Design and Implementation a Digital Teleprotection System

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Abstract

Protection systems have been used in order to detect commands and fix them in the high voltage line or network equipment. Correct commands reception and rapid response are necessary features for this type of systems. Teleprotection system acts as an interface between protection system and communication equipment. According to ready to use digital communication media in the electrical power industry, the need of teleprotection systems with capability to connect to this network is proposed. This paper describes the design and implementation of a digital teleprotection system in order to connect to digital communication network with line interfaces in accordance with ITU-T G.703 standard (64kbps and 2Mbps rates) or direct connection to optical fibers to transmit and receive maximum eight independent commands.

Key words: Communication interface, Digital Teleprotection System (DTPS), Protection, Relay interface, Type test.

1. Introduction

High voltage networks, transmission lines, bus bars, power transformers and so on, are mainly install and work in the outdoor and are exposed to natural disasters. Therefore, they should be protected against hazard events and they should be separated from other parts of the network, to prevent the damage expansion and blackouts. In order to protect the equipment upon an error occurrence, a protective system should be used to isolate the defective parts from the whole network and prevent the fault and limit the damage.

Teleprotections are used in conjunction with communication channels to establish a link between relays and control logic at one site and control logic and breakers at another site. In situation of breakdown in voltage lines or equipment, the Protection equipment with an available and reliable communication media, provide the possibility to isolate damaged sections of the entire network by sending commands in the shortest possible time. The performance of a teleprotection system is characterized by several parameters. Traditionally, the Propagation Delay, Dependability and Security have been considered the most important ones.

As mentioned before, the teleprotection system works as an interface between the protection system and the telecommunication devices (shown in Fig. 1). Therefore, it includes some

sections which prepare inputs and outputs based on these equipments. In general, teleprotection system is divided into three parts:

- Protection equipment interface
- Processing and making decisions
- Telecommunication equipment interface

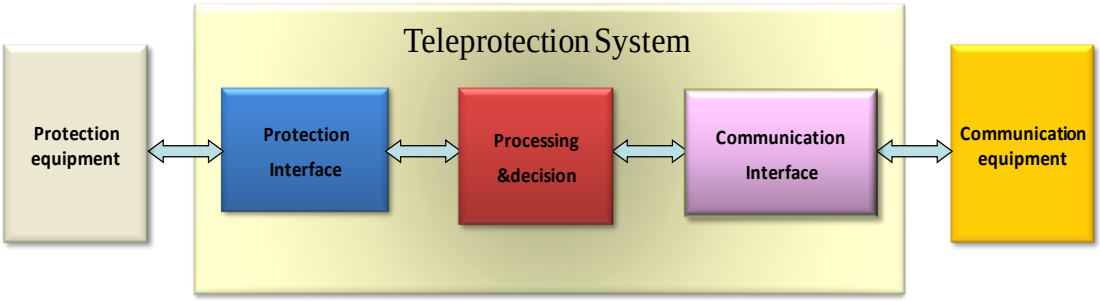

Fig 1: Generic Teleprotection blocks.

The protection interface (or high voltage relay interface) and the communication interface provide an isolated full-duplex communication. The processing unit controls the statuses and makes decisions respect to the receiver conditions.

Present analog teleprotection system with possibility to transmit up to four commands and capability to connect analog telecommunication systems, including analog PLCs, are mainly used in power utilities. Digital communication networks are being widely used in many industrial applications like as electrical power industry. Comprehensive protection and control of electrical power systems is achievable by using digital communication networks. Digital teleprotection systems (DTPS) are used in conjunction with digital communication equipments. These systems provide signal conditioning, data encoding/decoding and error detection capabilities. Due to their digital nature, DTPSs offer built-in high security and dependability along with fast response in comparison with analog ones.

In this article, the specification of commands in DTPS, the block diagram of different parts and the features of the designed and implemented DTPS are discussed. Besides, the type tests according to the IEC60834-1 standard for DTPS are presented.

2. Specification of Commands in the Designed System

One of the main advantages of DTPS to analog teleprotection systems is how to send commands. In DTPS, instead of changing the frequency and power of commands which sent in analog teleprotection systems, each corresponding protection command, is translated/ mapped to an n-bit code word that is generated and sent. This code is received with special consideration on the opposite side of the target. These code words are chosen in a way that the probability of conversion to other code words due to noise becomes minimal. We use a convolution coding algorithm to generate the 16-bit code words. The hamming distance of a code word is higher than a minimum 8-bit. The flexibility of digital framing and code words will provide a much greater diversification in transmit and receive commands. By using these specified code words and some other techniques such as repetition of sending series of frames, considering the decision threshold and acceptance window, the probability of unwanted or missed commands, is minimized. Therefore, higher security and dependability can be achievable in higher BER channels.

In general, the Guard code word is sent in normal condition and the command code words is sent in conditions of command motivation. The effective parameters in commands transmit

and receive is illustrated in Fig. 2. When a change in the status of input command happened, the input filter checks the validity of it, and the transmitter sends a command code word instead of Guard code word. This code word will be received after some delay, because of transmission media and receiver execution delay in the receiver of the opposite side. These delays make the nominal transmission time that is one of the main parameter in teleprotection systems.

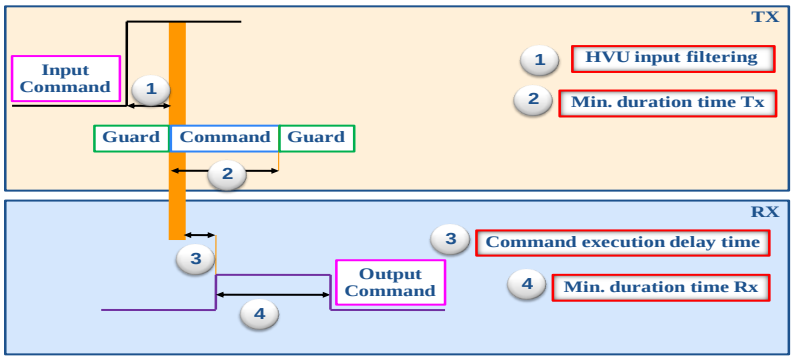

Fig 2: Parameters in commands transmit and receive.

3. Block Diagram of the Designed System

The main characteristics of the designed and implemented DTPS are:

- Possibility to send and receive eight commands as independent or simultaneous;
- Isolated interfaces for connecting to a protection system;
- The ability to connect telecommunication equipment with digital interface (E1 and 64kbps interfaces in accordance with ITU-T G.703 standard);
- Parameters adjustment by software;
- Possibility to record the history of commands and events;
- Possibility for synchronization with GPS;
- An isolated DC power supply;
- Modular parts and with a 3U standard sub rack;
- In compliance with IEC60834-1 standard.

The generic block diagram of the designed DTPS and their interactions is shown in Fig.3. It has a central controller unit, communication/line interfaces, H.V. relay interfaces, interface with GPS receiver, display units, user interfaces (HMI), and power supply converter.

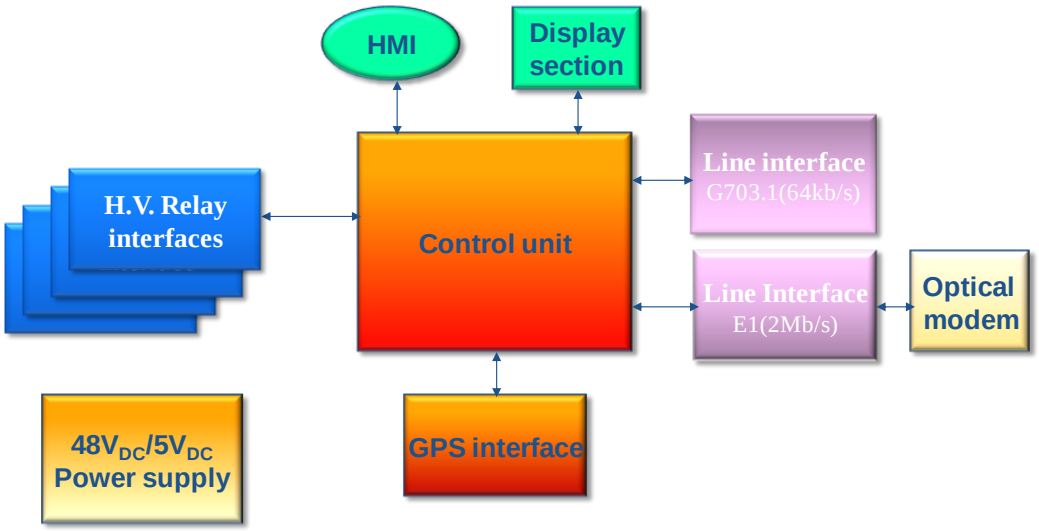

Fig 3: Generic blocks of the designed DTPS.

The main tasks of the units are described in below.

- Control Unit:

Some important processing are: making decisions according to relay status in the transmitter section, choosing appropriate code words, processing the received commands in the receiver side, checking the validity of commands, check the alarm conditions, controlling all the tasks and parameters configuration, interface for GPS receiver and HMI software.

- Line Interface Units:

Make a full duplex communication with telecommunication equipments; it includes line drivers, framer, and isolators.

- H.V. Relay Interface Units:

Receive the state of protection relays and transmit the necessary commands to protective relays, It includes level shifters, comparators, buffers, and isolators (opto-coupler and relay).

- Power Supply Unit:

Makes an isolated power for internal use in system, It includes line protection, EMI filter, line filter, DC/DC converters.

4. Type Tests of the Designed System

The functional and performance tests are the most popular tests. Besides, due to a variety of electronic equipments which are used in the industrial environments, the insulation and electromagnetic compatibility between them are very important. Also environmental tests will be done on the device. The IEC60834-1 standard is published for Teleprotection systems. It defines the tests level, and their acceptance criteria. The tests are listed below:

- Power Supply tests;
  - Power supply variation;
  - Interruptions;
  - LF disturbance emission;
  - Reverse polarity.

- TeleProtection System Performance tests;
  - Transmission time;
  - Security;
  - Dependability;
  - Security with sudden signal interruption;
  - Recover time;
  - Jitter;
  - Nominal impedance.
- Insulation Voltage Withstand tests;
  - Power frequency voltage withstand test and insulation resistance;
  - Impulse voltage withstand test.
- Electro Magnetic Compatibility tests;
  - Damped oscillatory wave immunity test;
  - Fast transient burst (EFT);
  - Electrostatic discharges (ESD);
  - Radiated electromagnetic field;
  - RF disturbance emission.
- Environmental Conditions tests.
  - Temperature and humidity;
    - Change of temperature test;
    - Damp heat test;
    - Dry heat test;
    - Cold test.
  - Mechanical.
    - Shock;
    - Vibration.

All of the above mentioned type tests have been performed on the designed DTPS in reference laboratory. Despite the practical and theoretical considerations, a variety of problems have been faced during the EMC tests. After some modifications, the final test results showed the compatibility to the IEC60834-1 standard.

5. Conclusions

The main characteristics of the implemented DTPS have been described. This product has the ability to connect digital telecommunication network through E1 and 64kbps interface (according to G.703 standard) and to send and receive up to eight independent or simultaneous commands. The parameters of this product are adjustable; therefore, it can be used in different protection schemes (direct, permissive and blocking) in 400, 230 and 63 kV substations. The results of type tests on this product meet the IEC60834-1 standard.

Acknowledgements

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