Teensy LC for Flame Rectification

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Abstract: Flame rectification is one of the most time-consuming processes. At present, it is still an experience-relying and manual operation. Because of lack in uniform flame rectification process, production has poor stability and productivity varies greatly among operators. In this paper, we design a flame rectification system based on teensyduino. A prototype system of automated flame rectification is achieved. The system has been tested on actual components, and the results were found to be quite accurate and efficiency.

Keywords: Flame detection, Flame rectification system, Sensing and control

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1. Flame Rectification Definition

Flame rectification is a procedure whereby the flame sensor (flame rod) is located in pilot or burner flame and a current applied to the sensor flows through the flame to the burner head and to the ground. Because the flame sensor is smaller than the ground electrode in a pilot ignition system or the main burner in a hot surface. The flame sensor receives an alternating current that flows in one direction before being rectified into a pulsating direct current DC. This current informs the control module that there is a flame present, and the system will run as long as the flame rod DC signal is present figure 1[1]. The control module quickly closed the main gas valve when the signal ceased, dropped below the specified level, or was interrupted, preventing an unsafe situation. The system will either recycle or lock out, requiring a reset by cycling the thermostat or, in some cases, a qualified technician inspection. The fact that a flame carries current can be utilized to determine whether or not there is a flame present. One can imagine a very simple system in which a voltage is applied between the burner and an electrode situated above the burner, and the current is measured. The flame is present if current passes. This works in theory, but it is not a secure system since dust or soot between the burner and the probe could conduct a current, indicating that the flame is present even if it is not. A system like this will not meet the requirements of a secure safety system[2].

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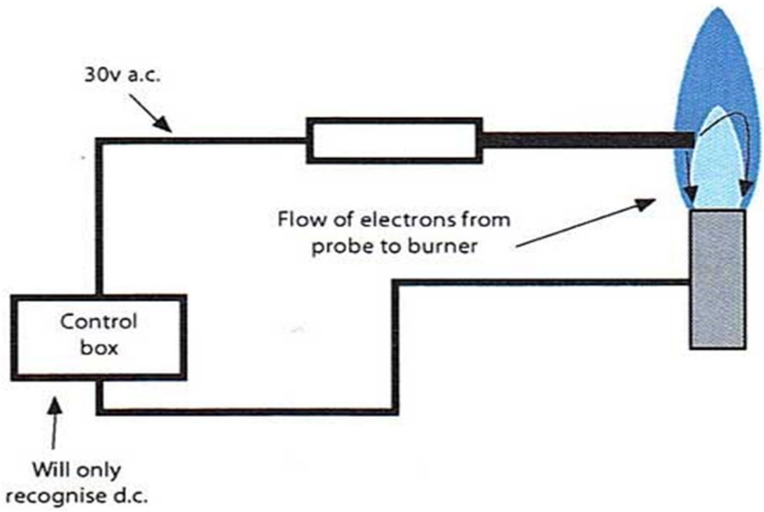

Figure 1. Flame rectification circuit block diagram.

Another fascinating feature of flames is that if the two electrodes to which the voltage is applied are not the same size or geometrical position, a different number of current passes depending on the voltage sign. This indicates that a flame works in the same way that a diode does. It allows current to flow in one direction but not the other. The smaller electrode (the probe) conducts electricity to the larger electrode (the burner). Because there is a return current, the flame isn't a perfect diode. A flame rectification quality makes it possible to identify it more reliably. If the flame is there, an AC voltage is delivered between the burner and a probe, resulting in a net current in the forward direction, but no current at all if the flame is not present. Because the rectification approach will only measure an AC if there is a short between the burner and the probe, it is significantly safer than just applying a DC voltage and sensing a current. Because the detecting mechanism requires an average net current in the forward direction, an AC is insufficient to detect the flame[4].

2. Flame Sensing Methods

Many fire detection methods have been designed, including light sensor, smoke sensor, temperature sensor, gas sensor etc. [5], [6]. In this paper, a novel flame detection system based on embedded teensyduino and flame rod is designed. After acquiring data from the rod sensor, the CPU in the teesyduino device processes and identifies the data directly at the flame sensor rod. By utilizing this powerful parallel computing capability of embedded teesyduino CPU, it can meet the requirements of large scale and real-time monitoring[7]. At the same time, the detection error caused by low resolution after transmission is avoided. In addition, the whole system is small in size and easy to install. Once the system detects the flame, the detection result is sent to the control panel, so as to realize the function of alarming, and facilitate the monitoring of flame and activation of the rectification system, which comprise a pilot gas regulator.

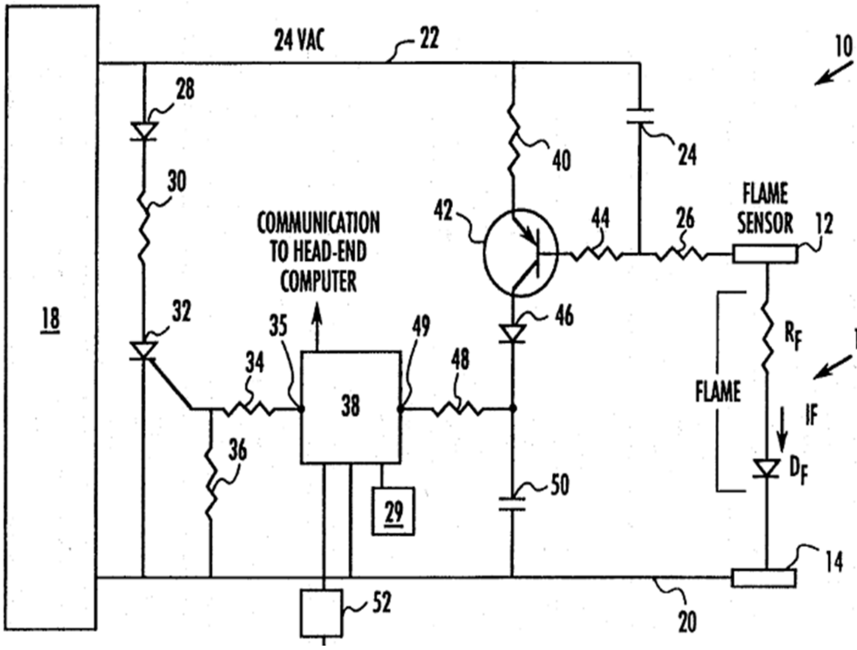

Figure 2. Flame rectification circuit.

Figure 2 shows the flame rectification circuit. A flame sensing is connected to a flame sensor (first electrode) 12 and a burner (second electrode) 14 in a furnace 5. When a flame 16 is present, electrode 12 is positioned within flame 16. As a result, flame 16 is electrically connected to first and second electrodes 12 and 14, and flame 16 ionized gases lower the resistance of the current path between. Electrodes 12 and 14 is below the resistance of the path without a flame. Flame 16 is modeled as a resistance Rf and a diode in general. More specifically, flame 16 operates as a rectifying circuit in part, with flame current ratios in opposing directions along the current route in flame 16 ranging from 1 to 5 depending on the placement of electrodes 12 and 14 [8].

The circuit is powered by a 24 VAC power supply 18 similar to that seen in household furnaces. A neutral lead 20 and a power lead 22 are included in supply 18. A capacitor 24 and a resistor 26 are connected in series to link lead 20 to electrode 14 and lead 22 to electrode 12. The voltage of supply 18 was chosen since it is the voltage that is generally accessible for use in furnace controls in household furnaces. Greater flame currents can be achieved by raising the voltage of supply 18, for example, and higher flame currents are often easier to monitor.

A LED 28, a resistor 30, a Silicon Control Rectifier 32, a resistor 34, a resistor 36, a microprocessor 38, a resistor 40, a transistor 42, a resistor 44, a diode 46, a resistor 48, and a capacitor 50 are included in Figure 2. Between lead 22 and lead 20, LED 28, resistor 30, and silicon control rectifier 32 are connected in series, with the anode of LED 28 connected to lead 22 and the cathode of silicon control rectifier 32 linked to lead 20. By resistor 34, the gate of silicon control rectifier 32 is connected to an I/O port 35 of processor 38, and by resistor 36 to lead 20. Between leads 22 and 20, a series connection is made with resistor 40, transistor 42, diode 46, and capacitor 50. Resistor 40 connects the emitter of transistor 42 to lead 22, resistor 46 connects the collector to the anode of diode 46, and resistor 44 connects the base to the junction between capacitor 24 and resistor 26. The cathode of diode 46 is connected to an I/O port 49 of processor 38 via resistor 48, and it is connected to lead 20 via capacitor 50. Processor 38 is grounded at lead 20. Figure 2 generates a voltage at capacitor 50 that rises with time at a rate that is roughly proportional to the magnitude of the current flowing between electrodes 12 and 14 (stream of flame). Processor 38 checks the condition of port 49 per cycle of the power source. With a 60 Hz power source, this occurs once every 0.0167 seconds. If the state of port 49 changes from low to high within a predetermined number of cycles, processor 38 will detect a flame between electrodes 12 and 14. As a result, processor 38 will generate appropriate output signals, which will be applied to a fuel valve 52 coupled to the primary burner 54 of furnace 5. This signal opens valve 52, which allows flame 16 to ignite the fuel at main burner 54. After each N cycles, processor 38 instructs port 49 to discharge capacitor 50. In addition to the functions listed above, Processor 38 is frequently programmed to operate other functions of furnace 5, such as blower control. If electrodes 12 and 14 are only somewhat dirty, the circuit will detect a flame current and allow the furnace to operate for a short period until the surface resistance climbs above the flame current detection threshold [9], [10]. The illustration of the circuit is shown in Figure 3.

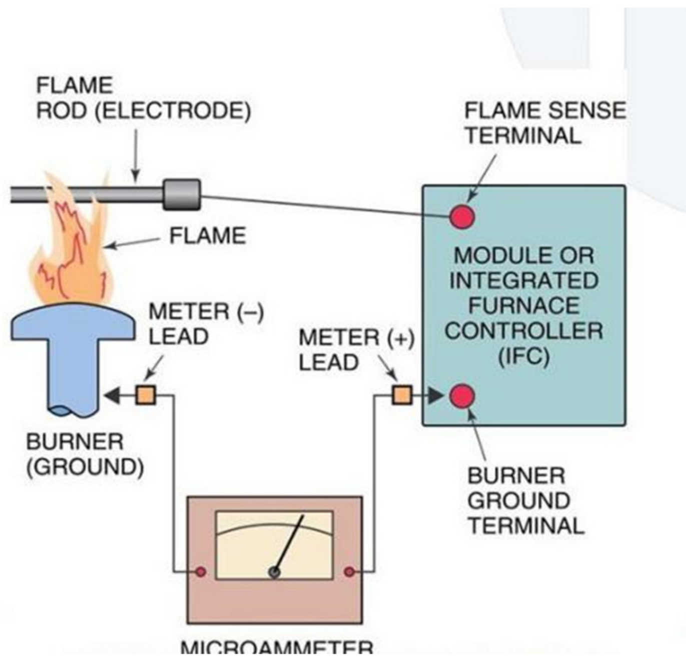

Figure 3. Circuit diagram.

In this design, the voltage across capacitor 50 is proportional to the flame current and the voltage is a linear function of time. The flame current is dictated by the following function: IF=K*8/M for M greater than 1 and less than or equal to 8, where IF denotes the flame current, M denotes the number of cycles until the voltage across resistor 48 and capacitor 50 exceeds 2 volts, and K denotes the proportionality constant determined by the flame current present when the voltage across resistor 48 and capacitor 50 reaches 2 volts after eight cycles. If a flame current of 50 nanoamps indicates the presence of a flame, K is 50 nanoamps. If processor 38 senses 2 volts at pin 49 twice, the flame current should be 200 nanoamps. According to the manufacturer, this version in Figure 2 detects flame current at more than two levels or thresholds. This embodiment, in particular, delivers M-1 flame current values. The resistance between electrodes 12 and 14 is frequently greater than 100 Mohs when there is no flame present. In the absence of a flame, Capacitor 24 acquires very little charge. As a result, transistor 42 remains non-conducting, and capacitor 50 does not charge up. When there is a flame between electrodes 12 and 14, the charge on capacitor 24 exceeds the forward voltage of transistor 42, allowing the base current to flow. A collector-to-emitter current will flow in response to the base current flow when lead 22 is positive. A voltage drops across resistor 40 is caused by the collector-to-emitter current, which monitors changes in capacitor 24 charge. During this time, the input impedance of transistor 42 will be nearly equal to the product of its gain and the value of resistor 40[5], [11] .

3. Flame Rod Sensor

A flame sensor is a tiny rod on the burner assembly that confirms the presence of a flame. It's a safety function on the furnace that prevents the furnace from continuing to emit gas inside the chamber if no flame is detected. If the flame sensor becomes dirty, it will be unable to detect a flame, and the furnace will not be able to finish the call for heat and will shut down. The flame rod is a stainless-steel wire that crosses over the flame (Figure. 4). Current flows from a flame rod to ground when an electric potential is supplied to it (in the case of a protection, it is 390 volts). The flame is a diode and resistor in series electrically[12], [13].

Figure 4. Flame sensor rode.

Even if the flame has been effectively produced and everything is running smoothly, the electrical channel becomes corrupted as these components become unclean, rusted, or corroded, and the flame current can be reduced. The burner will go through its normal ignition cycle, ignite the flame, and then shut off within seconds in this scenario. Some burners will go into retry mode and go through the process again and again. Others will be locked out until the power is turned back on. You may measure the flame signal and notice that it is feeble during the brief moment that the flame is ignited.

This is a typical reaction to a low flame signal. The ignition controller is doing its job and ensuring that everything is in working order. A filthy flame sensor is one of the most typical problems with gas furnaces. The dust and carbon buildup on the flame sensor causes it to become dirty. Carbon will build up on it over time due to its proximity to a flame, causing it to malfunction. Then, it is required to clean the furnace flame sensor.

4. Teensy LC Controller and Structure

Teensy LC is also known as the teesydruino. It is a breadboard-friendly development board with loads of features in a, well package. The Teensy LC (Low Cost) is a 32-bit microcontroller board that offers a simple way to get started with the Teensy family of products without breaking the bank. The bootloader on the Teensy LC is pre-flashed. There is no need for an outside coder. One can use the Arduino IDE Teensy Duino add-on to write Arduino sketches for Teensy. The Teensy processor also has USB access, allowing it to imitate whatever USB device is required, making it ideal for USB-MIDI and other HID projects[14]. In addition to numerous channels of Direct Memory Access and an I2S digital audio interface, the 32-bit processor has a few other features. Two separate interval timers are also included! The Teensy LC can also supply up to 5-20mA to other devices at a system voltage of 3.3V or 5V. Figure 5 show a typical Teensy LC board. The Pins for Digital Input Signals can be received using digital pins. The default state of the Teensy LC pins is low power disabled. These pins must be configured to input mode using the pin Mode function with input. The input can then be read using digital Read. 0 to 3.3V signals are accepted on the Teensy LC pins. The pins aren't resistant to 5V. Any digital pin should not be driven above 3.3V. Figure 6 shows the typical Teensy circuit digram.

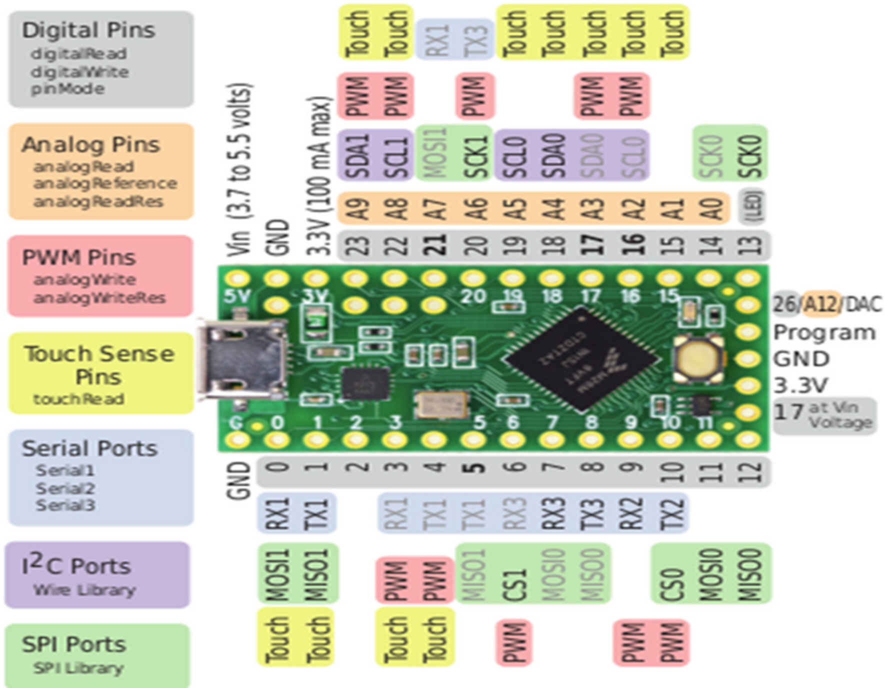

Figure 5. Teensy lc board.

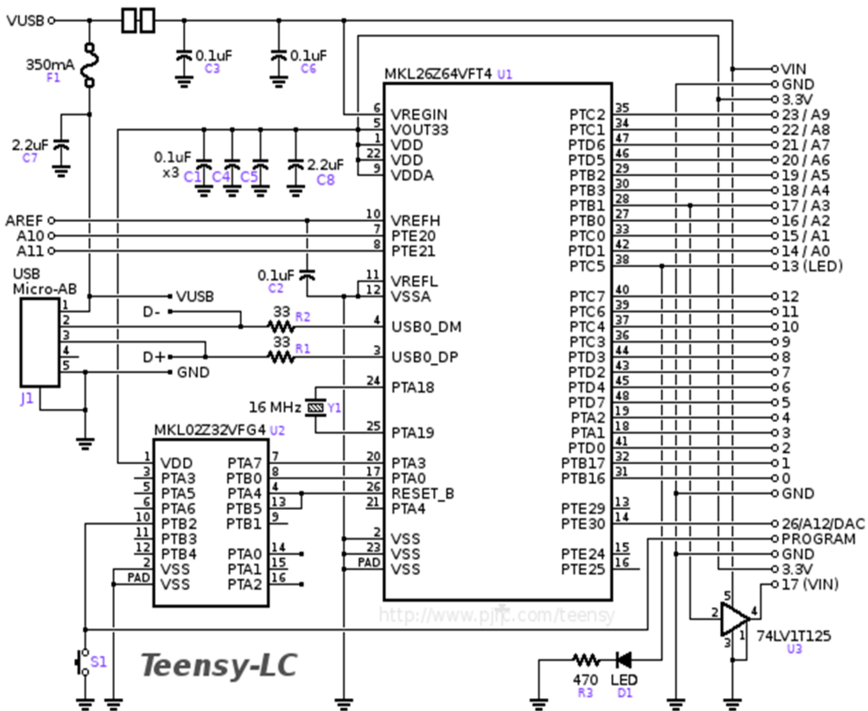

Figure 6. teensy circuit digram.

5. Conclusion and Future Development

MEMS sensors are integrated with a Teensy LC to achieve a system for the use of flame sensing and rectification. The software and control codes are achieved based on an Arduino platform. The Teensy LC based system were found to be suitable for various applications because they are not expensive and can be applied to ultra-small and low-power applications as well as have excellent operating characteristics. In addition, a rod flame sensor added in, so it can be used as a reference sensor comparing thermopile output signal abnormal signal generation.

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