CHAPTER 7

SOFTWARE DESIGN AND IMPLEMENTATION

7.1 INTRODUCTION

This chapter presents the design details of the software through flow chart & program coding and working principle of software blocks.

7.2 SOFTWARE ROUTINES BY FLOW CHART

Design of the software includes the following main and subroutines and the algorithm is explained in the flow charting for the main and few important subroutines:

i. Main routine,
ii. Current measurement and Overcurrent fault routine,
iii. Current measurement and Instantaneous overcurrent routine,
iv. Unbalance current measurement and overcurrent routine,
v. Unbalance current measurement and instantaneous overcurrent routine,
vi. Rate of rise of current measurement and comparison routine,
vii. Voltage measurement routine,
viii. Energy measurement routine,
ix. Downtime energy measurement,
x. Manual close / open routine,
xi. Breaker failure protection,
xii. Cubicle temperature measurement routine,
xiii. Fire alarm detection routine,
xiv. Breaker response time routine
xv. Display routine.

7.2.1 Main Routine

The main routine includes the resting the ARM processor, initializing all the devices in built in the processor and routines as shown in Figure 7.1.

**FLOW CHART FOR MAIN ROUTINE**

[Diagram showing flow chart for main routine of the ARM processor]

**Figure 7.1 Flow chart for main routine of the ARM processor.**
7.2.2 Overcurrent Detection and Breaker Trip Routine

The actual current is measured from the analog inputs, compares with the set value. On exceeding, the trip command is initiated according to operating time calculated based on IDMT characteristics. The routine is shown in Figure 7.2. Flow chart is similar for earth fault overcurrent function.

![Diagram](attachment://overcurrent_detection_flowchart.png)

**Figure 7.2 Flow chart for overcurrent detection and tripping**
7.2.3 Instantaneous Overcurrent Detection and Breaker Trip Routine

The instantaneous current is measured through the analog inputs, compared with the set value of current and the operating time, accordingly the trip command is issued is shown in Figure 7.3 as flow chart. Flow chart is similar for earth fault instantaneous overcurrent function.

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**INSTANTANEOUS OVERCURRENT DETECTION**

- **Start**
- Read the phase currents from the analog inputs
- Is $I > I_{set}$?
  - Yes: Load the instantaneous operating time into the counter3 and memory2
  - No: Display the actual values on LCD
- Decrement Counter3
- Increment Counter4
- Is Counter3 = 0?
  - No: Return
  - Yes: Initiate the trip command and display memory2 and counter4
- Return

**Figure 7.3 Flow chart for instantaneous overcurrent detection & tripping**
7.2.4 Rate of Rise of Fault Current Detection and Alarming

The change in steady state of the actual current is detected through the analog inputs, compares with the set value of the rate of rise of the fault current \((\text{di/dt})_{\text{set}}\) and on exceeding, the set value, the relay issues alarm. The function is shown as the flow chart in the Figure 7.4.

![Flow chart for rate rise of fault current detection & alarming.](image)

**Figure 7.4 Flow chart for rate rise of fault current detection & alarming.**
7.3 FUNCTIONAL BLOCKS OF SOFTWARE

The design of the software was approached also by functional block. Utilizing the various functional blocks designed in the ARM processor and the Human Machine Interface, the basis for writing the program was arrived.

7.3.1 Overcurrent Fault Operating Tripping Time (t)

The calculation of the relay operating time (t) on detection of the overcurrent based on the IDMT characteristics “Extremely inverse curve” is carried out by using the functional blocks of multiplier, divider etc., and is shown in Figure 7.5. The value of the constants (α & A) according to the selected curve is fed into the processor. The Time Multiplier Setting (TMS) value and the overcurrent set value is also stored in the locations of accessible parameters.

Figure 7.5 Software functional blocks for operating time calculation.
7.3.2 Instantaneous Overcurrent, RRFC and Over / Under Voltage

The program coding were written for designing the comparator blocks, rate of rise of fault current (di/dt) block for the functions of instantaneous overcurrent (I \( \gg \)) detection, Rate of Rise of Fault Current (RRFC) detection and over / under voltage (OV/UV) fault detection and is shown in Figure 7.6.

**Figure 7.6 functional blocks for I>>, RRFC and OV/UV detection.**
7.3.3 Energy Measurement

The measurement of energy is being done by the device ADE 7878 and the measured energy is fetched by the ARM processor, logged in the different memory locations as daily energy, total energy and the down time energy consumption based on the digital input generated internally and externally. The functional block diagram is shown in Figure 7.7.

![Functional block diagram for energy measurement](image)

**Figure 7.7 Functional blocks for energy measurement and logging.**

7.3.4 Cubicle Temperature and Breaker Response Time

The software program is also written for designing the software routines by functional blocks for measurement of cubicle temperature, detection of fire alarm from the digital input and opening and closing response time of the breaker on sensing the digital inputs of open & close commands respectively and is shown in Figure 7.8.
Figure 7.8  Functional blocks for cubicle temperature, response time of breaker and detection of fire alarm signal.
7.3.5 Display of Actual Values on a Real Time Basis and Logging

Displaying of the actual values of voltage, currents, power related parameters and temperature is made available by writing the program coding as functional blocks and shown in the Figure 7.9. The logging of the actual values at fault condition is also designed.

Figure 7.9 Software blocks for display of actual values and logging.
7.3.6 Accessibility of Different Menus in the Relay

The relay is designed for setting of different parameters, giving commands, viewing the various real time values, status and historical values and is shown in Figure 7.10.
7.3.7 Human Machine Interface (HMI) with GSM modem

The software is designed to accept the digital flags viz. breaker tripped, rate rise of fault current exceeded etc., from the relays along with the actual values and energy consumption and is shown in Figure 7.11. The quantity of the production is accepted and accordingly the specific energy report is prepared. The software is designed for sending the SMS messages through the GSM modem on detection of the respective inputs.

Figure 7.11 Functional block for HMI with the GSM Modem
7.4 SUMMARY

This chapter described the details of software design viz. software routines, flow chart, functioning of software blocks for the designed relay.