LOCAL AUTOMATION FOR MONITORING ELECTROMECHANICAL PROTECTION IN REMOTELY CONTROLLED SUB-STATIONS WITH DISTRIBUTED CONCEPT

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INTRODUCTION

Many years of analyzing the work done on protection of medium-voltage feeders, which have based on electromechanical relays, defined some of the most common causes of malfunctioning or irregularity in work of relay protection. The most frequent causes of malfunction are fault of time element on relay device, fault on the trip circuit of the circuit breaker or fault on the coil of circuit breaker. In addition, analyses have showed that the measuring element of relay is one of the most reliable parts of electromechanical relay. This fact presents the base point for algorithms, which have been thoroughly analyzing in this study. On the other hand, microprocessor units, which are part of derivative distributed concept of remote controlled distributive sub-station TS 110/10 kV "Nis 5", on consumption of EDN, have already been projected so that they have additional programmable digital inputs. These facts have been using for elaboration and realization of local automation, which have to monitor the functioning of electromechanical protection, and depending on the need, enable back up in the reaction of monitored protection.
There are three types of algorithms, which worked out separately for local units on 10 kV feeders and 110 kV and 10 kV transformers fields. Every of each algorithms presents one whole for itself and supervises work of all protection elements, at the same time. Algorithms have been developed in way to recognise almost every irregularity in work of elements of relay protection, which means: trip circuit supervision (time element on electromechanical relay, auxiliary relay for signalization and work off), and monitoring of tripping elements on the circuit breaker (trip coil), also. It is important to say that this local automation does not supervise executive element on relay, it only supervises the work of time element.

2. PRINCIPLE OF FUNCTIONS AND REACTION

Principle of functions of local automation is that it trips the circuit breaker exactly when it detects any irregularity in the basic system of protection. This kind of approach has been thoroughly examining on numerous named examples of protection of some elements of transformer sub-station 110/10 kV "Nis 5".

2.1. ELECTRICAL 10 kV FEEDER CELL

In 10 kV cells, microprocessor unit monitors the work of overcurrent protection, short circuit protection and earth-fault protection. Information of possible fault, in microprocessor unit, comes from executive contacts of electromechanical relay. Type of electromechanical relay is TZI 1322, which does not have time delay, i.e. it acts instantly. Therefore, it follows the functioning of time element of overcurrent protection element on relay itself, too. It is important to say that those contacts, which have been using for functioning of local automation, are actually contacts of auxiliary relays, which have being directly control by measuring element. This practically means that local automation is not in condition to

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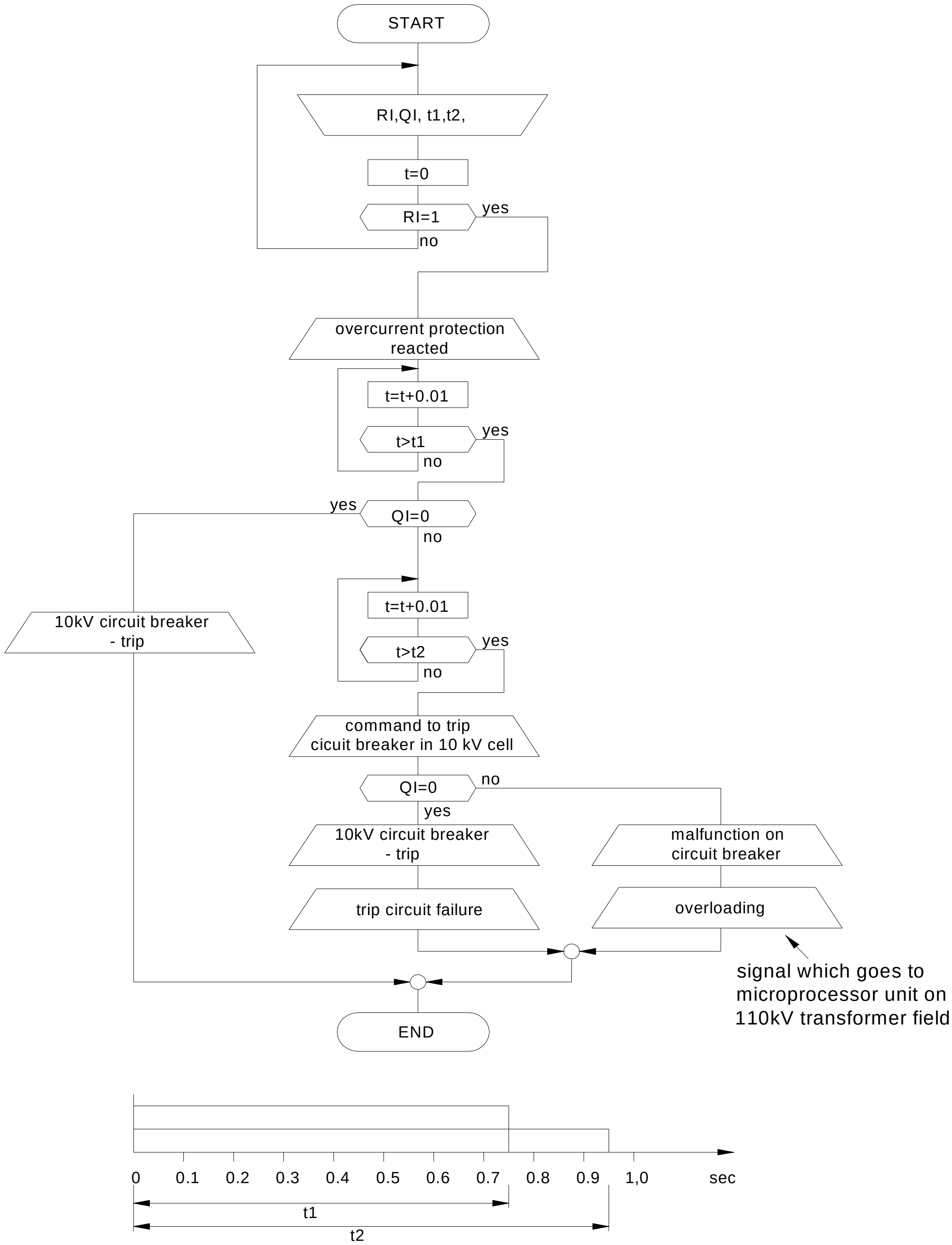
recognize fault done on the executive element, but only on the time element on relay itself. Picture 2.1 shows algorithm, which describes the actual mechanism of local automation.



Picture 2.1

LEGEND:
RI – signal from measuring element of overcurrent protection;
QI – signal from auxiliary contacts of 10kV circuit breaker;
t – counter with time step 0.01s;
t1 – pickup time for overcurrent protection;
t2 – time delay for new command to trip 10kV circuit breaker;
1 – signal exists; 0 – signal does not exist.

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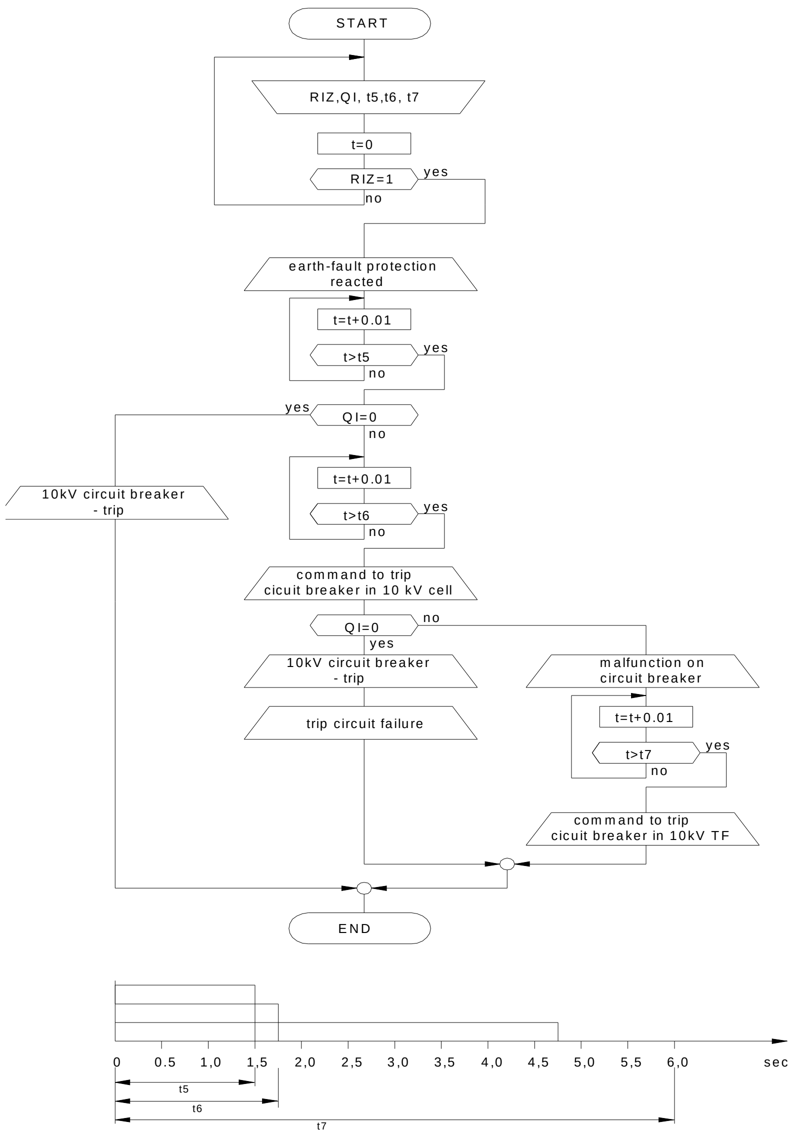
t1 is time predicted for trip the circuit breaker after the reaction of overcurrent protection. If in that time the actual trip happens, dispatching centre receives information that overcurrent protection has responded and circuit breaker has tripped. However, if circuit breaker is still on, microprocessor unit waits for additional time t2, and after that, it gives new command to trip the circuit breaker in the cell. In case that trip has been successful, dispatching centre receives information that the circuit breaker has tripped and that there is fault on the trip circuit of circuit breaker, as well. But if after second time of trying, circuit breaker is still on, device signalises that fault has been done on the circuit breaker itself, and forwards the signal to the microprocessor unit on 110 kV transformer field. Further procedure will be described when we consider algorithm on 110 kV transformer field. Difference in functions of local automation after reaction of overcurrent and after short circuit protection is that the supposing circuit breaker has not tripped after the responding of short circuit protection, device does not have time delay, yet it instantly gives new command to trip the circuit breaker. In case that circuit breaker is still on after second attempt, microprocessor unit, which monitors equipment in 10 kV cell, sends information of fault to the central unit. Central unit forwards that signal to device on 10 kV transformer fields, which instantly gives order to trip circuit breaker in 10 kV transformer field.
Picture 2.2 demonstrates algorithm of local automation due to reaction of earth-fault protection.



Picture 2.2

LEGEND:
RIZ – signal of earth-fault protection;
QI – signal from auxiliary contacts of 10kV circuit breaker;
t – counter with time step 0.01s;

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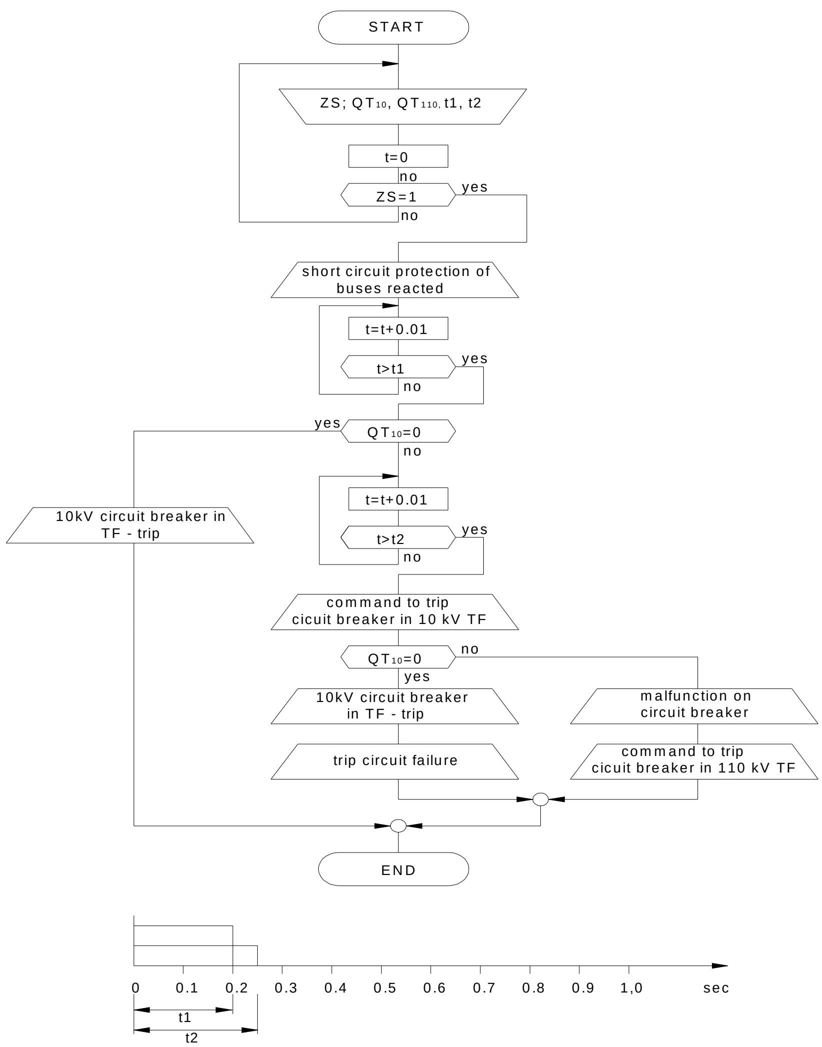
t5 – pickup time for earth-fault protection;
t6 – time delay for new command to trip 10kV circuit breaker
t7 – time delay for command to trip circuit breaker in 10 kV transformer cell;
1 – signal exists; 0 – signal does not exist.

If after pickup time, t5, for earth-fault protection, trip happens, dispatching centre resaves information that earth-fault protection reacted and tripped the circuit breaker. However, if circuit breaker is still on, microprocessor unit waits for additional time t6, and after that, it gives new command to trip the circuit breaker in cell. In case, that the tripping has been successful, dispatching centre receives information that the circuit breaker tripped and that there is a fault on trip circuit, as well. If after second time of trying, circuit breaker is still on, device signalise malfunction on circuit breaker itself and sends information to central unit. Central unit forwards that signal to device on 10 kV transformer fields, and when time t7 flows out, it gives order to trip the circuit breaker in 10 kV transformer cell. If in transformer substation does not exist redundancy earth-fault protection, as it is in TS 110/10 kV "Nis 5", time t7 is pickup time for redundancy earth-fault protection according to Tehnicke preporuke ED Srbije.

2.2. TRANSFORMER CELL 10 kV

Beside the response on commands, which microprocessors units in 10 kV transformer cells receive from devices in 10 kV feeder cells through central unit, they fallow the work of short circuit protection of buses and breaker failure protection, too. Algorithm, which has showed on picture 2.3, describes principle of local automation due to reaction of short circuit protection of buses.



Picture 2.3

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LEGEND:
ZS – signal short circuit protection of buses;
QT – signal from auxiliary contacts on circuit breaker in 10kV transformer cell;
t – counter with time step 0.01s;
t1 – pickup time for short circuit protection of buses;
t2 – time delay for command to trip circuit breaker in 10 kV transformer cell;
1 – signal exists; 0 – signal does not exist.

If after pickup time t1, short circuit protection of buses trips the circuit breaker, dispatching centre gets information that the short circuit protection of buses reacted and tripped the circuit breaker. However, if after that time, circuit breaker is still on, microprocessor unit waits for additional time t2, and after that, it gives new command to trip the circuit breaker in the cell. In case, that the tripping has been successful, dispatching centre gets information that the circuit breaker has tripped, but there has been fault on the trip circuit. If and after second time of trying, circuit breaker is still on, device signalise malfunction on circuit breaker itself and sends information to central unit. Central unit forwards that signal to device on 110kV transformer field, which gives order to trip the circuit breaker in 110 kV transformer field. Principle of acting of local automation is practically same due to reaction of breaker failure protection. Of course, difference is in pickup time for protection.

2.3. TRANSFORMER FIELD 110 kV

On this field in TS 110/10 kV “Nis 5”, some protections relays give command to trip the circuit breaker. There is differential protection, overcurrent protection on high voltage side, Bucholtz relay, Bucholtz protection of regulating clutch. Microprocessor unit on this place has programmed so it follows the work of mention protections. Principle of acting of the local automation after overcurrent protection reaction on high voltage level practically is the same as principle of acting after overcurrent protection reaction on 10 kV feeders. In this case, if after second time of trying to trip the circuit breaker in 110 kV transformer field, device from this place, through central unit, sends information to device on CB of 110 kV line, which gives command to trip the circuit breaker on CB of 110 kV line. On exam of differential protection reaction, local automation will be act in the way that describes algorithm shown on picture 2.4.
If after differential protection reaction, circuit breaker is still on, microprocessor unit waits for additional time t5, and after that, it gives new command to trip the circuit breaker in 110kV transformer field. In case, that the tripping has been successful, dispatching centre gets information, that circuit breaker has tripped and there is a fault on the trip circuit. If after second time of trying, circuit breaker is still on, device signalise fault on circuit breaker itself and sends information to central unit. Central unit forwards that signal to device on CB of 110 kV line, which instantly gives command to trip the circuit breaker in CB of 110 kV line. Of course, dispatching centre gets information of every event and possible failure.

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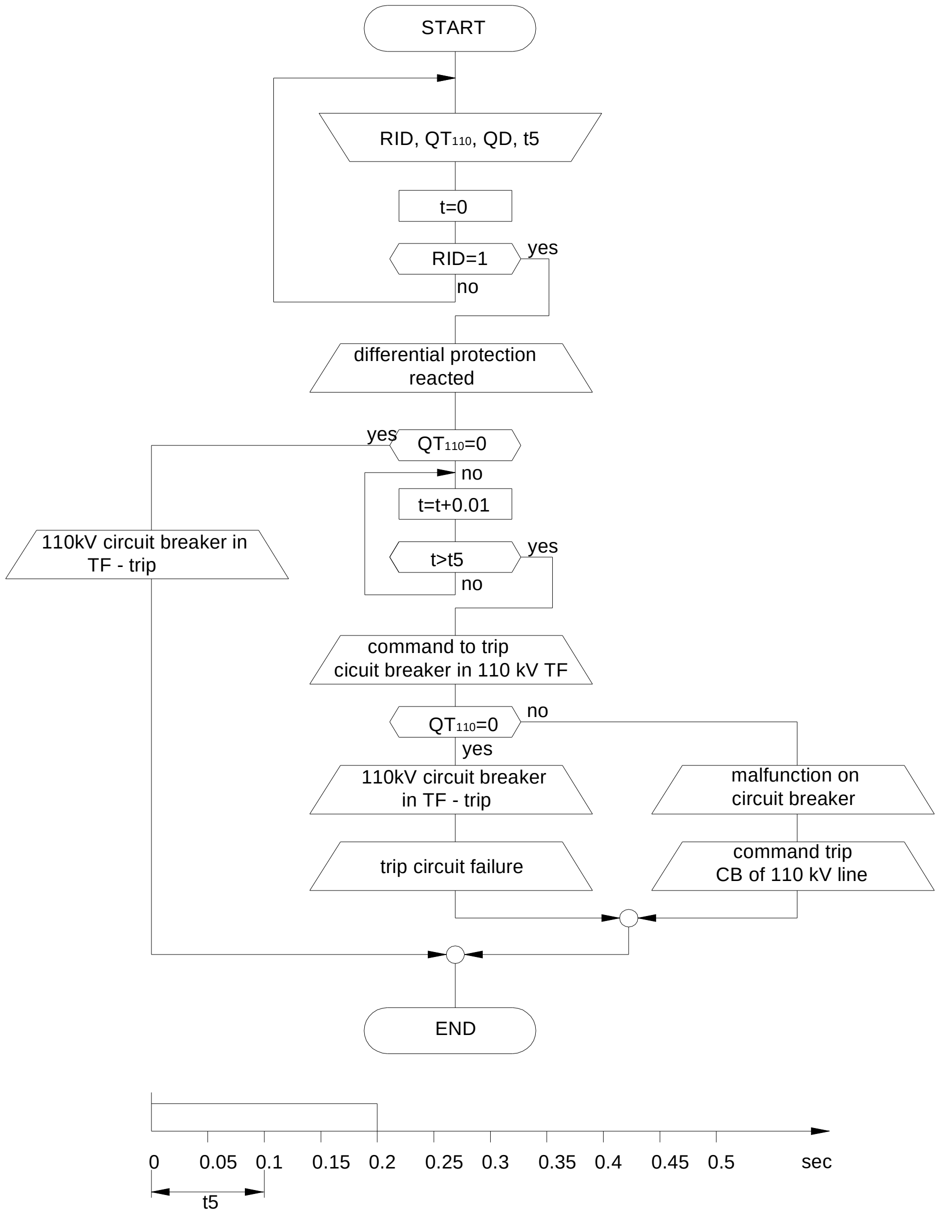

Picture 2.4

LEGEND:
RID – signal from differential protection;
QT – signal from auxiliary contacts of 110kV circuit breaker in transformer field;
t – counter with time step 0.01s;
t5 – time delay for command for turning off circuit breaker in feeder field;
1 – signal exists; 0 – signal does not exist.

Except already mention function, this algorithm has one more, nothing less important function, and that is automatically downloading of transformer, with intention to prevent completely tripping of transformer if comes to the overloading. Algorithm, which describes principles of function, was given on picture 2,5.

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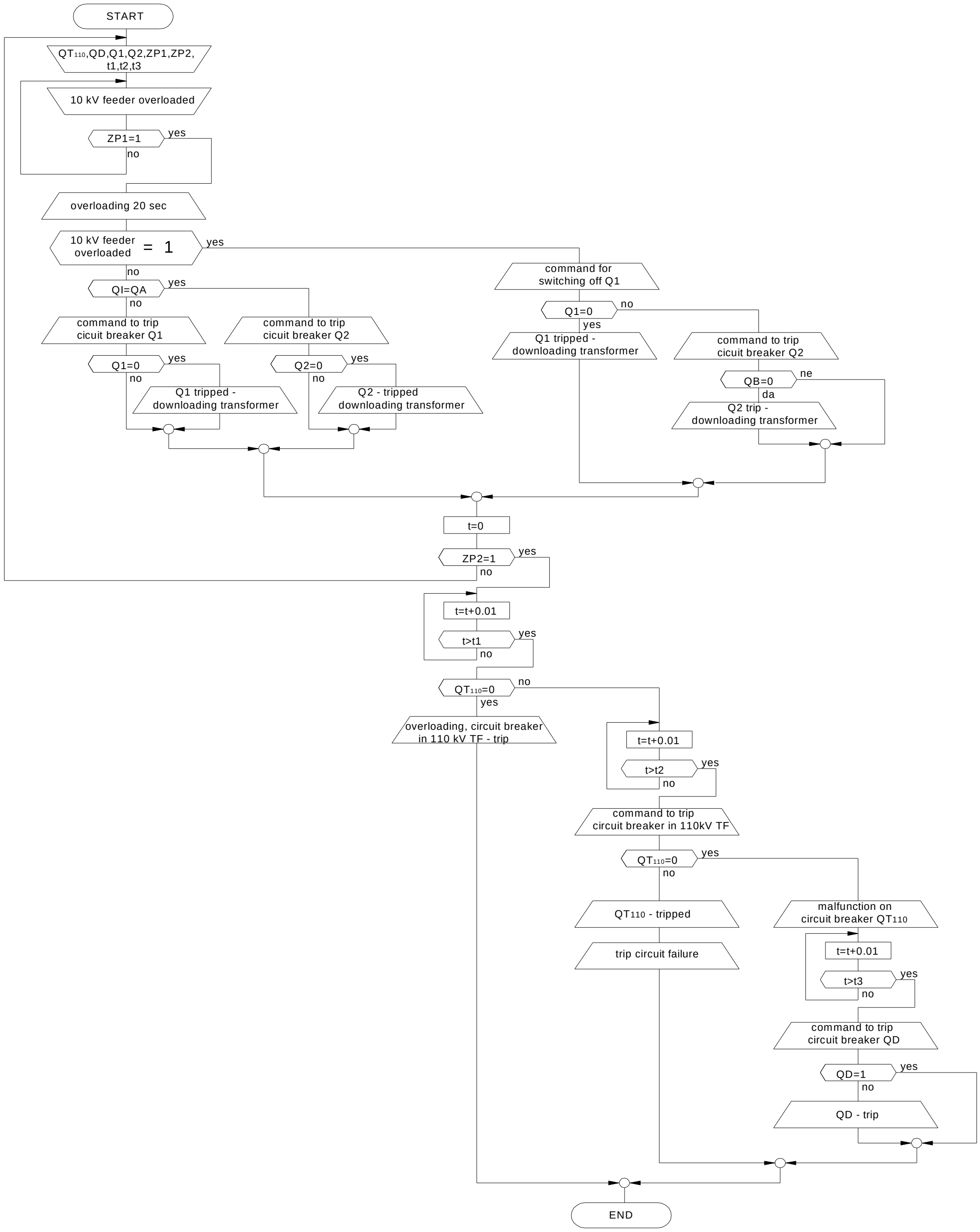

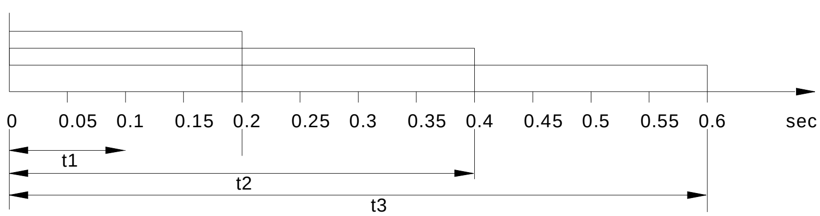

Picture 2.5

LEGEND:
ZP1 – signal preamble of overloading 20 sec;
ZP2 – signal overloading – trip;

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QI – circuit breaker in 10kV cell, where has been overcurrent protection reaction;
Q1 – circuit breaker in 10kV cell with the least priority;
Q2 – circuit breaker in 10kV cell with minor priority;
QT – signal from auxiliary contacts of 110kV circuit breaker in transformer field;
t – counter with time step 0.01s;
t1 – pickup time for overload protection;
t2 – time delay for new command for turning off 10kV circuit breaker in transformer fie ld;
t3 – time delay for command for turning off circuit breaker in feeder field;
1 – signal exists; 0 – signal does not exist.

Beside the signal of protection of overload and signals from auxiliary contacts of circuit breaker on 110 kV transformer field and CB of 110 kV line, input data on microprocessors unit are signals from circuit breakers in 10 kV cells too. Electrical 10 kV feeder cells have defined in such a manner that Q1 is circuit breaker in 10kV feeder cell, which feeds consumer with the least priority. Q1 will be trip first with intention to download transformer. Q2 is circuit breaker in the second 10kV cell, which will be trip if overload of transformer still exists after tripping of Q1, or Q1 has already tripped or malfunctioned. If we go back on principle of function of local automation in 10kV cells, we will see that if executive element has not tripped circuit breaker after overcurrent protection reaction, then will not come to the trip of transformer because of overloading on some off feeders. In that case, signal “feeder overload” goes to the unit on 110 kV transformer cell, through central unit. If this event causes transformer overloading, local automatic gets activate. It means, if the first level of overload protection has reacted, in dispatching centre arrives signal preamble overload 20 sec. Then central unit sends command for switching off the circuit breaker Q1, but before that, program demands is it Q1 feeder that has been overloading. If it is, local automation gives an order for trip the circuit breaker Q2. However, if the transformer is still overload, and meanwhile, second level of overload protection reacted, when the pickup time for overload protection flows out, program checks the condition of the circuit breaker in 110 kV transformer field. If in that time the actual trip happens, dispatching centre receives information that overcurrent protection has responded and trip the circuit breaker. But, if the circuit breaker is still on, microprocessor unit waits for additional time t2, and after that, it gives new command to trip the transformer. In case, that tripping has not been successful, dispatching centre receives information that there is malfunction on the circuit breaker itself. Device sends information to central unit. Central unit forwards that signal to device on CB of 110 kV line, and when time t3 flows out, it gives order to trip the circuit breaker in CB of 110 kV line.

CONCLUSION

Logical algorithms that have been described in this addition have intention to enable realisation of local automation as one type of transition solution between previous principles of adaptation of the transformer substation in the remote control system and the new system that has based on installation of microprocessor protection. Therefore, application of this contribution should be enable using all preferences of microprocessors in transformer substations that have been adapt in remote control system. After all, it is important to display that the possibility of the realisation of this local automatic has been directly conditioned by exist of local microprocessor units, which have possibility of the software programming of the logical algorithms.

Described principles of functional of local automaton in transformer substation that has been adapted in remote control system with distributed concept enable accurately localisation of malfunction in system of relay protection. This concept alleviates making decisions in intentions to eliminate the faults that have done and accelerate procedure for bringing equipment and plant itself in normal condition of working.

It is alternative to the existing protection system, which contributes reliability and quality in functionality of whole relay protection system in observed transformer substation.

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