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Auxiliary Power Change Over System for Sub-stations

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Abstract

Sub-station Protection, Control and Monitoring (PCM) system consisting of sensing devices and switching elements is highly critical for ensuring the reliable operation of substations. All these PCM components are to be operated even in the absence of primary incoming AC power supply using the Station Battery supply. In the event of AC power deterioration, reliable and high speed change-over system is very essential [2]. Proposed Auxiliary Power Change Over System (APCOS) for sub-stations, monitor the changes in input voltage and frequency from their normal range and initiates the transition to Battery Power System. APCOS is designed with a Triple Module Redundancy (TMR) concept based on ARM Cortex-M3 Microcontroller for achieving accurate detection with high reliability. Incoming AC voltages are monitored continuously and change-over is initiated based on its magnitude and frequency of the signal.

Keywords- Substation, Auxiliary power supply, AC Voltage and Frequency, Triple Module Redundancy**.**

INTRODUCTION

PCM is most critical sub-system for the reliable operation of the sub-stations. PCM consisting of various protection relays, breakers, Intelligent Electronic Devises (IED's), etc. requires an un-interrupted auxiliary DC power supply for performing their operations. Auxiliary supply to these devices is to be maintained even in the absence of incoming AC grid power supply to the substation. Normally Station Batteries are used to provide the auxiliary supply during the AC power supply failure. During normal conditions Station Batteries will get charged with AC supply and supplies the auxiliary power to PCM in the event of AC supply failure. Reliable detection of incoming AC power supply failure and high speed change-over to Battery supply without causing any discontinuity of auxiliary power supply is very critical. Hence, APCOS based on the TMR for high reliability along with high speed sensing using 32-bit Micro-controller has been developed.

APCOS is designed to detect the degradation in the input voltage and frequency. If voltage or frequency falls below a set limit, it will generate command to the breaker which will switch the supply from normal to Battery supply [1]. APCOS hardware is designed using 32bit MCU ARM based Cortex M3 processor [3]. APCOS is developed based on Triple Modular Redundancy (TMR) for high reliability and fail safe operation. Three (3) identical ARM processor based modules will sense the input voltage and frequency signals independently. The output from each module is subjected to a hardware based voting (logic) concept. Based on the majority (2/3) the final output is generated. The output of the APCOS is declared only when 2 of the 3 systems will confirm. This will eliminate any spurious output.

SYSTEM ARCHITECTURE

As show in the Fig.1 the APCOS consist of three voltage sensors which monitors the RYB phase of the AC supply. The micro controller based hardware consist of three ARM microcontroller cards connected to a TMR circuit which generate an output signal based on two out of three logics. The three parallel ARM based cards and TMR circuit provides a very high reliable detection and transition system.

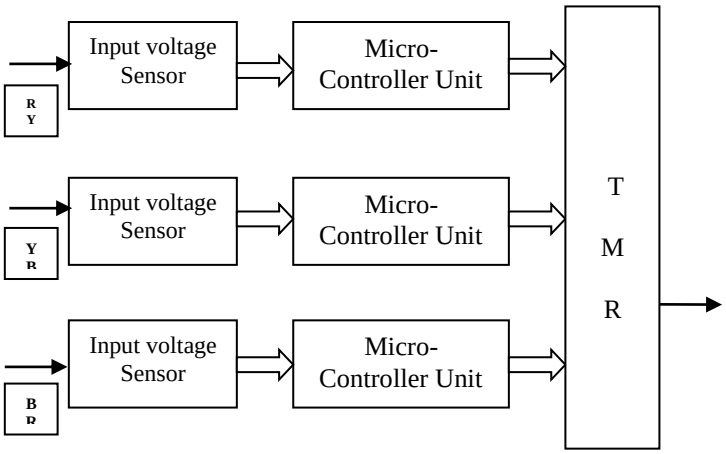


Figure 1. System Architecture of APCOS

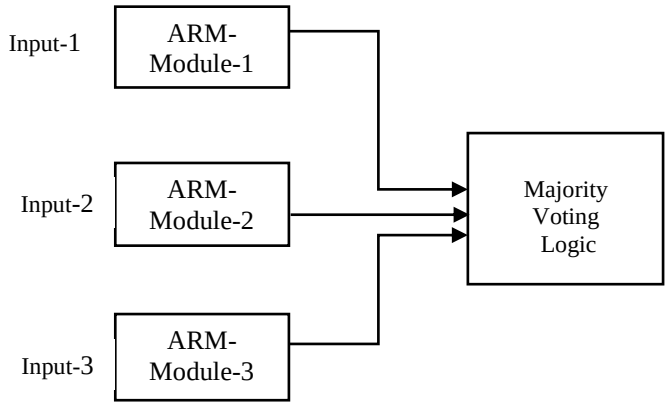
MEASUREMENT OF VOLTAGE AND FREQUENCY

Voltage signals are measured using Hall effect (LEM) sensors Sensor output signal is then passed through a gain circuit which is used for amplifying the voltage signal [4]. The output voltage goes to the RMS to DC converter and the zero crossing detector module. The output of the RMS to DC converter is scaled down to a voltage of 0-3.3volts using a scaling circuit and given to the analog input of the ARM processor where the voltage signal is processed. The zero crossing detector circuit generates the output square wave which goes to digital input of the ARM processor where the frequency is calculated. There is a predefined limit set for the voltage and the frequency in the ARM processor. Whenever the calculated voltage and frequency crosses the predefined limit, ARM processor generates an ouput signal which goes to the opto-isolated digital output circuit For a typical AC sine wave of 50 Hz, zero crossing detector generate a square wave with a periodicity of 20 ms. Calculation of frequency and voltage

takes around 12 ms and 25 ms respectively. Adding a delay of 10 ms for actuating a typical relay, it takes less than 50 ms to implement the detection and transition.

TRIPLE MPDULAR REDUNDANCY

The TMR circuit is a majority gate circuit which receives input from the all three ARM based modules. If two out of three signals are high, then TMR output signal is true and the output of the TMR circuit is high.



TESTING AND EXPERIMENTAL RESULTS

The three ARM based modules are connected in parallel along with the sensors and the whole system is assembled in an enclosure as shown in Figure 2:

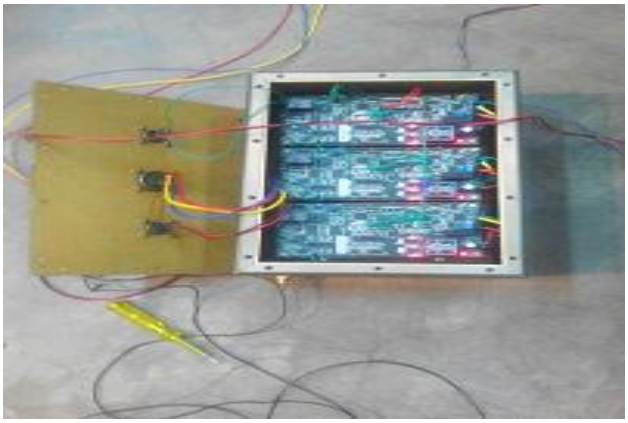


Figure 2. Assembled APCOS Unit

For testing of the APCOS module, the input signals are simulated from the variable auto transformer for varying the input voltage and a function generator is used for varying the frequency. The output of APCOS is connected to LED bulb for indicating the fault. The degradation of the voltage is simulated through auto transformer whereas degradation in frequency is simulated using the function generator. Frequency decreasing test: The frequency is decreased from 50 Hz to 47 Hz, the frequency limit is set to 48 Hz the timing to trip relay is 15.60 ms

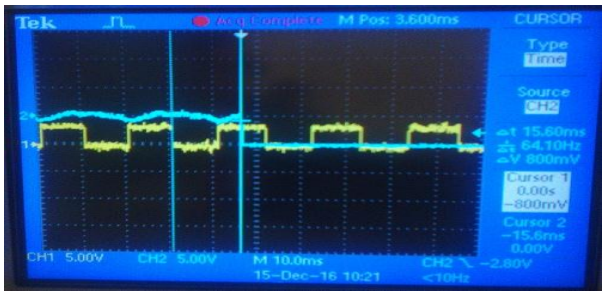


Figure 4. Frequency dip to 47 Hz; Relay Response Time 15.60 ms (Yellow: Frequency; Blue: Relay)

Voltage Variation test: The voltage is decreased from 204 V to 173 V, The voltage limit is set to 200 volts and the timing to trip relay is 40 ms.

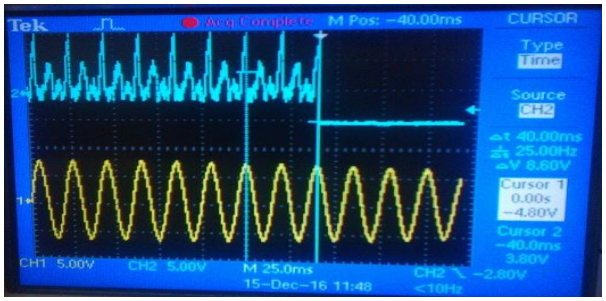


Figure 6. Voltage dip to 173 volts; Relay response time: 40 ms.

CONCLUSION

Highly reliable Auxiliary Power Change Over System (APCOS) has been developed to implement the transition from normal supply to Battery Supply with Triple Modular Redundancy (TMR). Response time of the APCOS for detection and transition is less than 50 ms for all possible conditions. Due to TMR based design, APCOS system continuous to perform even if one of the card is failed. Hence, APCOS is a reliable detection and change over system for switching from normal AC supply to alternate supply for host of applications.

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