>OC/OCG, UV/OVG directional earth fault, control</td>
<td>FTU</td>
</tr>
<tr>
<td>Generator protection</td>
<td>Ratio differential, negative OC</td>
<td>MGP-H</td>
</tr>
</tbody>
</table>
Fig. 1 Integrated protection and control system with IEDs

Fig. 3 Hardware block diagram