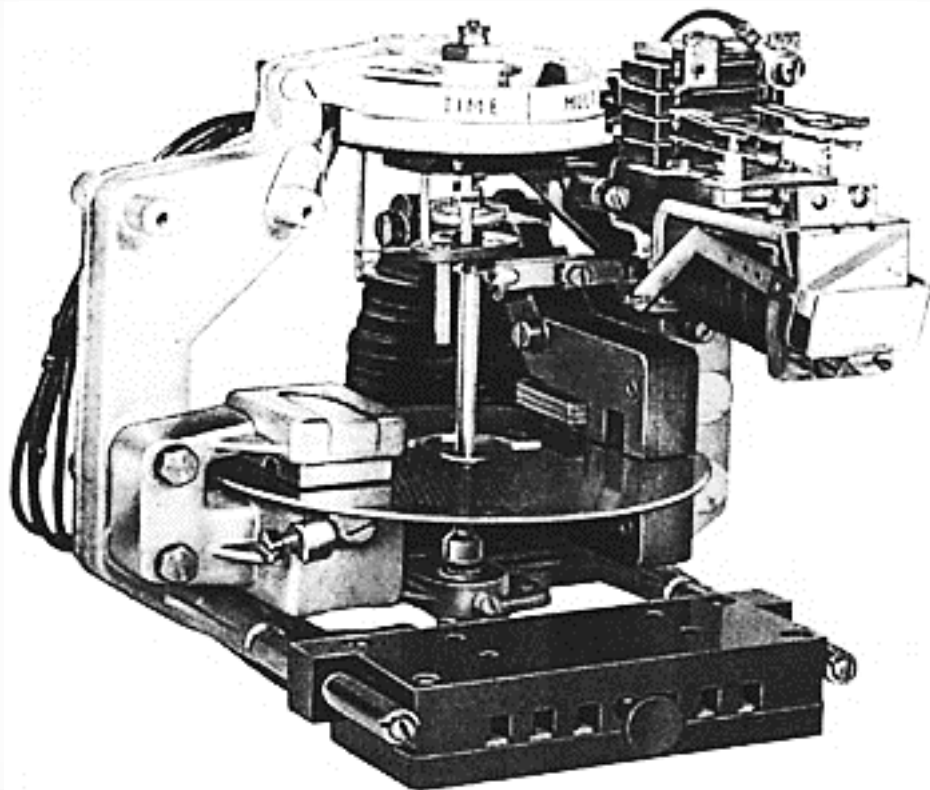# Numerical Relay

HAMED NAJAFIPOUR
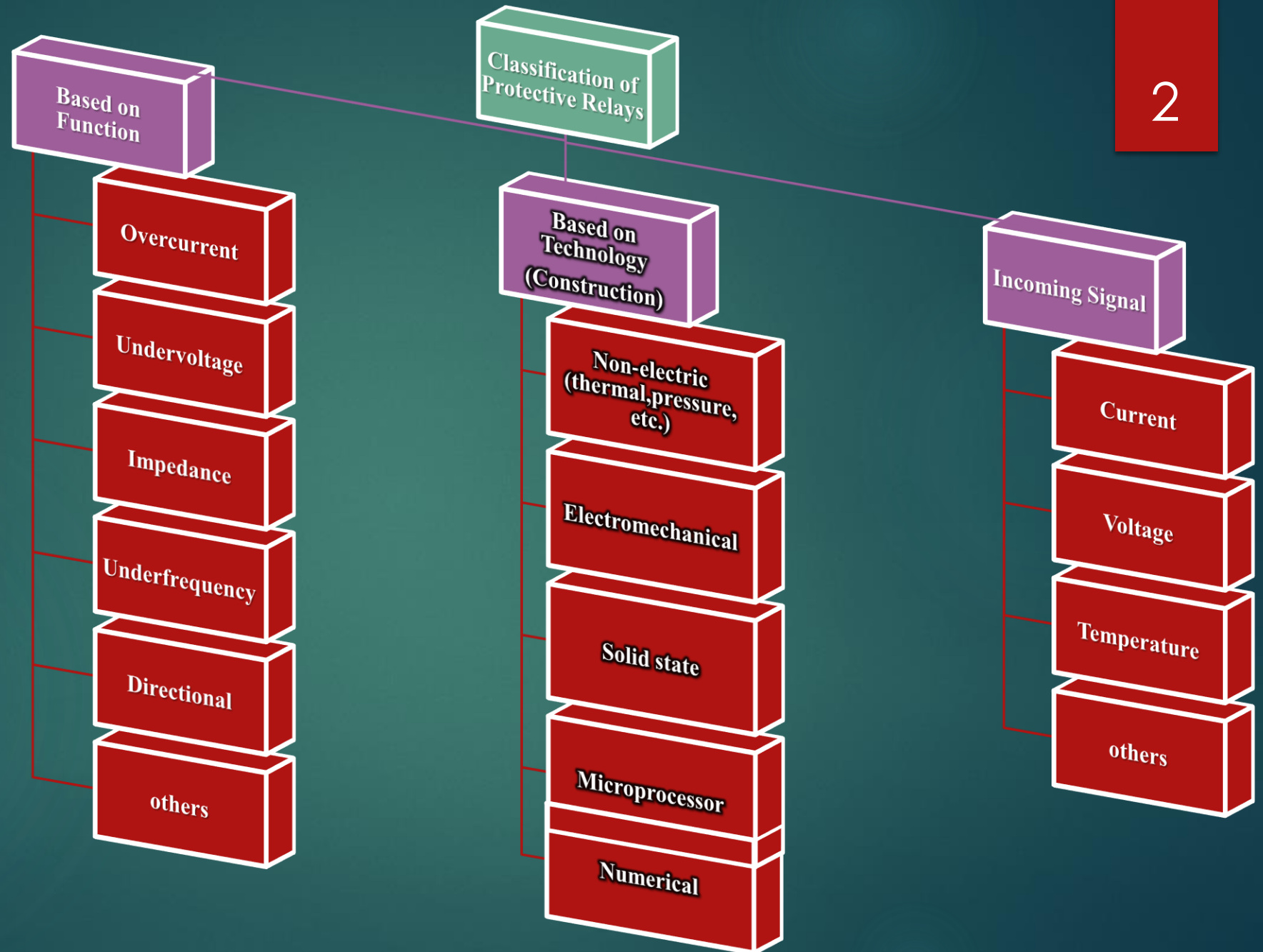
SRTTU

December 2018

Overview

A protection relay is a device that senses any change in the signal it is receiving, usually from a current and/or voltage source. If the magnitude of the incoming signal is outside a pre-set value the relay will carry out a specific operation, generally to close or open electrical contacts to initiate some further operation, for example the tripping of a circuit breaker.

Classification of Protective Relays

Based on Function
- Overcurrent
- Undervoltage
- Impedance
- Underfrequency
- Directional
- others

Based on Technology (Construction)
- Non-electric (thermal, pressure, etc.)
- Electromechanical
- Solid state
- Microprocessor
- Numerical

Incoming Signal
- Current
- Voltage
- Temperature
- others

Classification of Protective Relays

Based on Technology (Construction)

Non-electric (thermal, pressure, etc.)

Electromechanical

Solid state
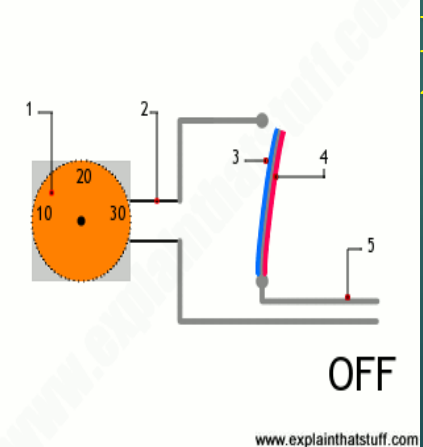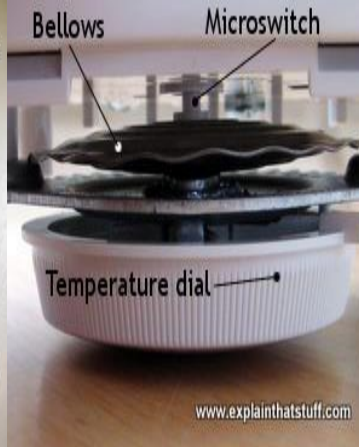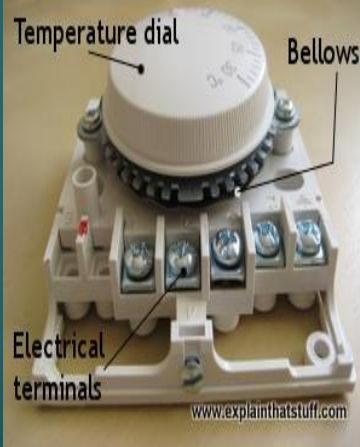
Microprocessor

Numerical

Two ball-shaped floats and two glass-enclosed reed switches are visible inside this cutaway view of a **Buchholz relay**

https://en.wikipedia.org/wiki/Buchholz_relay

Centrifugal switch

https://www.witmermotorservice.com/

Bimetallic thermostat

Temperature dial

Bellows

Bellows

Microswitch

Temperature dial
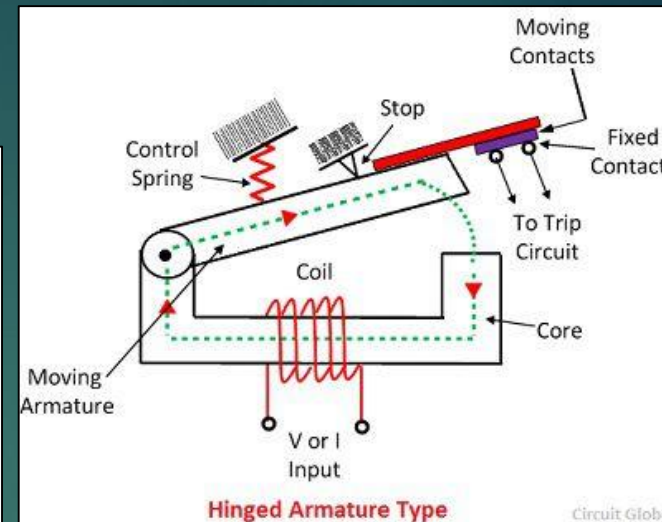
1 2

3 4

20

10 30

5

OFF

www.explainthatstuff.com

Electrical terminals

www.explainthatstuff.com

www.explainthatstuff.com

www.explainthatstuff.com

Classification of Protective Relays

Based on Technology (Construction)

Non-electric (thermal, pressure, etc.)

Electromechanical

Solid state

Microprocessor

Numerical

Attraction:
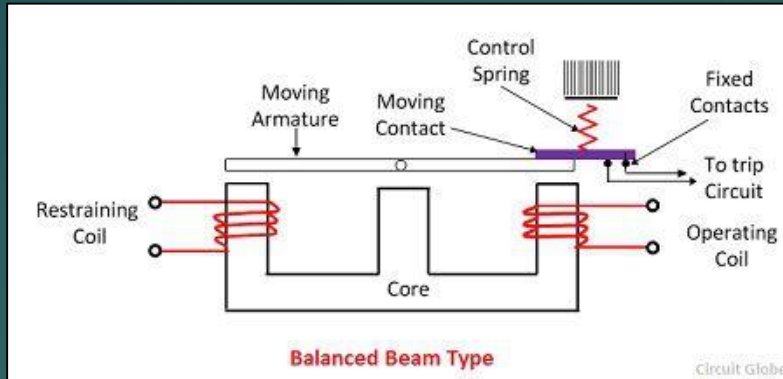
Balanced Beam Type

Hinged Armature Type

Induction:

Induction Cup Relay

Shaded Pole Construction of Induction Disc Relay

Watt-hour Meter Type Induction Disc Relay

Classification of Protective Relays

Based on Technology (Construction)

Non-electric (thermal, pressure, etc.)

Electromechanical

Solid state

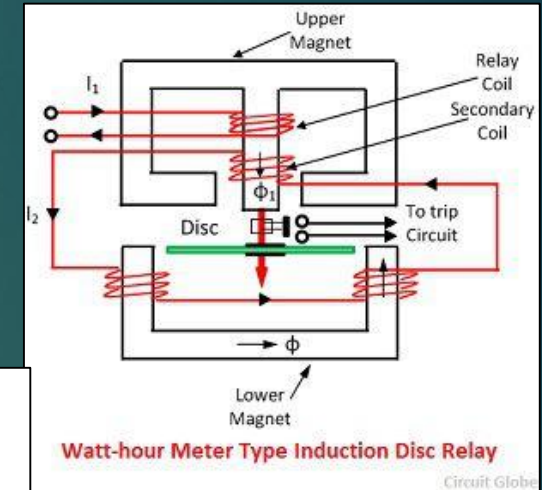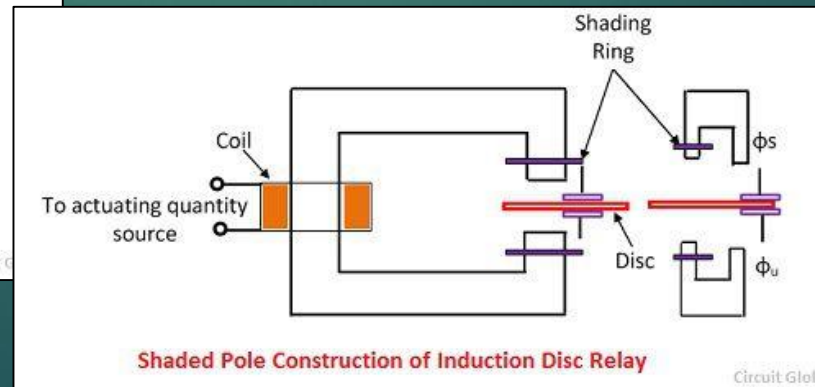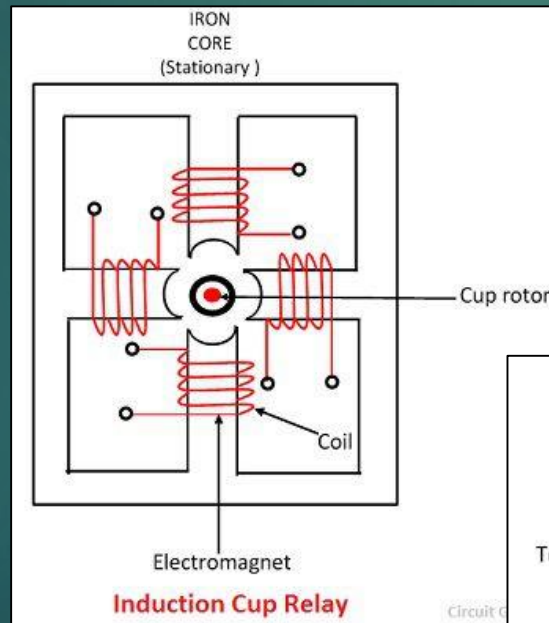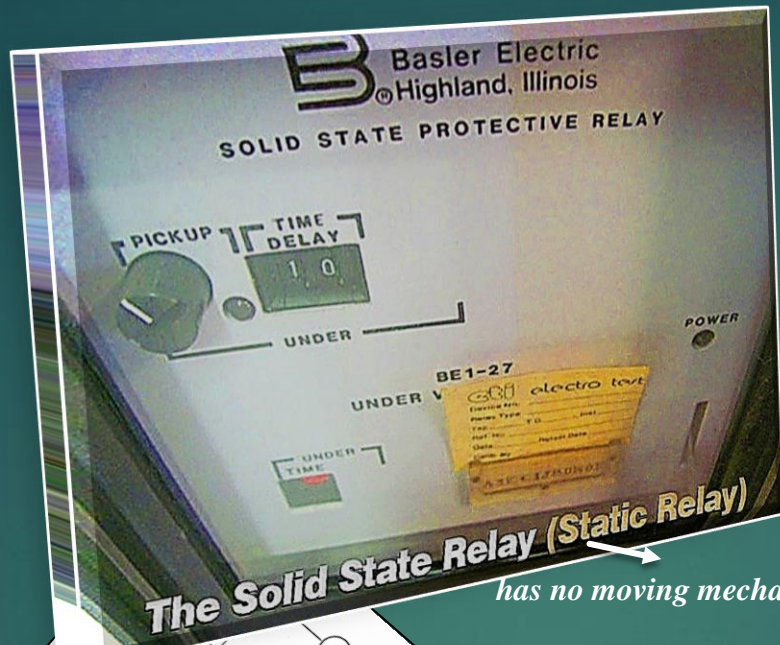**Microprocessor**

Basler Electric
Highland, Illinois

SOLID STATE PROTECTIVE RELAY

PICKUP   TIME DELAY
1.0
UNDER

POWER

BE1-27

UNDER V

UNDER TIME

The Solid State Relay (Static Relay)

has no moving mechanical parts

The Solid Static relays use *analogue electronic devices* instead of magnetic coils and mechanical components to create the relay characteristics. The measurement is carried out by static circuits consisting of comparators, level detectors, filter etc while in a conventional electromagnetic relay it is done by comparing operating torque (*or force*) with restraining torque (*or force*).

Secondaries of CT or PT or Transducer

Relaying Quantity

Rectifier → Relay Measuring Circuit → Amplifier → Output Device → Trip Circuit

DC Supply

Block Diagram of Static Relay

Circuit Globe

S. E. ZOCHO
STATIC TIME-OVERCURREN

1969

FIG.3.

FIG.4.
COMPARISON OF INDUCTION DISK RELAY CURVES WITH STATIC RELAY WITH VARIABLE REFERENCE

3,444,434
STATIC TIME-OVERCURRENT RELAY
Stanley E. Zocholl, Holland, Pa., assignor, by mesne assignments, to I-T-E Imperial Corporation, Philadelphia, Pa., a corporation of Delaware
Filed Mar. 6, 1967, Ser. No. 620,701
Int. Cl. H02h 3/08
U.S. Cl. 317—36   9 Claims

ABSTRACT OF THE DISCLOSURE
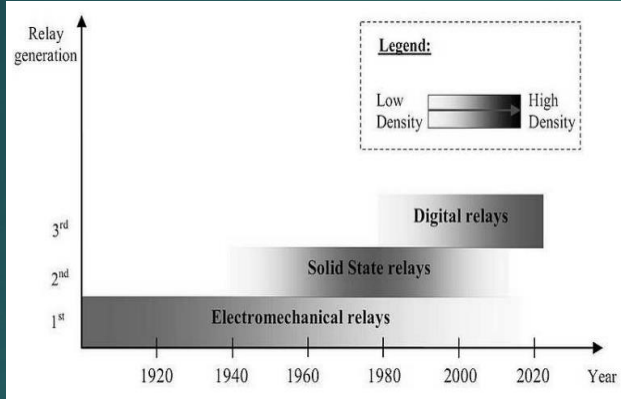This invention teaches a static overcurrent relay, which

United States Patent Office

3,444,434
Patented May 13, 1969

RACID Microprocessor time overcurrent relay (ABB)
year: 1981

Legend:
Low Density → High Density

3rd — Digital relays
2nd — Solid State relays
1st — Electromechanical relays

1920 1940 1960 1980 2000 2020 Year
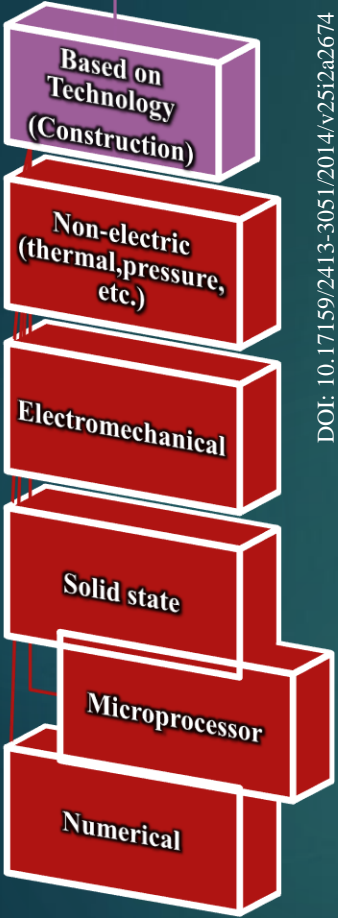
Measuring principles:
- ✓ A2D
- ✓ Microprocessor : counting technique, use the Discrete Fourier Transform (DFT),limited processing capacity and memory compared to that provided in numerical relays.

Function:
- ✓ wider range of settings, and greater accuracy. A communications link to a remote computer may also be provided

Operation of Relay:
Digital relay consists of:
(1) Analogue input subsystem
(2) Digital input subsystem
(3)Digital output subsystem
(4) A processor along with RAM (data scratch pad), main memory (historical data file)
and Power supply

Classification of Protective Relays

Based on Technology (Construction)

Non-electric (thermal,pressure, etc.)

Electromechanical

Solid state

Microprocessor

Numerical

Limitations of Digital Relay:

Short lifetime due to the continuous development of new technologies.
The devices become obsolete rapidly.
Susceptibility to power system transients.
As digital systems become increasingly more complex they require specially trained staff for Operation.

Input Signal

Digital Relay

Relay Output

ANALOG INPUT SYSTEM
- Surge Filter
- Anti-aliasing Filter
- A/D Sample/Hold

Power Supply

DIGITAL OUTPUT SYSTEM

PROCESSOR

Classification of Protective Relays

- Based on Technology (Construction)
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  - Electromechanical
  - Solid state
  - Microprocessor
  - Numerical

µ-controller diagram

Crystal → µ-controller → Serial Port → To Outside world

Output Control → Relay Contacts

Steady state data

MUX

A TO D | A TO D | A TO D | A TO D

Direct AC Sampling

A | B | C | E ← Current Sampling

ASHIDA Smart Solutions for Power Protection & Control

Typical numerical relay hardware architecture

Main processor board

- SRAM — Alarm, event, fault disturbance & maintenance records
- SRAM — Executable code & data, setting database data
- Flash memory — Default settings & paramaters, language text, code, present settings
- Front LCD display
- CPU

Ethernet and IRIG-B board

- IRIG-B Signal → IRIG-B
- Ethernet comms → Ethernet

Relay board

- Output relay contacts → Output relays

Coprocessor board

- FPGA — Comms between main and coprocessor board
  - CPU
  - SRAM
  - GPS interface
- 1pps GPS input

Input board

- ADC
- Opto-inputs ← Digital inputs
- Analogue Input signals

Parallel Data Bus

Serial data link

Power supply Rear comms data

Power Supply Board

- Power supply
- Watchdog contacts
- Rear RS485 comms

Transformer Board

- Current and voltage inputs

Typical numerical relay hardware architecture

Classification of Protective Relays

Based on Technology (Construction)

Non-electric (thermal, pressure, etc.)
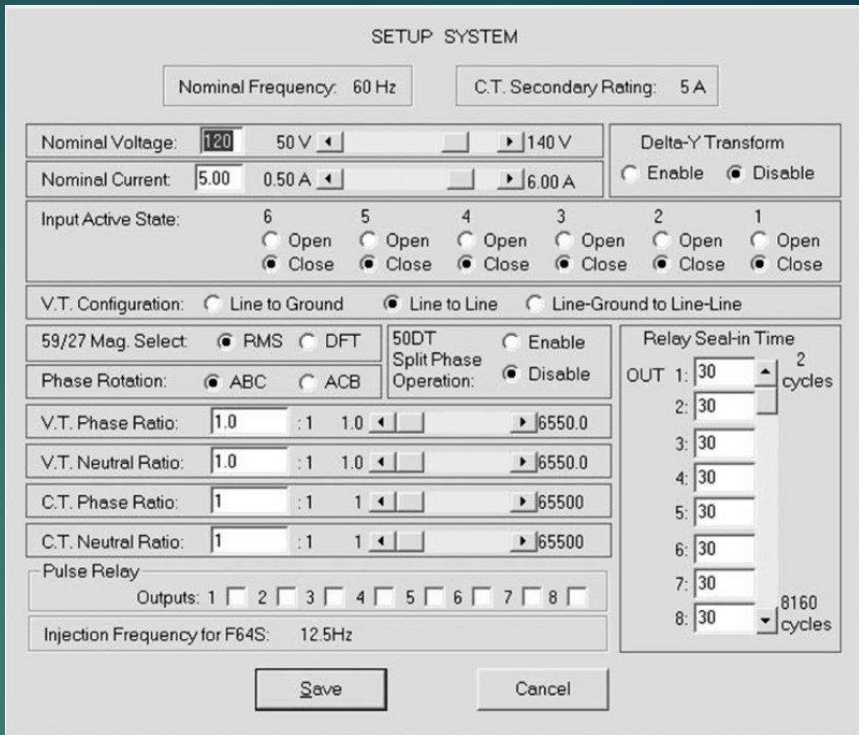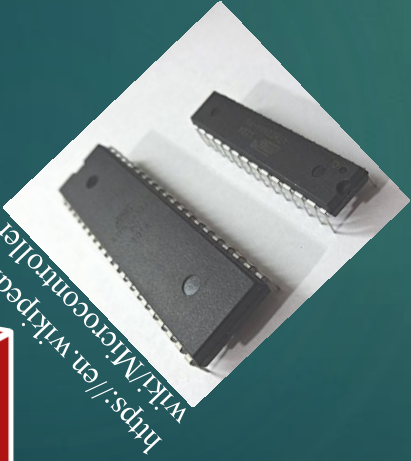
Electromechanical

Solid state

Microprocessor

Numerical

photo credit: omicronenergy.com

Commissioning Numerical Protection and Procedure For Carrying Out Performance Tests

SETUP SYSTEM

Nominal Frequency: 60 Hz   C.T. Secondary Rating: 5 A

Nominal Voltage: 120 50 V ◄ | ► 140 V   Delta-Y Transform ○ Enable ● Disable

Nominal Current: 5.00 0.50 A ◄ | ► 6.00 A

Input Active State: 6 5 4 3 2 1
○ Open ○ Open ○ Open ○ Open ○ Open ○ Open
● Close ● Close ● Close ● Close ● Close ● Close

V.T. Configuration: ○ Line to Ground ● Line to Line ○ Line-Ground to Line-Line

59/27 Mag. Select: ● RMS ○ DFT   50DT Split Phase Operation ○ Enable ● Disable   Relay Seal-in Time
OUT 1: 30 ▲ 2 cycles

Phase Rotation: ● ABC ○ ACB

V.T. Phase Ratio: 1.0 : 1 1.0 ◄ | ► 6550.0   2: 30

V.T. Neutral Ratio: 1.0 : 1 1.0 ◄ | ► 6550.0   3: 30
4: 30

C.T. Phase Ratio: 1 : 1 1 ◄ | ► 65500   5: 30

C.T. Neutral Ratio: 1 : 1 1 ◄ | ► 65500   6: 30

Pulse Relay   7: 30
Outputs: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐   8: 30 ▼ 8160 cycles

Injection Frequency for F64S: 12.5Hz

Save   Cancel

Set-up system configuration of a numerical protection system (Beckwith M-3425)
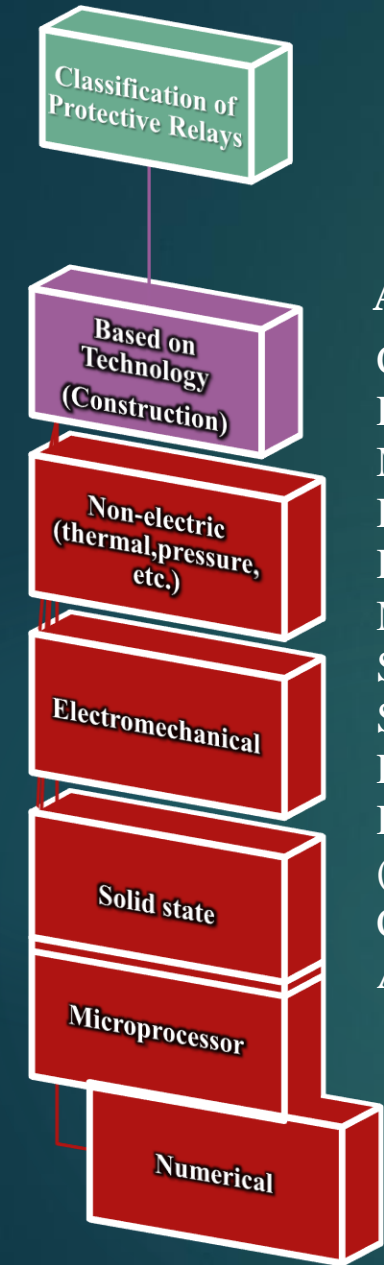

https://en.wikipedia.org/wiki/Microcontroller

Conventional electromechanical and static relays are hard wired relays. Their wiring is fixed, only their setting can
be manually changed. Numeric relays are programmable relays. The characteristics and behaviour of the relay
are can be programmed

Classification of Protective Relays

- Based on Technology (Construction)
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  - Solid state
  - Microprocessor
  - Numerical

Advantages of Numerical relays:

Compact Size
Flexibility
Multi Function Capability
Different types of relay characteristics
Digital communication capabilities
Modular frame
Sensitivity
Speed
Fast Resetting
Data History
(1)Nature of fault, (2) Magnitude of fault level, (3) Breaker problem, (4)
C.T. saturation , (5) Duration of fault
Auto Resetting & Self Diagnosis

Limitations of Numerical Relay:

potential risk of
hacking
shares common functions

Thanks!