

# Industrial Boiler Flame Control by using Control Area Network

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**ABSTRACT:** This paper presents where area of research in only limited literature are reported, hence the research in this area finds a lot of scope which will enable the researchers to develop an indigenous technique for flame stability improvement. The main objective is to design and analyze the operation of Boiler Flame Control by Control Area Network is an important aspect of the thesis. As a part of the thesis work overall system will be controlled and monitored using Dock light software. In this thesis work the entire system will be controlled and temperature reading for flame generated by burner will be recorded at different stages.

**KEYWORDS:** Dock Light Software, MCCP 251, CAN trans receiver, CAN Bus.

## I. INTRODUCTION

In the past few decades, the need for improvements in automotive technology caused increased usage of electronic control systems for functions such as engine timing, anti-lock brake systems, and distributor less ignition. Originally, point-to-point wiring systems connected electronic devices in vehicles. More and more electronics in vehicles resulted in bulky wire harnesses that were heavy and expensive. To eliminate point-to-point wiring, automotive manufacturers replaced dedicated wiring with in-vehicle networks, which reduced wiring cost, complexity, and weight. In 1985, Bosch developed the Controller Area Network (CAN), which has emerged as the standard in-vehicle network. CAN provides a cheap, durable network that allows the devices to speak through the Electronic Control Unit (ECU). CAN allow the ECU to have one CAN interface rather than analog inputs to every device in the system. This decreases overall cost and weight in automobiles and boiler plants. Each of the devices on the network has a CAN controller chip and is therefore intelligent. All transmitted messages are seen by all devices on the network. Each device can decide if the message is relevant or if it can be filtered. Maintaining a good flame in a boiler is the key to a good boiler performance. Unstable flame is always a threat for boiler furnace explosion, which can lead to a large outage of the boiler and economic loss. When a flame failure occurs in a boiler, the boiler desk operator and the local operators will have to act immediately and bring the boiler back on line with all safety taken in to consideration. It is always seen that the greatest number of explosions in boilers takes place during start-up and shutdown. It is during this period that the probability for unburned to accumulate in flue gas path of the boiler is very high. Hence it has become a practice of all boiler designers to interlock purging the boiler with boiler start-up. There are various advantages offered by the transition away from dedicated signal lines, low cost, resistance to harsh environments, real-time capabilities. These advantages led to the use of CAN in industrial applications such as textile machinery, packaging machines, and production line equipment such as photoelectric sensors and motion.

## II. LITERATURE SURVEY

In this area of research only limited literature are reported, hence the research in this area finds a lot of scope which will enable the researchers to develop an indigenous technique for flame stability improvement. Flame Doctor, a burner flame monitoring system was developed by Timothy et al (2004) to reduce NO<sub>x</sub> emissions and to improve the overall performance. The signals from an optical flame scanner diagnose the operation of the burners. Continuous monitoring by flame doctor makes it possible to analyze the flame color thereby optimizing the overall performance of the furnace load changes, fuel quality variations, and equipment modifications. This article describes the status of an ongoing EPRI Beta Test Program and the results from combustion tuning service work and as a result demonstrated performance improvements include reductions of 20% in NO<sub>x</sub>, 70% in CO, and 70% in LOI. These improvements are sustainable and translate directly into significant cost savings in the expenditure of the power plants.

1. **“The first well-described framework was developed by Simons (1995, 2000). His “lever of control framework”** is based on huge amount of case studies and quantitative surveys in different US and Canadian industries. Simons (1995) designed his lever of control to study the effectiveness of a company’s business strategy. The main idea is to give “a complete picture of a wide range of possible controls”.

Simons provides two extreme benchmarks to classify the use of management control systems: interactive versus diagnostic. The first dimension is the degree of involvement of the top management. In the interactive benchmark, top managers intensely involve themselves in the process, while in the diagnostic benchmark, they remain at a distance. The compensation dimension was introduced by Simons (i.e. formula-based for diagnostic process and contribution-based for interactive process), though this dimension has rarely been explored in practice so far. According to ever of control, the main actors in a diagnostic control system are the gatekeepers (accountants, planners, engineers, and quality controllers), who must focus the attention of the managers on the mismatching; for interactive use, the main actors are operational managers. Although Simons also stressed an important role of the middle managers, he did not discuss much the patterns of motivation and behavior that were necessary for middle managers to fulfill these expectations. IDEALITY mostly increased due to accomplishing better outcomes, but not to decreasing of costs and harms.

2. **“M Habermehi et al, 2012 investigated the effect of burner on flame stabilization”**. Starting from an existing burner design for a bench scale burner, a new burner concept based on aerodynamic stabilization of an oxy fuel swirl flame was developed. For this development process, CFD was intensively used as a design tool.

Adapted models for homogeneous and heterogeneous reactions were integrated into the CFD code to take the different conditions for Oxy fuel combustion into account. As a result, a burner able to operate in air and oxy fuel conditions was developed and its functionality was demonstrated in experiments and it was proven that applying the measures for oxy coal swirl flame stabilization an oxycoal flame can be stabilized aero-dynamically at an oxygen concentration for wet and dry recirculation.

3. **“(ColakIlhami et al., 2008) developed Internet controlled Heating Ventilation Air Conditioning (HVAC) system”**. The system can be controlled by three different units (web based remote control, remote control by hand-held device and keypad control mounted on AC). The hardware system of AC is controlled by PIC16F877 microcontroller. A DAQ board inserted into PCI bus of web server is used to control system over web. User is able to access system parameters over web by logging and setting parameters on forms available on main control page. User submits forms to web server having CGI program which performs requested tasks and reports status of system operation. The current operational parameters of the system are measured by microcontroller and displayed on LCD. Using web camera focused on LCD, these parameters are monitored online by client PC.

4. **“Fuzzy Logic Control (FLC) was been successfully by Timo Hyppanen et al (2000)”**, where the operator’s process expertise can be transformed into automation Circulating Fluidized Bed (CFB) boilers are widely used for multi fuel combustion of waste and bio fuels. When several non-homogeneous fuels, having varying heat values, are burned simultaneously, the boiler control system can be affected by various control challenges, especially since it is not feasible to reliably measure the energy content of the multi fuel flow. To fulfill the energy production needs and maintain the ability to burn low grade fuels, co-firing with high heat value fuels such as gas, oil or coal is needed.

### III. PROPOSED SYSTEM

#### 3.1 Abstract

In the past few decades, the need for improvements in automotive technology caused increased usage of electronic control systems. The Controller Area Network (CAN), which has emerged as the standard in-vehicle network. CAN provides a cheap, durable network that allows the devices to speak through the Electronic Control Unit (ECU). CAN allow the ECU to have one CAN interface rather than analog inputs to every device in the system. This decreases overall cost and weight in automobiles and boiler plants. So, this paper handles to maintain a good flame in a boiler is the key to a good boiler performance. When a flame failure occurs in a boiler, the boiler desk operator and the local operators will have to act immediately and bring the boiler back on line with all safety taken in to consideration which leads to explosions in boilers and shutdown. Hence it has become a practice of all boiler designers to interlock purging the boiler with boiler start-up.

CAN provides a cheap, durable network that allows the devices to speak through the Electronic Control Unit (ECU). CAN allow the ECU to have one CAN interface rather than analog inputs to every device in the system. This decreases overall cost and weight in automobiles and boiler plants. Each of the devices on the network has a CAN controller chip

and is therefore intelligent. All transmitted messages are seen by all devices on the network. Each device can decide if the message is relevant or if it can be filtered.

### 3.2 Explanation

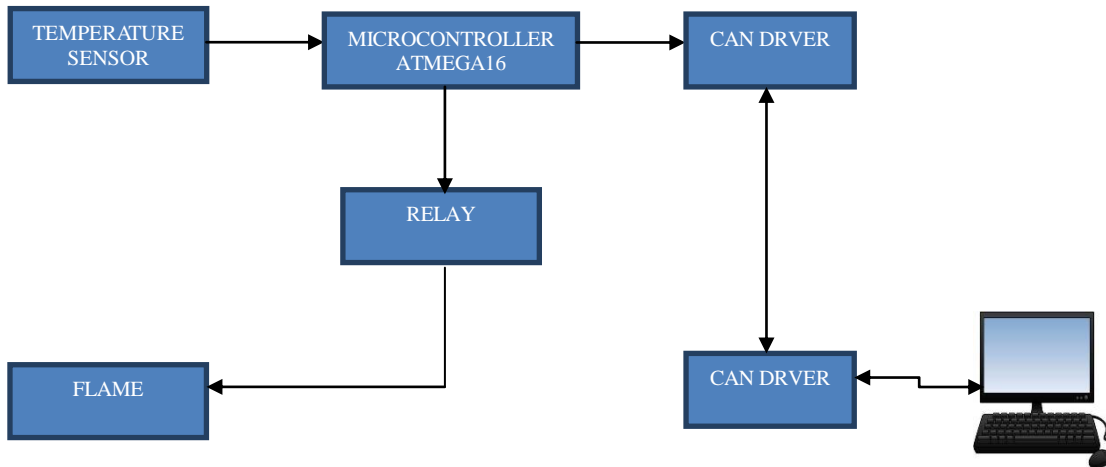


Figure 1. Block Diagram Illustrating the Design of CAN.

The LM35 temperature series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature with an advantage over linear temperature sensors calibrated in Kelvin. The LM35 device does not require any external calibration or trimming to provide typical accuracies of  $\pm 1/4^\circ\text{C}$  at room temperature and  $\pm 3/4^\circ$  over a full  $-55^\circ\text{C}$  to  $150^\circ\text{C}$  temperature range. The LM35 temperature sensor is held near the flame of the burner to measure the temperature that is recorded in the Dock light.

The CP2102 USB to UART Bridge provides a complete plug and play interface solution that includes royalty-free drivers which is connected to the computer to get the readings on the Dock light once the flame starts. This USB 2.0 compliant device includes 0 digital I/O pins and is available in a 5x5 mm QFN28 package. The ATmega16 used is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system to optimize power consumption versus processing speed. For working of ATMEGA16, first we need to save the program HEX code in ATMEGA16 FLASH MEMORY. The SG90 Micro Servo Motor connected to the burner has a torque of 2.5kg/cm so that the motor can pull a weight of 2.5kg when it is suspended at 1cm. For this Servo Motor the PWM signals is received from the Microcontroller platforms.

### 3.3 Control Strategy: -

#### DOCK LIGHT SOFTWARE: -

Dock light's communication window shows the current communication on the selected serial port(s). Dock light distinguishes between two communication channels (channel 1 and channel 2), which represent the incoming and outgoing data in Send/Receive Mode or the two communication channels being observed in Monitoring Mode.

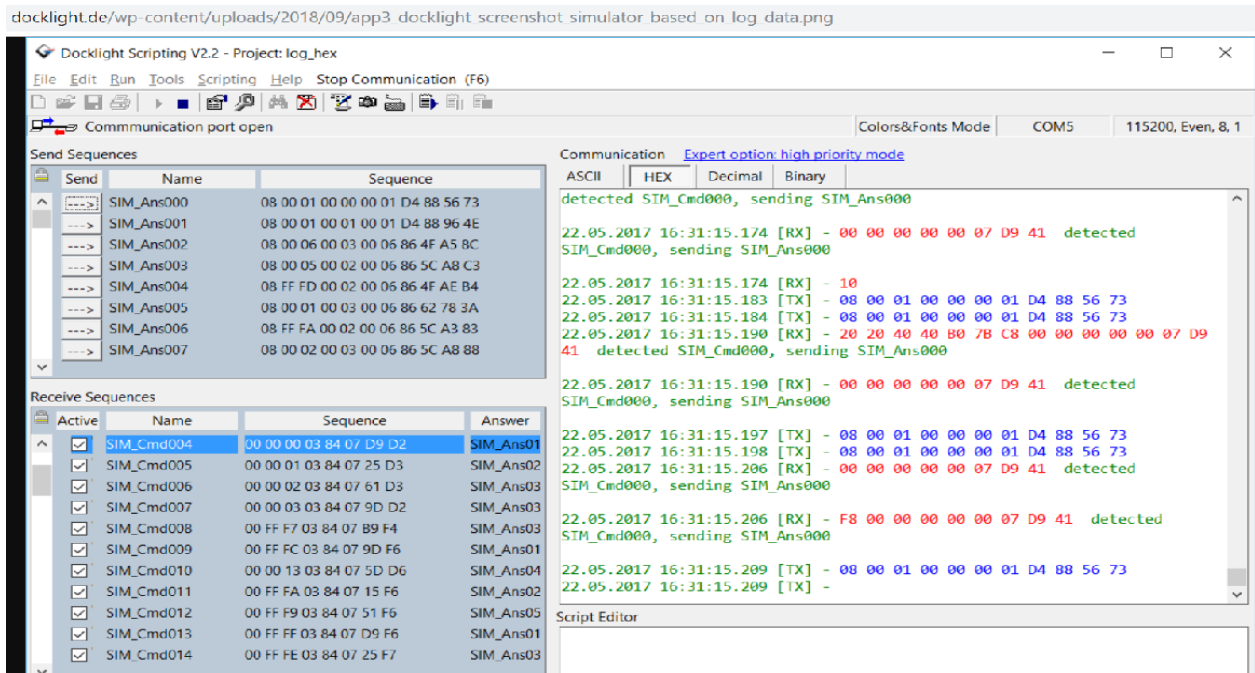


Figure2.Dock light Software

Dock light can process serial data streams containing any ASCII code 0 - 255 decimal. Since there are non-printing control characters (ASCII code < 32) and different encodings for ASCII code > 127, not all these characters can be displayed in the ASCII text window. Nonetheless, all characters will be processed properly by Dock light and can be displayed in HEX, Decimal or Binary format. Dock light will process the serial data on any language version of the Windows operating system in the same way, although the ASCII display might be different. A Dock light project mainly consists of user-defined sequences. These may be either Send Sequences, which may be transmitted by Dock light itself, or Receive Sequences, to detect a special message within the incoming serial data.

### MCP2551 CAN TRANSRECEIVER BLOCK DIAGRAM

The MCP2551 device provides differential transmit and receive capability for the CAN protocol controller and is fully compatible with the ISO-11898 standard, including 24V requirements. It will operate at speeds of up to 1 Mb/s.

The CAN bus has two states: Dominant and Recessive. A Dominant state occurs when the differential voltage between CANH and CANL is greater than a defined voltage (e.g., 1.2V). A Recessive state occurs when the differential voltage is less than a defined voltage (typically 0V). The Dominant and Recessive states correspond to the Low and High state of the TXD input pin, respectively. However, a Dominant state initiated by another CAN node will override a Recessive state on the CAN bus. The MCP2551 CAN outputs will drive a minimum load of 45Ω, allowing a maximum of 112 nodes to be connected (given a minimum differential input resistance of 20 kΩ and a nominal termination resistor value of 120Ω).

The RXD output pin reflects the differential bus voltage between CANH and CANL. The Low and High states of the RXD output pin correspond to the Dominant and Recessive states of the CAN bus, respectively.

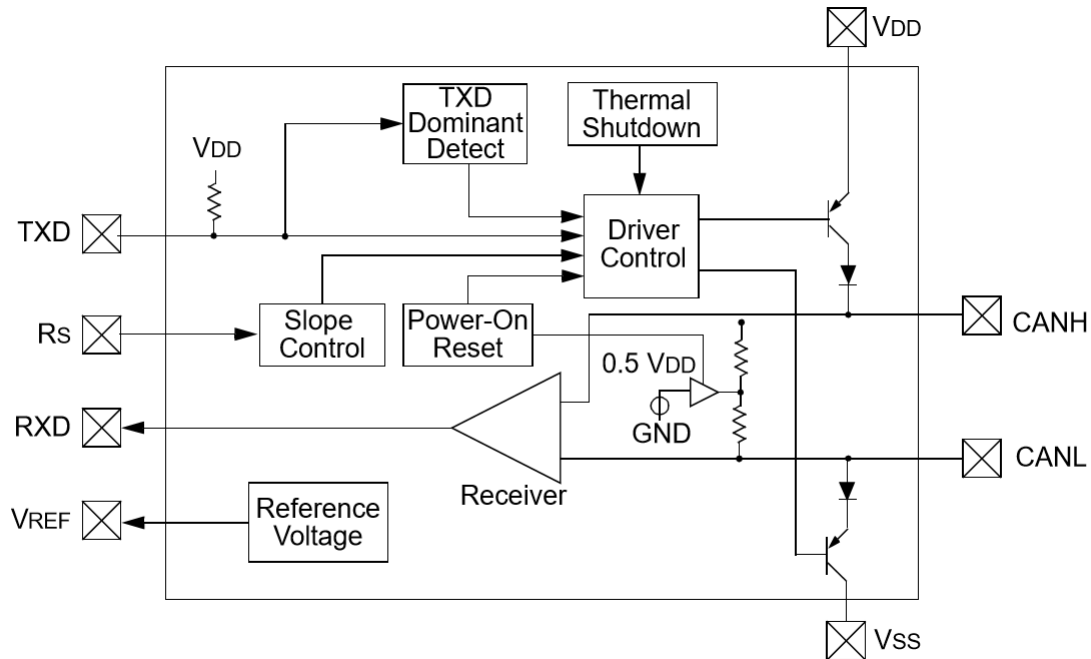


Figure3. MCP 2551 CAN TRANSCEIVER

When the device is powered on, CANH and CANL remain in a high-impedance state until VDD reaches the voltage-level VPORH. In addition, CANH and CANL will remain in a high-impedance state if TXD is Low when VDD reaches VPORH. CANH and CANL will become active only after TXD is asserted High. Once powered on, CANH and CANL will enter a high-impedance state if the voltage level at VDD falls below VPORL, providing voltage brown-out protection during normal operation.

**THE CAN BUS: -**

The data link and physical signaling layers, which are normally transparent to a system operator, are included in any controller that implements the CAN protocol, such as TI's TMS320LF2812 3.3-V DSP with integrated CAN controller. Connection to the physical medium is then implemented through a line transceiver such as TI's SN65HVD230 3.3-V CAN transceiver to form a system node.

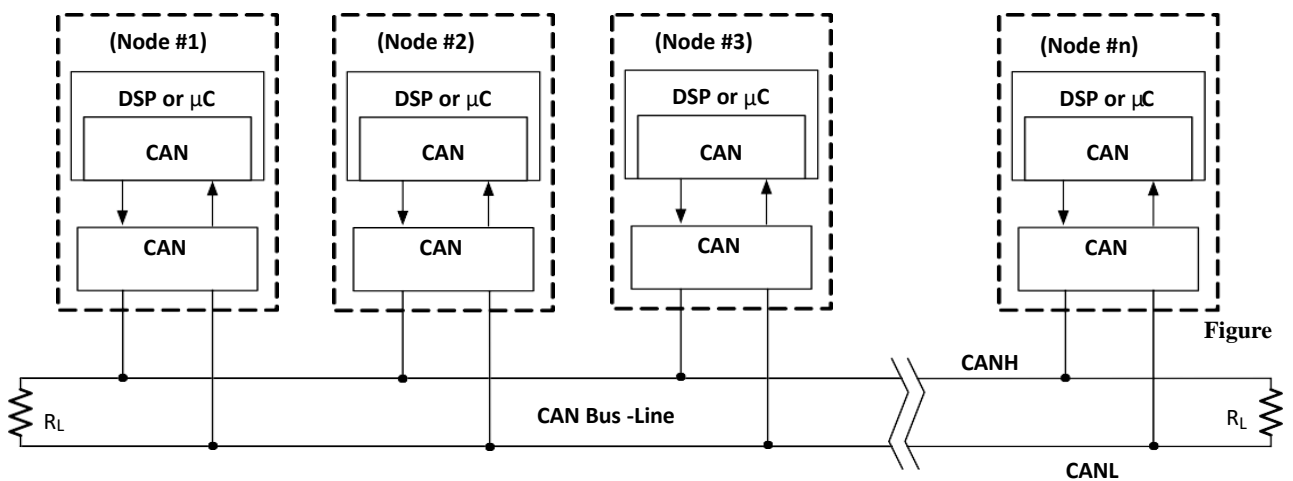


Figure4. THE CAN BUS.



#### IV. RESULTS AND DISCUSSIONS

The flame control process inside a boiler is highly complex and nonlinear with strong-coupling and time delayed influences. It is well understood in literature that it is not easy to achieve high efficiency in operating large utility boilers and most existing practices in the industry are highly sub-optimal. Nonuniform temperature distribution inside a boiler is known to cause tube rupture, a frequent failure mechanism for boiler operations. But to maintain a uniform temperature distribution inside a boiler is difficult even for domain expert in practice due to the dynamic air flow inside the boiler. One of the most frequently used practices today to deal with nonuniform temperature distribution is spraying water inside a boiler, which introduces unnecessary efficiency loss and additional operating cost. Another practice is to remold a boiler by re-arranging super-heater panels to alleviate the uneven temperature distribution, which requires to shut down the boiler and cannot be done in real-time. Hence, to avoid solving the physical-based CFD models, researchers have proposed to use machine learning-based methods to predict boiler temperature or other related parameters to control boiler flame.

Figure 5. Industrial Boiler Flame Control By using CAN.



#### V. APPLICATIONS

##### 1. CAN IN VEHICLE ELECTRONIC NETWORKING

CAN was first created for automotive use, so its most common application is in-vehicle electronic networking. However, as other industries have realized the dependability and advantages of CAN over the past 20 years, they have adopted the bus for a wide variety of applications. Railway applications such as streetcars, trams, undergrounds, light railways, and long-distance trains incorporate CAN. You can find CAN on different levels of the multiple networks within these vehicles – for example, in linking the door units or brake controllers, passenger counting units, and more. CAN also has applications in aircraft with flight-state sensors, navigation systems, and research PCs in the cockpit. In addition, you can find CAN buses in many aerospace applications, ranging from in-flight data analysis to aircraft engine control systems such as fuel systems, pumps, and linear actuators.

##### 2. CAN IN MEDICAL APPLICATIONS

Medical equipment manufacturers use CAN as an embedded network in medical devices. In fact, some hospitals use CAN to manage complete operating rooms. Hospitals control operating room components such as lights, tables, cameras, X-ray machines, and patient beds with CAN-based systems. Lifts and escalators use embedded CAN networks, and hospitals use the CAN open protocol to link lift devices, such as panels, controllers, doors, and light barriers, to each other and control them. CAN open also is used in nonindustrial applications such as laboratory equipment, sports cameras, telescopes, automatic doors, and even coffee machines.

### 3. CAN IN OTHER APPLICATIONS

The controller area network (CAN) is used in aircraft with flight state sensors, navigation systems, flight data analysis to aircraft engine control systems such as fuel systems, linear actuators and pumps, transmission airbags, antilock braking, electric power steering etc.

### VI. CONCLUSION

The design, development and control-oriented models and appropriate control strategy for the optimization of flame control for a power boiler have been presented in this work. The effectiveness of the system identification scheme used for the development of the CAN model can be validated on a running boiler. The Control network and sensors has aided in the implementation of advanced control strategies for optimization of main stream temperature control. Unmeasurable temperature variables were estimated using the Dock light software. It would be more appropriate to use this control method in running boilers to control the main steam temperature with good precision at the optimum value and thereby increase the power generation to the optimum level. Besides, as literature survey reveals, all aspects of the thesis it would be excellent tools in the hands of power plant authorities for framing boiler simulators and to provide operator training.

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