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Investigation of Modernized Numerical Relay with Watchdog Timers to Achieve Reliability

[1] Asha.K [2] Meghana.S.N [3] Vijaya Kumara.M.G [4] Teli Rekha Appasaheb [5] Manjunatha S
[1][2][3][4][5] UG Scholar
[1][2][3][4][5]EEE Department, Sri Sairam College of Engineering, Bengaluru

Abstract: -- **The recent trend in protection has been a shift to numerical relay protection techniques, thanks to the development using the single chip digital signal processors with high crunching capability, which has made it possible to design digital filters in real time. In the protection field, numerical techniques have got first application to line protection, and other complementary functions like fault locator, disturbance recorder & auto-reclosing. The present work describes latest salient features of the numerical protection technology, different multifunctional relays going to be installed in modern power system protection and their methods of protection. Malfunction of relay protection is one of the main causes of the heavy failures that periodically occur in power systems all over the world. Thus the reliability of a power system depends on the reliability of relay protection in many respects. Watchdog timers are an excellent way to insure that a microprocessor based system continues to operate unattended if occasional failures occur. The way that a watchdog timer does its job is to monitor a particular signal sent by the microprocessor.**

Keywords:-- **Watchdog Timer, CPU, Numerical Relay, Reliability.**

I. INTRODUCTION

Traditional entities involved in securing adequate protection and control for the system may soon become inadequate, and the emergence of the new participants (non-utility generation, transmission, and distribution companies) requires coordinated approach and careful coordination of the new operating conditions. The power system components include synchronous machines, bus bars, transformers, transmission lines and distribution system consisting of complex and composite loads. However, during faults, voltage, current, phase angle, power or frequency quantities become abnormal and it is necessary that there must be a device which senses these abnormal conditions and the element or component wherein the abnormality has taken place is removed.

Functions of Protective Relay

The relays, which are associated with microprocessor and work on numbers representing instantaneous values of the signals such that current, voltage, frequency and power factor etc. are called numerical relays. These are also called digital relay, computer-based relay or microprocessor-based relay.

The modern numerical relay provides more than one primary protection functions, so they are also named as multifunctional relay. These protection devices operate on the basis of numerical measuring principles. The analog measured values of current and voltage are calculated from the plant secondary circuits via input transducers. After analog filtering, the sampling and the analog to digital conversion takes place. The sampling rate is depending on the different protection principles. With certain devices a continuous adjustment of the sampling rate takes place depending on the actual system frequency. The numerical protection concept offers a variety of advantages, especially with regard to higher security, reliability and user friendliness. The modern numerical protection relay, which protects the power system from various faults, plays an extremely important role in power system stability. Its main functions are as follows:

Prevention of power supply interruption: Fault clearance and resumption of healthy power transmission as soon as possible. Prevention of damage to equipment: Consecutive system faults will eventually lead to damage to primary plant, for example destruction of insulators, rupture of lines, burning of transformers, etc. The protection relay can help prevent such damage to equipment.

Prevention of system instability: is necessary to remove power system faults at high speed by using protection relays as the existence of a system fault for an extended period of time may initiate a generator out-of-step condition.

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Modern Numerical Relay Protection Requirements

The protection relay, which plays the important role of protecting the power system from faults, must meet several requirements. These requirements can be summarized as follows:

Selectivity: All faults that occur on the power system should be removed but at the same time it must be ensured that only the minimum section of the power system must be isolated in order to clear the fault. It is important to prevent blind spots in power system protection design.

High speed: In order to avoid damage to equipment or power system instability, it is important to shorten the duration of faults by applying high-speed protection relays. However, the operating time of the circuit breaker and transmission delay in the case of carrier protection, etc. must also be taken into consideration.

Reliability: A fundamental requirement to ensure that the reliability of the protection relay is high is that its components must be extremely reliable. This can be achieved by using high quality components and reducing the number of components.

In order to dramatically improve the operating reliability of the relay in the event of a system fault, there are two options: to use a protection relay with a duplicated protection system or to provide an additional fault detection relay within the relay with AND logic.

Block Diagram of Modern Numerical Relay

A current signal from CT is converted into proportional voltage signal using I to V converter. The AC voltage proportional to load current is converted into DC using precision rectifier and is given to multiplexer (MUX) which accepts more than one input and gives one output. Microprocessor sends command signal to the multiplexer to switch on desired channel to accept rectified voltage proportional to current in a desired circuit. Output of Multiplexer is fed

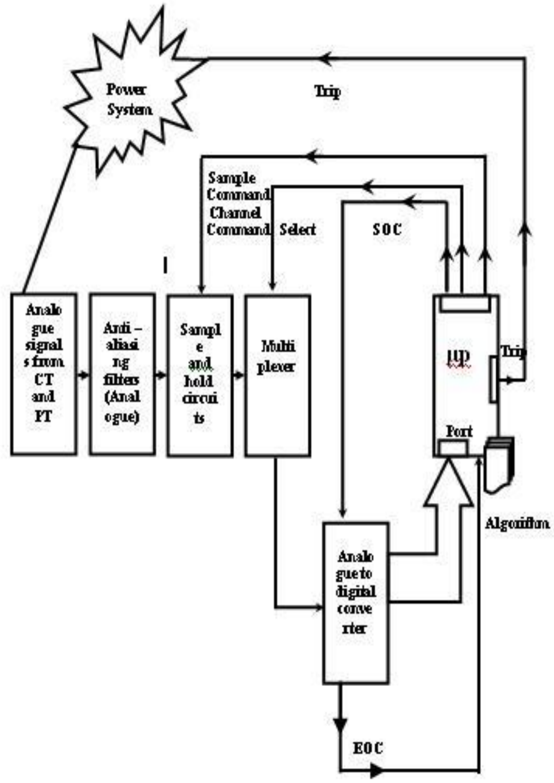

Fig.1: Block Diagram of Modern Numerical Relay

to analog to digital converter (ADC) to obtain signal in digital form. Microprocessor then sends a signal ADC for start of conversion (SOC), examines whether the conversion is completed and on receipt of end of conversion (EOC) from ADC, receives the data in digital form. The microprocessor then compares the data with pick-up value. If the input is greater than pick-up value the microprocessor send a trip signal to circuit breaker of the desired circuit. In case of instantaneous over current relay there is no intentional time delay and circuit breaker trips instantly. In case of normal inverse, very inverse, extremely inverse and long inverse over current relay the inverse current-time characteristics are stored in the memory of microprocessor in tabular form called as look-up table.

Central Processor Unit (CPU)

It simply sends control cycling pulses with a period set to the so-called watchdog timer- the watchdog timer is reset to an initial condition with arrival of each new control pulse, and then begins a new cycle of time reckoning. If at a certain moment the next control pulse from the CPU has not arrived, the timer starts the CPU reloads.

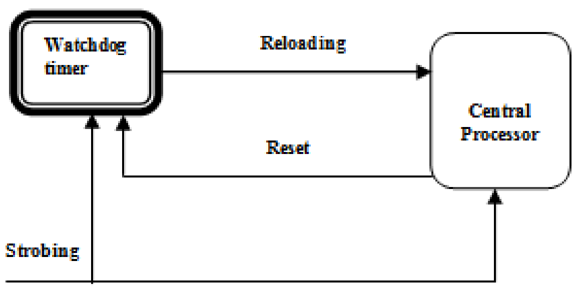

Fig.2: A principle of the monitoring of reliability of the microprocessor with the help of the watchdog timer

A serious malfunction of the microprocessor and its "lag" during reloading process which is found out by the timer as the repeated absence of a control signal causes the locking of the CPU and transmitting a signal about CPU malfunction. Process on tracking control pulses by the watchdog timer is synchronized with the help of external clock pulses (so-called “strobing”). Sometimes the watchdog timer is built directly in the microprocessor, and sometimes (which is more preferable) it is an external specialized integrated microcircuits (IC).

Watch Dog Timer (WDT)

Watchdog timers come in many configurations, and most allow their configurations to be altered. Configuration elements include:

- Physical location
- Within a chip external to the processor
- In circuitry included within the CPU chip, as is done in many microcontrollers
- On an expansion card in the computer's chassis
- In software, such as in the mobile operating system iOS
- Clock source for the watchdog
- The CPU clock
- An independent clock, so that a CPU clock failure will cause a watchdog timeout
- How long a timeout must be to
- trigger the watchdog
- Typical timeouts are from 10 milliseconds to 10 seconds
- What action the watchdog takes on a timeout
- Processor reset
- Non-maskable interrupt

Flowchart of Development cycle of a modern numerical relay algorithm

We can implement an existing relaying concept using the numerical technique. However, the possibilities of developing a new numerical relay are almost endless and there is very little standardization. The process of development of a new numerical relay is shown in the flowchart.

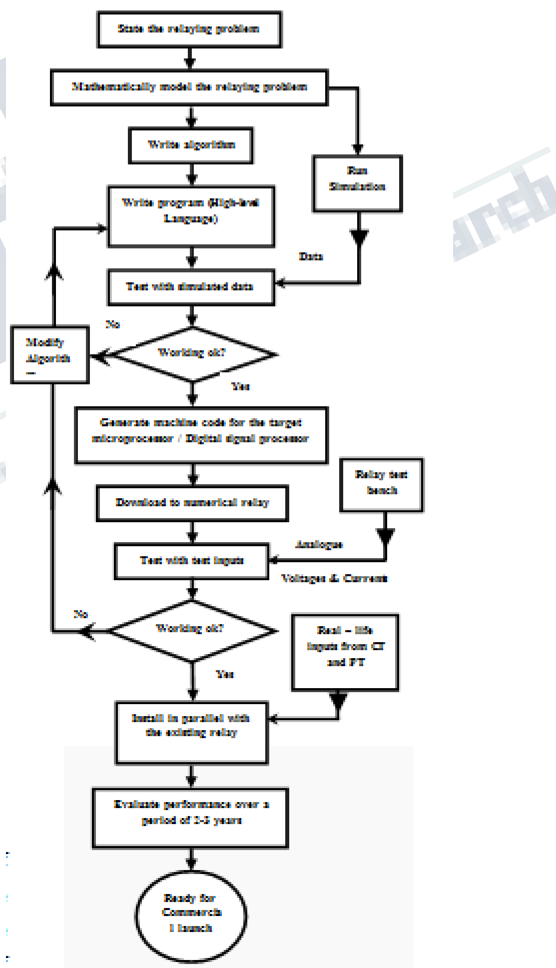

Fig.3: Development Cycle of a Modern Numerical Relay

Comparison Table

Characteristic	Electro Mechanical Relay	Static Relay	Digital Relay	Numerical Relay
Technology Standard	1st generation relays.	2nd generation relays.	Present generation relays.	Present generation relays.
Operating Principle	They use principle of electromagnetic principle.	In this relays transistors and IC's been used	They use microprocessor. Within built software with predefined values	They use microprocessor. Within built software with predefined values
Measuring elements/ Hardware	Induction disc, electromagnets, induction cup, balance beam	R, L, C, transistors, analogue ICs comparator	Microprocessors, digital ICs, DSPs	Microprocessors, digital ICs, DSPs
Measuring method	Electrical qualities converted into mechanical force, torque	Level detects, comparison with reference value in analogue comparator	A/D conversion, numerical algorithm techniques	A/D conversion, numerical algorithm techniques
Relay Size	Bulky	Small	Small	Compact
Speed of Response	Slow	Fast	Fast	Very fast
Timing Function	Mechanical clock works, dashpot	Static timers	Counter	Counter
Time of Accuracy	Temp. Dependant	Temp. dependant	Stable	Stable
Reliability	High	Low	High	High
Vibration Proof	No	Yes	Yes	Yes
Characteristics	Limited	Wide	Wide	Wide
Requirement of Draw Out	Required	Required	Not required	Not Required
CT Burden	High	Low	Low	Low
Reset Time	Very High	Less	Less	Less
Auxiliary supply	Required	Required	Required	Required
Range of settings	Limited	Wide	Wide	Wide
Isolation Voltage	Low	High	High	High
Function	Single `Function	Single function	Multi function	Single function
Maintenance Resistance	Frequent 100 mille	Frequent 10 Ohms	Low 10 Ohms	Very Low 10 Ohms
Deterioration due to Operation	Yes	No	No	No
Relay Programming	No	Partially	Programmable	Programmable
SCADA Compatibility	No	No	Possible	Yes
Operational Value indication	Not Possible	Not Possible	Not Possible	Not Possible
Visual indication	Flags, targets	LEDs	LEDs, LCD	LEDs, LCD
Self monitoring	No	Yes	Yes	Yes
Parameter Setting	Plug setting, Dial setting	Thumb Wheel, deal in line Switches	Keypad for numeric Values, through computer	Keypad for numeric values, Through computer
Fault Disturbance Recording	Not possible	Not possible	Possible	Possible

II. CONCLUSION

From this paper, it can be concluded that watchdog timers when employed in conjunction with modern numerical relay will achieve powerful relay protection scheme. Thus helping the power system from blackouts and odd calamities.

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