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Faults Detection in EPDS through a BEAGLEBONE Black Card

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Abstract

Objectives: The fault detection in Electrical Power Distribution Systems through a Beaglebone Black card made on a low voltage. **Methods:** This paper aims to validate the good functioning of the system, especially the display and the safeguarding of the signal of fault. For these tests, we realized a card of conditioning able to register samples for three seconds of the signals of the departure, of which the values, before and after defect, necessary for the application of fault detection algorithms. **Findings:** This work opens the door to the evaluation of the algorithm on real networks. **Applications:** The goal of this work is to reduce the intervention time and the repetitive power outages according to the behavior of the signal at the moment of the fault.

Keywords: Beaglebone Black Card, Electric Power Distribution Systems, Fault Location, Faults Detection

1. Introduction

The electricity networks are since long time the object of studies in order to control their good use for the systems they supply. In recent years, the environment of the electric world and its modes of organization are changing rapidly. With the liberalization of the electricity market, economic rules are changing: consumers can compete and distribution companies can expand their markets[1].

The RAK's mission is to distribute electricity to consumers, and to achieve this mission, it has made many efforts to ensure the quality of its product. However, interruptions in power supplies are a major problem that degrades the quality of service provided[2], so the growing need to improve power quality requires a rigid and reliable distribution system for fault location.

It is in this sense that our study is written: "acquisition and detection of defects on medium voltage lines". This work aims to reduce the intervention time and the repetitive power cuts based on the behavior of the signal at the moment of the fault.

To complete this work, we have structured it in two parts, the first of which is devoted to a detailed study on the detection of defects and the usefulness of the beagle one card. The second part deals with the implementation part of the project incorporating the acquisition of the signals and their treatments, the implementation of a control application and the results of the tests will be studied in this part.

This project titled "Acquisition and Detection of Faults in a Medium Voltage Network Through a Beaglebone Card" aims, as its name suggests, the acquisition and detection of faults on power lines; that is to say, in a first step, acquire the necessary information (voltages and currents) to analyze the state of the electricity transport and then use the same information to see if there is a fault (short-circuit, overvoltage or cable break).

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2. Fault Location Procedure

2.1 Fault Location Steps

The equipping of electricity, in terms of safety and availability, is a key point in the management of electricity grids, when distribution system outages occur, fast and precise fault location is crucial in accelerating system recovery, reducing outage time and significantly improving system reliability, and thereby improving the quality of services and customer satisfaction.

Fault localization is the most important mission of network management. In general, there are three levels of treatment following the occurrence of a fault in a distribution network.

Fault Detection: Must be very fast because it will open the circuit breakers in order to put off the defective part of the network. It is made from locally available information of Fault Passage Indicators (FPI) and protective relay (currents and voltages measurement)[3].

Fault Location: Can insulate the faulted zone (faultysections) by the network reconfiguration. The fault location can be slower than the detection. However, it must be more precise in order to operate optimally the network switches. Nevertheless, we must not overlook that a slow location may delay renewal of the clients, and impact the quality of service by growing the not distributed energy[4].

Fault Searching: Is to calculate more accurately the distance between the fault point and a reference point of the line often represented by the bus-bar output from the source station. These last two steps are integrated by the current researches in the field of fault localization to have an accurate and a real-time fault location[5], which requires data before and during the fault in contrast to what is present in existing relays.

2.2 Data Processing Procedure for Fault Detection

For protection in the existing protection system, and for fault localization in the target systems, it is necessary to treat the data available on the network, such as the parameters of lines and voltages and currents before and during the fault[6], in order to reach that, the following procedure is necessary:

The Acquisition Card: Indeed, the average voltage of 20 kV cannot be processed directly by the black card hence the use of a relay card step down or acquisition card. This card will obtain the image of the three currents and the three voltages (three-phase system) of the network to adapt them to that of processing [Figure 1].

Figure 1. Data Processing procedure for fault detection in EPDS.

- Voltage range from 0 V to 1.8 V

The Beaglebone Black Card: The beagle one is an electronic card with ideal characteristics to address the issue of data manipulation through the Nano-computer acquisition card[7].

3. Tests and Results

The verification of the effectiveness of the proposed test bench consists first to realize the processing electronic card that assembles all the elements presented above, and then check its reliability on a practical case of fault.

3.1 The Electronic Card

To assemble the cards made in our work, we have designed an electronic card that contains the parts described above this achievement is divided into two stages:

- **Design the Artwork**

From the overall montage, we realized the artwork. The dimensions of the components are in the standards and the final map (acquisition) at 14.4mm in length and 12mm in width [Figure 2&3].

- **Realization of the Circuit**

The final prototype is then shown in the following [Figure 4]. The source station is allied to a circuit breaker for protection before continuing to the fault provided 70 meters from the line and at the end the three loads that are connected.

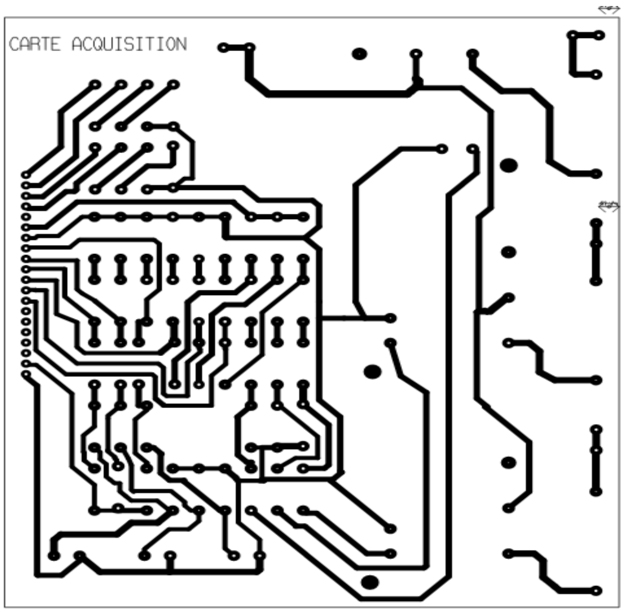

Figure 2. The artwork of the global Card.

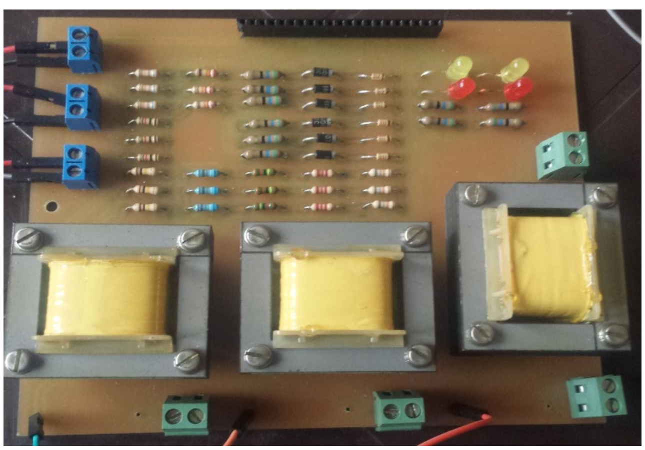

Figure 3. The Circuit of the global Card.

Figure 4. The Prototype of the Test Bench.

3.2 System Simulated

The system studied, as shown in the [Figure 5], is a part of a low voltage network simulating a fault on a three-phase cable that powers resistive loads. The low voltage line is used because of the difficulty of making a test on a real Electric Power Distribution System.

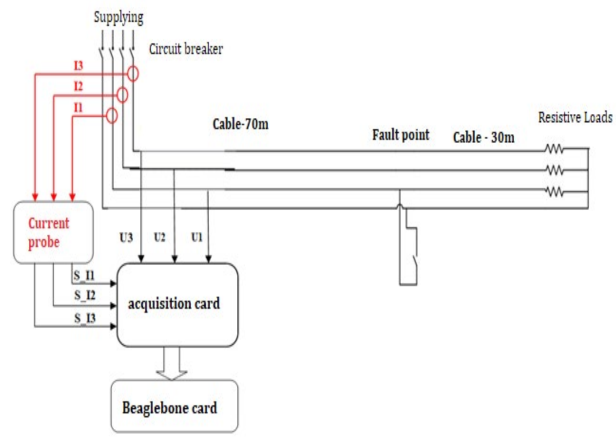

Figure 5. Simulated System.

3.3 Results

3.3.1 Normal State

We carried out several tests, the results of which are automatically saved in the Beaglebone map[8] and the curves and values displayed on the interface.

Let us see the variations for normal operation before the presence of a disturbance:

- **Variation of Currents**

The three measured currents have a maximum variation of 6A (for a 1kw 230V load). It is noted that the curves of the currents are not perfectly sinusoidal. Harmonics and the choice of caliber are the causes. Indeed, the caliber of the probe used is 3000A (0.33mv/A) in order to be able to measure the short-circuit current in the order of 2000A. For a current variation of 4.1A, a voltage of 1.35mV is obtained at the output [Figure 6]. The latter being weak is sensitive to perturbations such as temperature, heat, humidity.

- **Variation of Voltages**

The voltages are out of phase with one another, we can notice here the absence of the peaks [Figure 7].

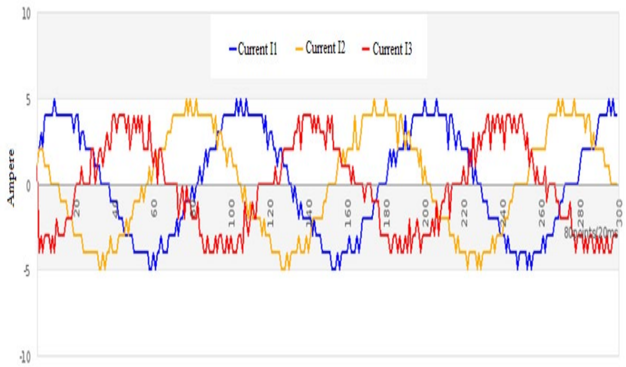

Figure 6. Curves of the three currents in normal state.

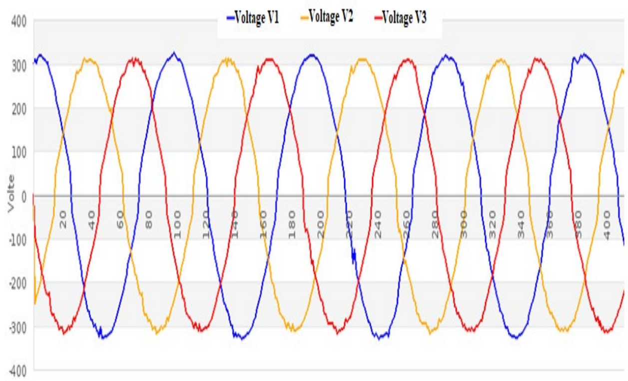

Figure 7. Curves of three normal state voltages.

3.3.2 At the Time of Fault

- **Fault Current**

After creating the defects, we obtain the following curves [Figure 8] the curve in blue represents the image of the current of the faulty line. We can see a slight influence on the other phases.

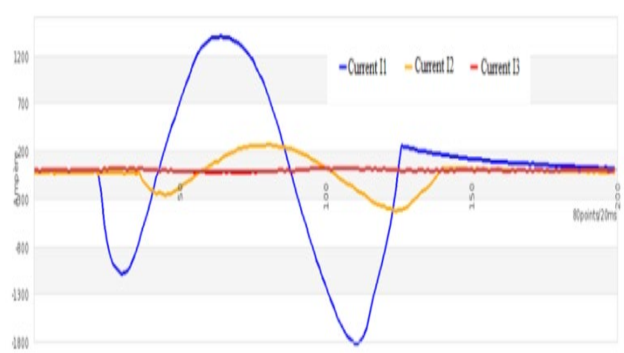

Figure 8. Curve of Fault Current.

Note: The fault variation time is small, because the breaker cut-off time is instantaneous.

- **Voltage at the Time of the Fault**

The voltage vanishes as soon as the fault occurs (short circuit) [Figure 9].

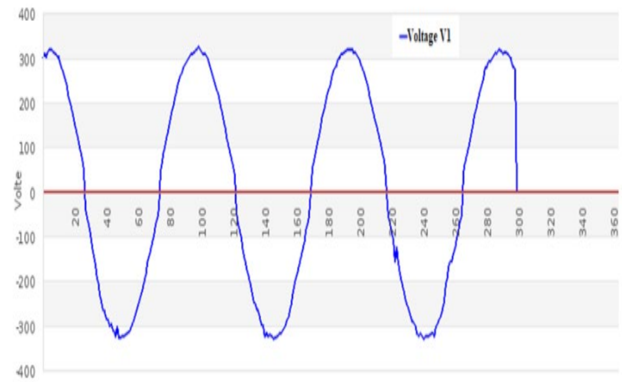

Figure 9. Curve of the faulty voltage.

4. Conclusion

We confirm that our mission whose goal was "Acquisition and faults detection in an EPDS through a Beaglebone card" was a total success. Indeed, we have made a conditioning card able of registration samples for three second of the signals of the departure. These contain the values, before and after fault, required for the application of the fault detection algorithms. The tests carried out on a low voltage start enabled the system to validate the correct performance, especially viewing and recording the fault signals. The result of these results opens the door for testing the algorithm on real networks.

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