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A Novel Fault Identification System in Substations Using Real Time Thermal Image Processing

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Abstract: Thermal Imaging has been an area of potential military interest in the last three decades and has been shrouded by veil of secrecy. Recently there has been resurgence of the interest in thermal imaging due to its use in non military applications such as biomedical engineering; conservation of natural resources, astronomy etc., and list of such applications is growing day by day. In this paper we focus at identifying the type of fault in the substation components before the actual fault to occur using thermal imaging camera. The substation components are captured using thermal imaging camera during working and still condition. The fault that to occur forehand is detected through naked eye by knowing the intensity of each color in the image captured. The image is processed through very large scale integration (VLSI) using field programmable gate array (FPGA) for enhancement of the image using various techniques such as image acquisition, preprocessing, segmentation, classification and decision making. The database is established to find the actual fault to occur for each and every temperature using the pixel calculated. This system eases of the time for analyzing the type of fault by providing the fault likely to occur for the desired temperature through the database and provides immediate solution for the fault.
Keywords: Thermal image, FPGA

I. Introduction

The main aim of the paper is to identify the fault likely to be occurring in various components of substation through thermography by use of thermal imaging camera and identifying the spot of the fault and analyzing it through VLSI board to identify the type of fault from the database framed .

The broad objective of "THERMAL IMAGING CAMERA" is to identify the fault likely to occur before the electrical apparatus gets damaged or tripped. It gives the entire picture of the component with current temperature status of the electrical apparatus thereby which paves the way for identifying the hotter regions that are prone to fault occurrence. The main objective are 1.They are as easy to use as a camcorder or a digital camera.2.It gives a full image of the situation.3.Allows performing inspections when systems are under load.4. Identify and locate the problem. 5. Measure temperatures and Store information.6. It helps to find fault before real problems occur. 7. Saves valuable time and money.

Thermal imaging cameras for monitoring the components in substation are powerful and non invasive tools for monitoring and diagnosing the condition of electrical and mechanical installations and components. With a thermal imaging camera we can identify problems early, allowing them to be documented and corrected before becoming more serious and more costly to repair.

A. Existing system

In existing system thermal imaging cameras are used for predicting failures because they make the invisible visible. On a thermal image problems seem to jump right out at you. To keep plants operational at all times many industries have combined their predictive maintenance programs with the most valuable diagnostic tools for industrial applications on the market: thermal imaging cameras. This only gives the hot spot of the system rather giving out the immediate solution to the fault that's likely to occur.

B. Proposed system

In proposed system the thermal images captured are processed at board level by very large scale integration (VLSI) through field programmable gate array (FPGA) for enhancement of image and identifying the type of fault that is likely to be occurring for the temperature that's shown in the image at hot spot. This gives the immediate solution for the technician so that the system can be protected prior from damage.

II. Technology

Human eyes can only see light in the visible spectrum, ranging from about 400 nm to a little over 700 nm. The electromagnetic spectrum is a band of all electromagnetic waves arrange according to frequency and wavelength. As shown in Fig. 1, the wavelength spectrum of infrared light ranges from about 1 mm down to 750 nm. All objects emit energy proportional to its surface temperature. However, the energy radiated can only be detected by an infrared detector that depends on the emissivity coefficient of the surface under measurement. The core of the camera is the infrared detector, which absorbs the IR energy emitted by the object (whose surface temperature is to be measured) and converts it into electrical voltage or current. Any object emits energy proportional to its surface temperature. However, the energy really detected (by the infrared detector) depends on the emissivity coefficient of the surface under measurement. The emissivity tells us how much of the thermal radiation from an object that is emitted due to the temperature of the object. All objects above absolute zero(0 Kelvin) emit infrared radiation. The Stefan-Boltzmann law describes the total maximum radiation that can be released from a surface. Since thermal imaging systems only respond to a small portion of the spectrum, it is necessary to introduce Planck's blackbody law.

A. Measurement and Analysis method

A widely used method of using thermography in electrical equipment inspection is by employing the ΔT criteria. Qualitative measurements are sometimes called comparative thermography. When the comparative technique is used appropriately and correctly, the differences between the two (or more) samples will often be indicative of their condition. The severity or the level of overheating of the electrical equipments will refer to the temperature-rating table. This table is usually divided into three or four different categories to indicate the maintenance priority based on the equipment's temperature rise with respect to other similar component (Lindquist et al., 2005). Table 2 shows the maintenance testing specifications for electrical equipment published by the Inter National Electrical Testing Association (NETA) ("Standard for Infrared Inspection of Electrical Systems & Rotating Equipment," 2008). NETA provides guidelines for thermal inspections of electrical equipment. These guidelines are based on differences in temperature from one phase conductor or component to another. Recommended action is dependent on the difference in the temperature.

TABLE I

Priority	ΔT between similar components under similar load(oC)	ΔT over ambient temperature (oC)	Recommended actions
4	1-3	1-10	Possible deficiency, warrants investigation
3	4-15	11-20	Indicates probable deficiency, repair as time permits
2	_	21-40	Monitor until control measures can be accomplished
1	> 15	>40	Major discrepancy, repair immediately

Maintenance testing specifications for electrical equipment

Here we are using VT02 Thermal viewer for Electrical Inspection

B. VLSI

The main objective of Very Large Scale Integration are to reduce the testing equipment size and increase the response time and reduce the power consumption. Here we are using Xilinx software for Simulation purpose and Spartan3E Xilinx Hardware kit for implementation purpose.

III. Methodology

The real time image of components in substation is captured using thermal imaging camera under load and normal conditions. The image is roughly analyzed through naked eye for location of the hotter region in the image. The image is analyzed using various techniques such as image correlation, image enhancement, filtering and morphing. This image is processed with Altera field programmable gate array (FPGA) and analyzed for substation identification of fault level in the component. Software's such as XILLINX for coding in field programmable gate array (FPGA) and smart viewer for report generation is used.

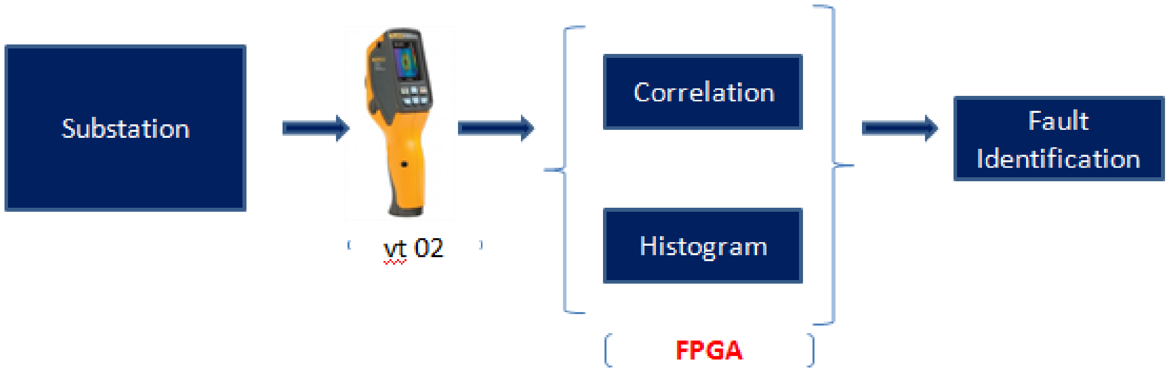
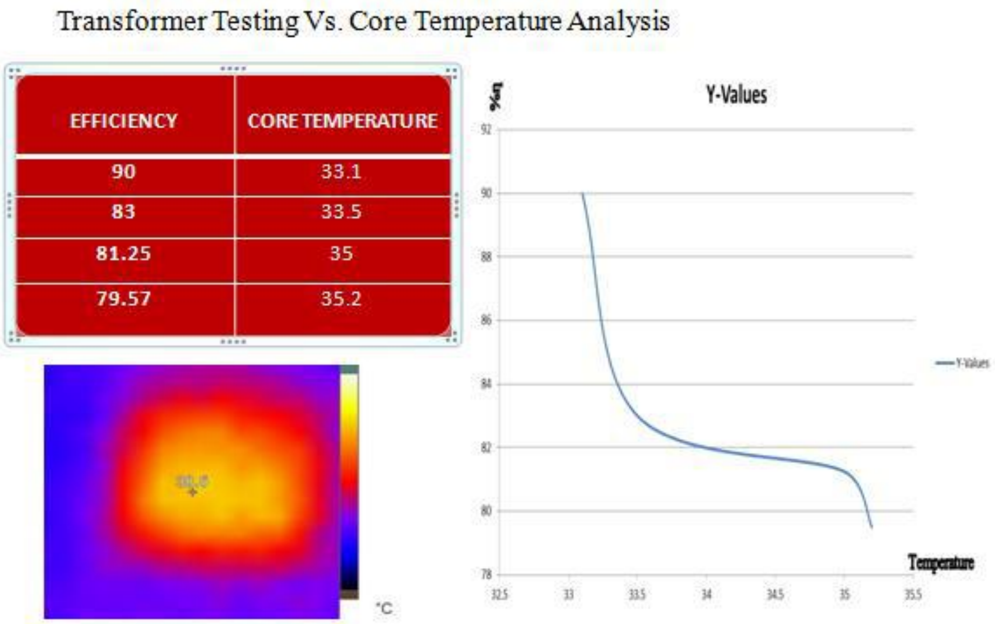


Fig: Proposed Block Diagram

A. Temperature Test:

In Substation we are consider only power transformer, we are conducted varies transformer testing such as OC test and SC Test by the experimental view. By the experimental result we are clearly absorbed The core temperature and Transformer efficiency is directly propositional.



EFFICIENCY	CORE TEMPERATURE
90	33.1
83	33.5
81.25	35
79.57	35.2

Fig 2. Core Temp Vs Efficiency

From the Short circuit test and open circuit test we can related efficiency with transformer's temperature . Below experiment result explained that the temperature of transformer and overall efficiency of transformer is indirectly propositional, if transformer temperature increases means the efficiency is reduced. The both experiment result calculated by manually.

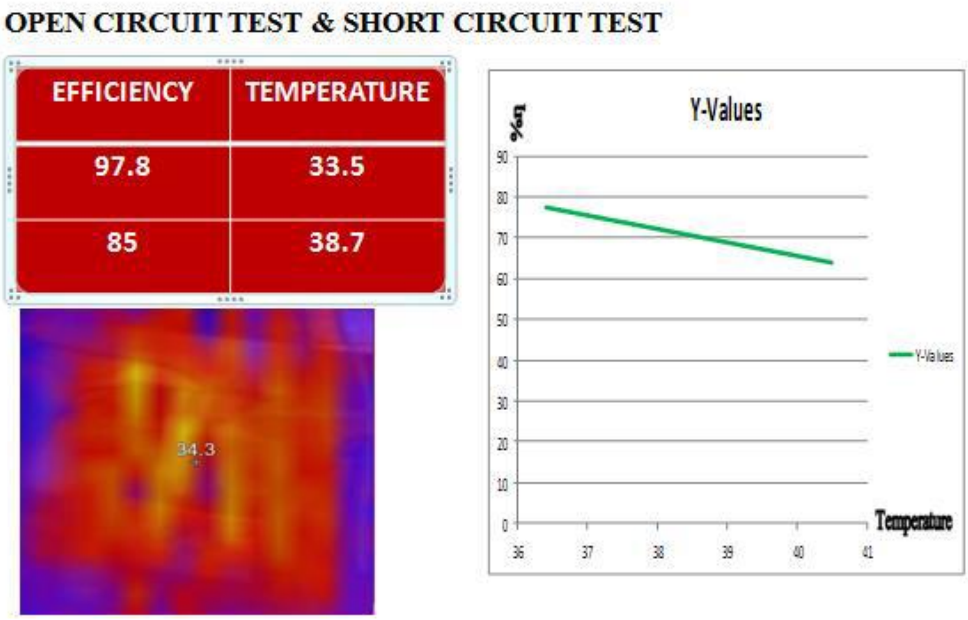
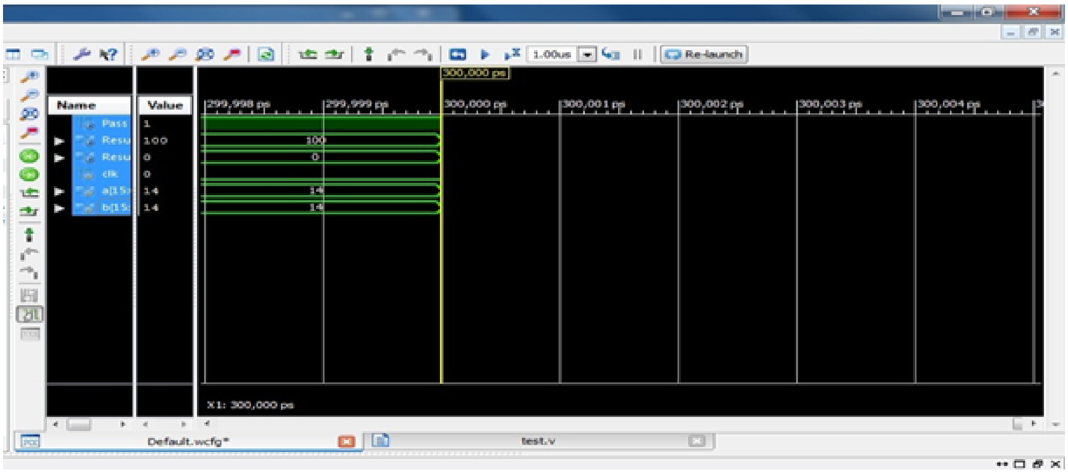


Fig3. SC Test & OC T

B. Simulation Result

Using xillinx software:



Threshold value:

➢Minimum 70 % below there is no fault.

➢Maximum 75 % above there occurs fault.

Fig 4. Correlation Result.

Image fault identification was done using xillinx and MATLAB simulation software.The image was converted to pixel values using MATLAB and then checked with correlation formula for identifying the fault`.Here the threshold value was set to 70 to 85 percentages. If it goes above the threshold value then fault has occurred which is needed to be rectified.

C. Advantage

We propose an approach based on thermal image processing using very large scale integration (VLSI) through field programmable gate array (FPGA), widely applied in thermal image processing for monitoring and identifying faults in substations. The proposed approach provides efficient and accurate results in identification of fault.A low-cost intelligent board level processing is adopted for fault recognition in substation components.The system is of low cost, which makes it a useful supplement of modern Monitoring system. It is helpful tool in predictive maintenance in electrical industries It reduces the inspection time and minimizes the cost of analysis that is to be done for identifying the fault.

IV. Conclusion

In this paper we proposed a method to identify the fault that is to occur in components of substation using very large scale integration (VLSI) through field programmable gate array (FPGA) with image processing algorithms. The captured images were processed for enhancement of the image using various techniques such as image acquisition, preprocessing, segmentation, classification and decision making. To obtain a meaningful solution, we studied the relationship between the thermal and electrical parameters for setting up the fault database. It provides efficient and accurate results for fault identification through board level image processing.

A. FUTURE SCOPE:

Currently, the capturing technique is not automated. Thus, it is not suitable for automatic capturing of image for fault detection and correction. In the future, we plan to develop the automated system which is monitored using thermal video camera through power line carrier communication that identifies the fault level and isolates the specific component that has temperature beyond the specified limit.

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