POWER DISTRIBUTION SUPERVISORY CONTROL SYSTEM BY POLLING

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ABSTRACT

This paper describes a new Supervisory Control System (SCS) which adopts a dynamic polling structure. The need for a thinking unit at the line head for managing a SCS is unavoidable. The thinking unit (µP) moreover, allows a communication network to be built up which uses the line without voltage, with a variable number of transmitter-receiver stations attached to the equipped centres.

Configuration of the Distribution Network is discussed, the aims that the SCS must fulfil, the system functions and a digital data transmission system description.

INTRODUCTION

The electrical energy distribution networks need remote control systems that are centralised and integrated as far as the functions they can develop are concerned. The need for a thinking unit at the line head for managing a Supervisory Control System is unavoidable. The thinking unit (microprocessor) moreover, allows a communication network to be built up which uses the line without voltage with a variable number of transmitter-receiver stations attached to the equipped centres, as discussed in this paper.

This paper considers a strategy and the execution of a Supervisory Control System which adopts a dynamic polling structure and which is believed to be more attractive and economical than that adopted by rigid network structures. (1)

The following paragraphs discuss the configuration of the Distribution Network, the aims that the Supervisory Control System must fulfil, the system functions and a transmission system description.

CONFIGURATION OF THE NETWORK

The Supervisory Control System considered in this paper takes into account a distribution network configuration in which there is an operating voltage network configuration in which there is an operating voltage of 25 kV outside the primary station or sub-station walls. The Network is meshed (except in some isolated cases of totally rural areas where operation, both on overhead and underground lines, is radial. (2)

Figure 1 shows elements which usually make up the type of Network into which the Supervisory System is introduced. Also worth mentioning are the T-R blocks which will allow the exchange of information between the line head and the equipped Centres under the management of a microprocessor.

AIMS

The main aims of the Supervisory Control System are:

- Fault location. It is understood that a fault has been located when the equipped Centres closest to it are known.
- Fault isolation. It is understood that a fault has been isolated when the open-close subsystems have been activated in such a way that they prevent the fault lies.
- Renewal of service. This is understood to mean the actions to be taken by means of the open-close elements with a view to establishing service on the Network, except on the section affected by the fault.
- Centralised recording of all actions on the Network.
- Open-ended, that is, that the system allows variations in the Network without the need for modifying its own structure.

SYSTEM FUNCTIONS

Under normal working conditions of the distribution network, the supervisory

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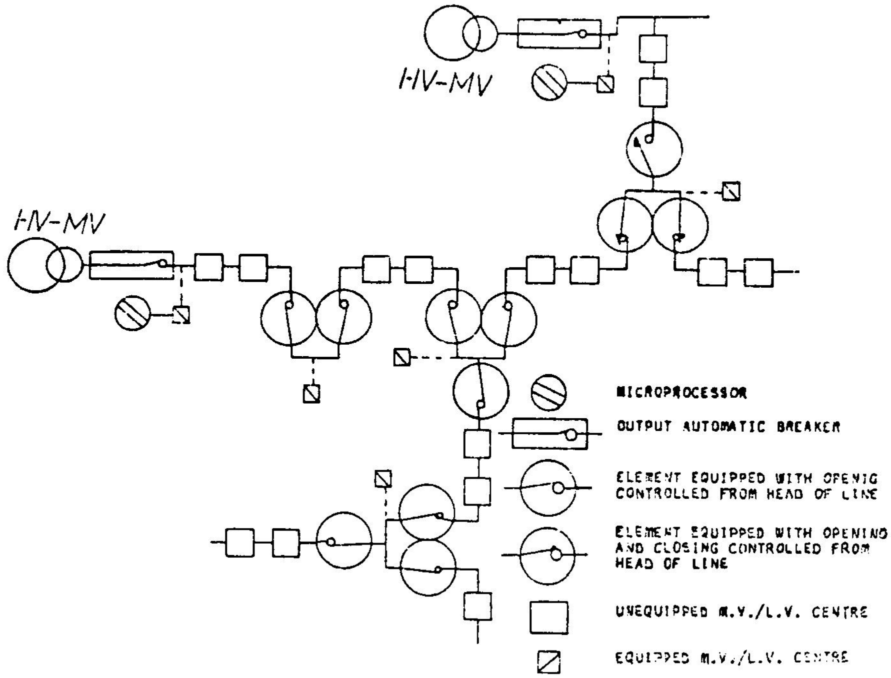

Figure 1

system is disconnected and only part of it remains alert.

The moment a fault occurs (once it is verified that the network is lacking the 25 kilovolt voltage) each of the T-R blocks in the equipped centres will automatically connect up to the network (to the secondary of the medium/low voltage transformer in the case of the remote stations, and to the medium voltage line through a current transformer in the case of a line head station).

Following the connection of the supervisory system, all the remote stations wait for information from the line head station.

A flowchart representing the information exchange process between the line head station and the T-R stations of the equipped centres is shown in figure 2 and described below. It consists of three steps.

First Step

The line head station queries the remote stations dependent on it, sequentially. The order of interrogation is established by means of the microprocessor program and is conditioned by the network structure. The aim in this first step is to determine whether the remote station consulted "has seen" or "has not seen" a fault current. The structure of the program written into the microprocessor will be such that it allows location of the section of line in

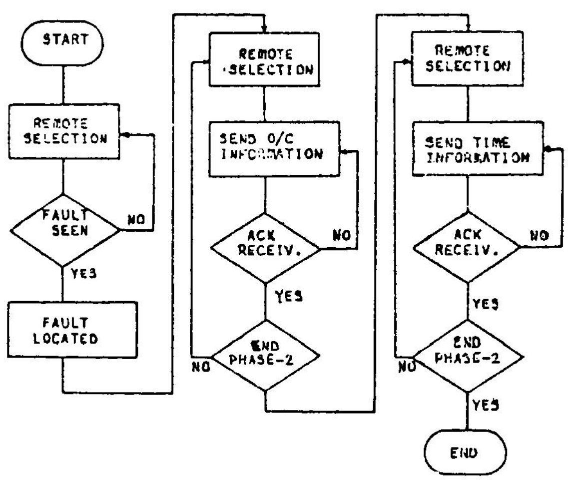

Figure 2

which the fault has occurred (located between two equipped centres) when a negative reply is obtained following a series of affirmative ones, thereby achieving the aim of fault location described in the previous section.

Second Step

The line head station converses only with the equipped centres that are adjacent to the section of line in which the fault has occurred and with the nearest centre equipped with an under load circuit opening /closing element.

In this second step the transmission of the opening/closing orders of the isolating switches in the aforementioned centres must be checked, since these orders will enable the fault isolation and renewal of service aims to be fulfilled once the third step has been executed.

In order to avoid any misoperation the remote stations queried in this second step transmit an ACK (acknowledgement) signal to the line head station which thus knows that the microprocessor's orders have been correctly received. In the event of error, the microprocessor would not initiate the third step until it had received the positive ACK from the T-R blocks of the stations mentioned in this second step.

Third Step

The microprocessor backing onto the T-R Block of the line head station sequentially orders the execution of the orders written in the previous step (second step). In this step the stations return the ACK to the line head station and the supervisory system can hold up the process indefinitely should any anomalies in the transmission/reception of the information be detected. The opening and closing of the isolating switches will occur when a period of time marked by a timer has elapsed, so that all the T-R blocks of the equipped centres are disconnected from the line before the renewal of service takes place.

TRANSMISSION SYSTEM DESCRIPTION

Figure 3 shows the line head T-R block diagram. The interface of the microprocessor with the peripheral works asynchronously, transferring the information in two stages.

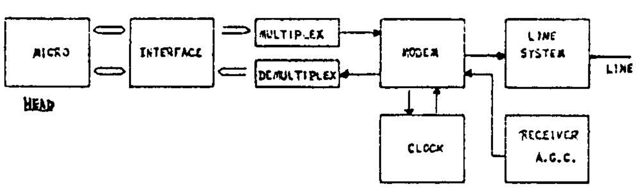

Figure 3

On the Transmission Mode the interface loads the following information into the Multiplexor:

- Code of the station of destination.
- Information bits.

The Multiplexor structures the information to be transmitted according to the format in Figure 4, where it can be seen that:

- the first 30 bits are used to inform the receiver on the level of the signal it is receiving,
- the next 6 bits are used for the synchronisation of the receiving clock,
- the following 6 bits determine the station to which the information is directed,
- the next 6 bits identify the station from which the information is coming (64 remote stations are possible),
- the following 3 bits are used for coding what is called INFORMATION (fault current "seen" or "not seen" in the first step; opening/closing of the isolating switches in the second step and ACK, exclusively, in the third step),
- the following 2 bits are used to detect transmission errors by means of parity control which, together with the ACK-sending process, makes up the protection system against transmission errors,
- the last 3 bits are used to take the information from the step that is being executed, as shown on the Flowchart.

The electrical signal corresponding to the binary train which is produced at the output of the Multiplexor modulates a carrier wave of 225 Hz generated in the clock unit and in synchronisation with the bit clock (transmission), in order that the passages through zero of the carrier coincide with possible binary transitions and avoid any switchover transients that may damage the amplifier. The ASK signal is applied to the line equipment whose basic element is a linear amplifier (class B) that gives the signal the appropriate level for it to be transmitted through the power cable.

On the Receiving Mode the line equipment switches the input/output terminal of the power cable to the receiver (Half-duplex mode). The receiver has an appropriate band for receiving the signal and for rejecting the interferences caused by harmonics of the network frequency (50 Hz) corresponding to power signals that are transmitted by cables located near the cable under consideration. The receiver also has an Automatic Gain Control, the purpose of which is to deliver at the output a constant-level signal (independent of the distance between stations).

On the receiving mode the Modem consists of an envelope demodulator and a sampling type detector subsystem that decides bit by bit at the moments indicated by the receiving clock, previously synchronised with the ingoing binary train by means of the Bits destined for this purpose (synchronisation bits).

The Demultiplexor consists of a Shift Register that loads up with the recovered binary train and a comparator that carries out a bit by bit search of the screen synchronising code. When this code is found it means that the position occupied by the bits in the Shift Register is the right one for carrying out the demultiplexing which implies the unloading of the Shift Register into a Buffer that will store the information.

The Interface transfers, sequentially, the information stored in the above-mentioned Buffer to the microprocessor, under the control of the reading subroutine.

The microprocessor carries out the following tasks in the order in which they are given:

- determines whether the station of destination code is that of the station under consideration,
- determines whether the parity bits are correct,
- acknowledges the ACK of the station from which the information has come,
- stores the information with the purpose of managing the communication network.

Figure 5 shows the block diagram of a

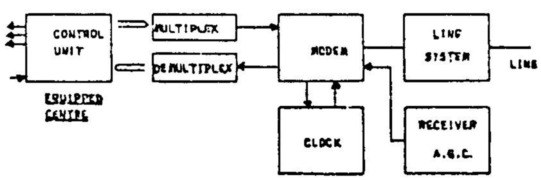

Figure 5

remote station where one can see that the only difference between it and the line head station described previously lies in the block called the Control Unit, that fundamentally exercises the same functions as the microprocessor (with wired logic) and, moreover, supplies the output drivers with the three remote control signals and the input driver with the remote-signalling signal.

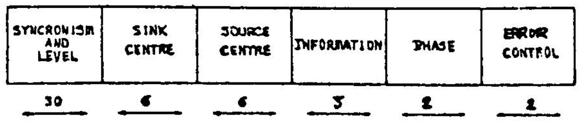

Figure 4

(1) R. Minondo Fominaya, "A power distribu-ion supervisory control description", (in Spanish), UNESA meeting, Madrid, July 1979.

(2) J. Delgado-Penín, J. Serrat Fernández, R. Minondo Fominaya, "A systems approach on power distribution supervisory control", IEEE Canadian Communications and energy Conference, 1982, pp. 103.