THERMOGRAPHY BASED HOTSPOT DETECTION AND PROTECTION SYSTEM

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Abstract

This paper is about the thermal diagnosis and control of electric machines or transformer using a Thermal image camera, color sensor, a microcontroller and a PLC. A color sensor is developed which respond to the colors of thermographic images and when overheating or Hot spot occurs it automatically give alarm signal or it can be used to switch off the electric machines or transformer.

Keywords: Thermal image camera, Hotspot, Automation, PLC, Color sensor, Protection.

1. Introduction

Thermography is based on the detection of infrared radiation (IR) which is emitted by a body at temperature above absolute zero i.e. zero Kelvin. It is also known as thermo vision. Thermography converts infrared radiation into visible light in form of a thermal image.

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Thermal image is a map of the temperature field on the object’s surface.[1] The power of radiation depends on the radiant property of body. Thermo vision or thermographic cameras is used to perform these test.

Thermo vision system is special kind of thermometer that can make temperature snapshots from a distance. Thermography is an effective and noninvasive diagnostic method.[2] The thermal images are generated on a temperature map which is interpreted graphically.[3] The thermal image of the object can be easily seen on the viewfinder or report IR because all temperatures are assigned by different colors.[4] With our designed color sensor each of these colors on thermal image generates a different unique code. This sensor is connected to microcontroller, which generate alarm or can be used to automatically switch off the electric machines or transformer using PLC when overheating or Hot spot is detected by thermal image (thermographic) camera.[5]

2. Key Benefits

The main advantage of a thermographic method is that the measurements are made during usual working conditions without making any contact to the electric machine or transformer.[6] Thermography method is characterized by high accuracy of measurements and may be applied to different types of electrical machines.[7]

The Automatic Hotspot detection and protection system is designed and have the following merits:

- Automatic condition monitoring is possible.
- Cheap.
- Efficient.
- Can be easily programmed as per adopted color-scale and relationship to scale of temperatures.
- Can be easily connected to PLC.
- Detect any faults that creates a rise in temperature and then this system will generate alarm or switch OFF electrical machines or transformer for fault diagnosis.

3. Thermographic Camera

A thermographic camera, also called as FLIR (Forward Looking InfraRed), or an infrared camera, is a device that forms an image using infrared radiation (IR), similar to a common camera that forms an image using visible light. Instead of the 450–750 nanometer range of the visible light camera, infrared cameras operate in wavelengths as long as 14,000 nm (14 µm) as shown in Fig.1. Cameras create a thermal image of observed target, generally in scale from black (coolest) through red to white (hottest), and also provide on the image a reference scale. Thermographic cameras can be broadly divided into two types: those with cooled infrared image detectors and those with uncooled detectors.[8]

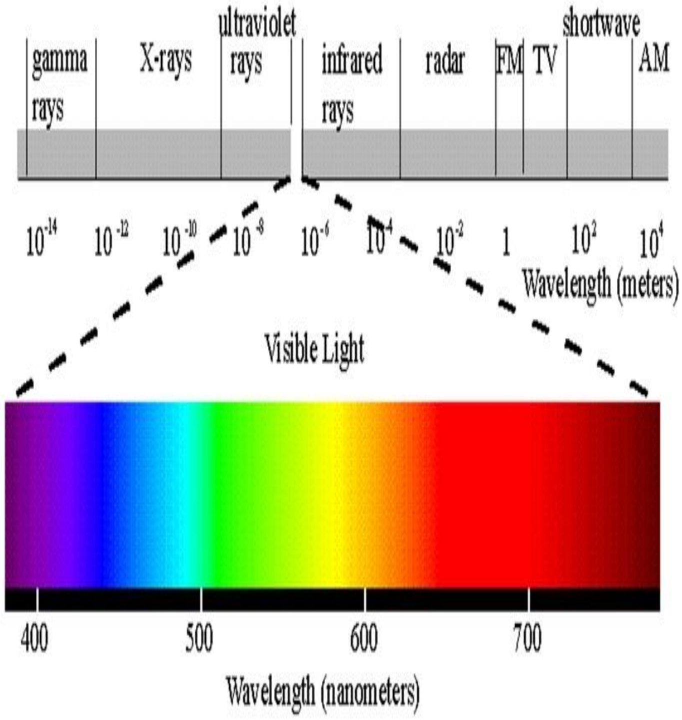

Fig.1. Light spectrum.

4. Principle

A color sensor is used to pick up different colors from the thermal image of thermographic camera and if a hotspot is detected it will automatically generate alarm. Fig. 2 shows the block diagram of automatic hotspot protection system which uses a thermal image camera to generate thermal image, color sensor to detect color, a microcontroller to program the system for detecting hotspot from thermal image on camera and a PLC system whose input is a signal from microcontroller and PLC output is used to energized the contactor or circuit breaker. Table I shows that when the output of microcontroller is LOW the system is healthy and PLC output is HIGH, so electric machine or transformer will run normally. When microcontroller alarm output is HIGH, it will generate alarm that means a hotspot is detected in electric machine or transformer and the PLC output will remain HIGH. However if multiple hotspot are detected in system then under such condition trip output of microcontroller will become HIGH and the immediate shutdown is required in order to prevent further damage.

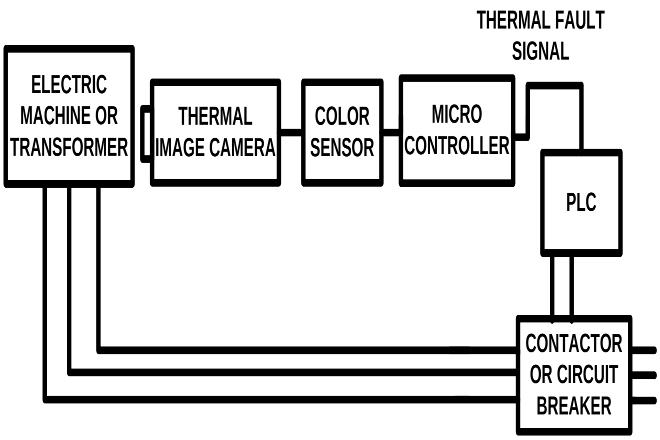

Fig.2. Block diagram of Hotspot sensor used for protection of electric machine or transformer.

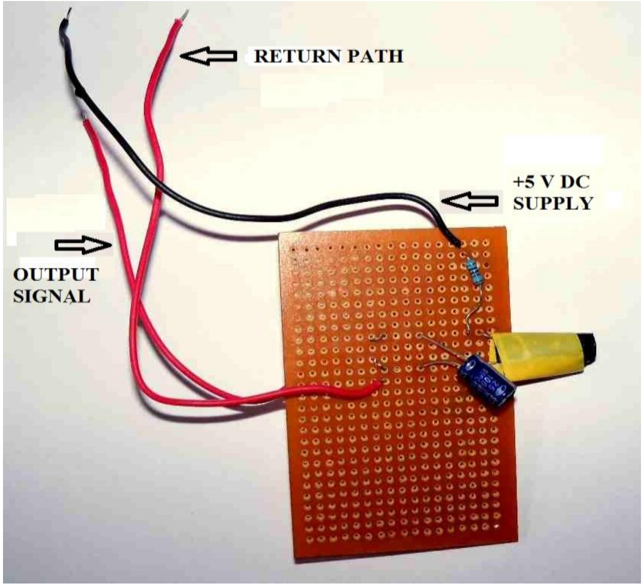

Fig.3. Three wires Color sensor developed.

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Table.1 Control Strategies

COLOR SENSOR OUTPUT	ARDUINO ALARM SIGNAL (PIN 4)	ARDUINO TRIP SIGNAL (PIN 5)	PLC OUTPUT
No Hotspot	LOW	LOW	HIGH
Hotspot (one section)	HIGH	LOW	HIGH and generate ALARM
Multiple Hotspot	HIGH	HIGH	LOW

5. Hardware Developed

On line condition monitoring of electrical machines has become an area of growing interest and importance.[9-11] Digitally condition monitoring of electrical machines has received considerable attention in recent years. These methods are containing microcontroller, microprocessor, computer and programmable logic controller (PLC).[12-14]

Fig.3 shows the hardware developed for color sensor. The sensor is moved gradually on the screen of the thermal image camera, if a hotspot is detected in the thermal image of electrical machines or transformer then the sensor will automatically generate alarm. The alarm can be in form of LED or a buzzer or both depending upon the application.

The sensor developed is a color sensor with three wires. One wire used as supply i.e., +5 V DC, second wire as a return path and the third wire are used to give output in the form of voltage. When sensor detects the hotspot section then the output voltage is 4.5 V dc. This output wire is connected to the analog input pin A0 of the microcontroller, so it will generate a codes corresponding to all voltage level from 0-5 V dc. The microcontroller is programmed such that when a white or white-yellow color is detected in the thermal image taken from the thermal image camera, then alarm signal output (Pin 4) of microcontroller will be HIGH and it will generate alarm in form of light or buzzer and when multiple hotspot is detected then the trip signal output (Pin 5) of microcontroller which is connected to the PLC will become HIGH and then the electric machine or transformer will switch OFF automatically. Fig.4 shows the connection diagram for automatic hotspot protection system which comprises of a thermal image camera, color sensor, Arduino based microcontroller, PLC. Fig.5 shows the microcontroller that is used to give overheating fault and alarm signal to PLC. Siemens LOGO PLC is used in this project. Fig.6 shows the control and power circuit panel.

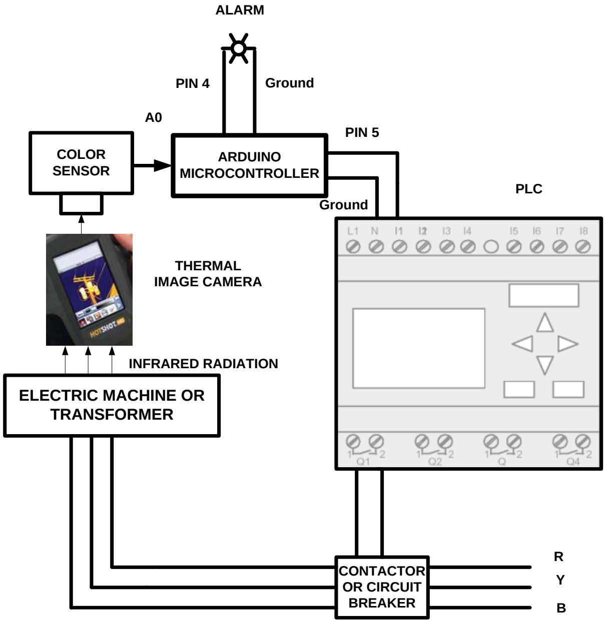

Fig.4. Connection diagram for automatic hotspot protection system.

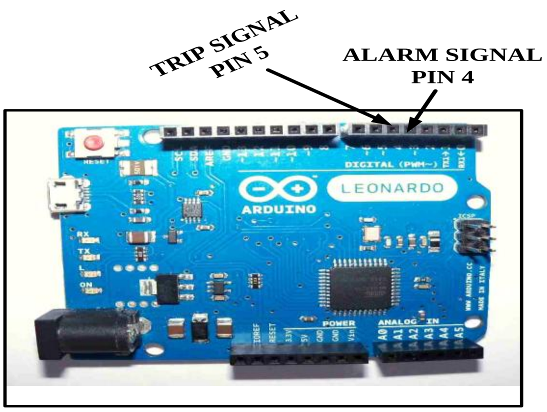

Fig.5. Arduino Microcontroller.

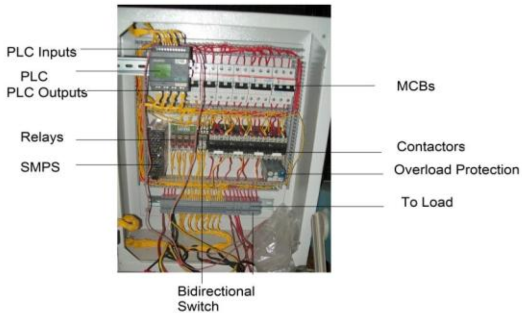

Fig.6. PLC based control and power panel.

6. Results

Fig.7 shows the thermal image of coupling of an induction motor drive and Fig.8 shows the thermal image of a step down three phase transformer where the hotspot is shown in white color. When this type of white color is there in a thermal image the color sensor will automatically detect it and generate an alarm signal but when multiple hotspot occurs as seen in Fig.8, then under these circumstances the system will automatically switch OFF for fault diagnosis by generating a trip signal from the microcontroller.

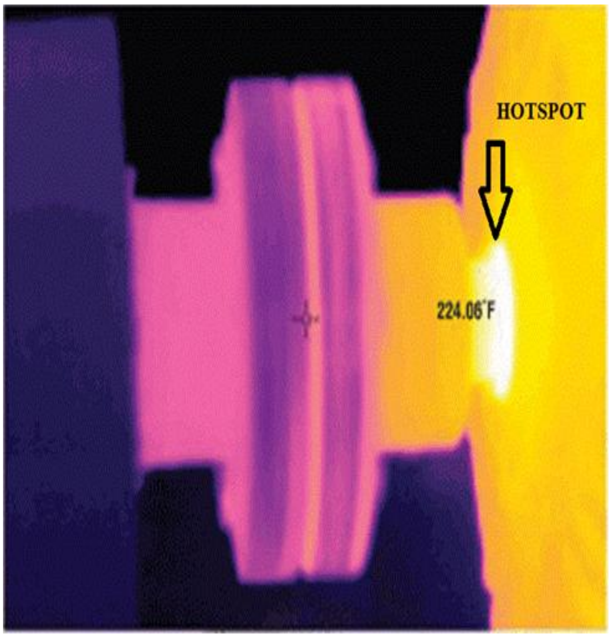

Fig.7. Thermography of coupling of an electric drive.

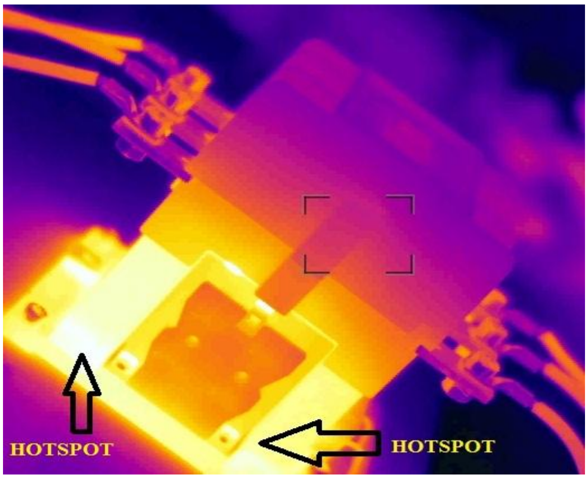

Fig.8. Thermography of 3 phase transformer (step down).

7. Conclusion and Scope of Future Work

The color sensor was tested on various thermal images and it respond quickly to hotspots when generated. It only provides us the presence of hotspot but does not provide its location i.e. in which section of electrical machine or transformer overheating occurs. In order to detect exact fault section location, a robotic arm driven by servomotors can be used. A co-ordinate system has to be generated for various parts of an electrical machine or transformer under observation for determining the exact hotspot location i.e. in which section of electric machine and transformer overheating occurs.

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