International Core Journal of Engineering Volume 12 Issue 8, 2026
ISSN: 2414-1895 DOI: 10.6919/ICJE.202608_12(8).0013

Design of Core Drilling Rig Data Monitoring System based on STM32

Shuaipeng Li, Xiao Zeng*

School of Mechanical Engineering, Xihua University, Chengdu 610039, China

*Corresponding author: Xiao Zeng (Email: zengxiao@mail.xhu.edu.cn)

Abstract

To improve the drilling efficiency and intelligence level of core drilling rigs, a local data monitoring system was designed based on the STM32F407VGT6 and the Boke Screen F150E. The system uses Kinco DTools configuration software for interface design and employs CAN bus communication technology to monitor and communicate with the host computer. Test results show that the system can monitor various parameters of the core drilling rig in real time, which can enhance the intelligence level of the rig and has certain practical engineering value.

Keywords

STM32F407VGT6; Boke Screen; Kinco DTools; Data Monitoring System.

1. Introduction

Geological exploration is currently facing technical challenges as it moves toward deeper and more refined development[1]. Core drilling rigs are key equipment in deep drilling, characterized by high asset value, high equipment integration, and high equipment risk[2]. Operators find it difficult to directly observe the drilling process and status of the equipment. Therefore, there is an urgent need to design a system that can monitor multiple parameters of a core drilling rig in real time[3]. Lu Chengda[4] and others pointed out that intelligent control in geological drilling has evolved from the early single-parameter monitoring stage to a stage of multi-parameter sensing, operational analysis, and intelligent decision-making, covering parameters like drilling pressure, rotation speed, pump pressure, torque, and feed rate. At the same time, the development and demonstration application of 5000-meter-class intelligent geological drilling equipment, extra-deep core drilling technology, and key components continue to advance[5], showing that China has already built a solid foundation in deep drilling capabilities, equipment standardization, and engineering adaptability. While considering cost optimization, and in order to effectively improve drilling efficiency and equipment intelligence, this paper designs a core drilling rig data monitoring system based on STM32F407 and BocoScreen F150E. This system can monitor the status and drilling progress of a core drilling rig in real time, improving the safety, reliability, and efficiency of the equipment.

2. Overall System Design

2.1 System Composition and Architecture

The monitoring system mainly comprises three components: data acquisition, data processing, and user interaction. Data acquisition is handled by an intelligent controller designed based on the STM32, which is responsible for real-time collection of environmental data and drilling parameters of the core drilling rig, as well as parsing, calculating, and analyzing the collected data. It can also promptly issue risk alerts based on pre-set fault parameters and thresholds. The user interaction module utilizes a

ISSN: 2414-1895
DOI: 10.6919/ICJE.202608_12(8).0013

Beckhoff industrial touchscreen to display the processed data and alert information to operators through a visual interface, assisting users in real-time monitoring of the core drilling rig.

2.2 Monitoring Parameter Analysis

In China, drilling operations mainly use fully hydraulic top-drive rigs[6]. The monitoring system collects parameters like engine data, temperature, oil levels, and drilling parameters, while core drilling rigs have separate sensors for pressure, temperature, and inclination. The drilling parameters mainly include top drive speed, torque, feed force, hoisting force, mud pump pressure, drilling speed, feed angle, and other hydraulic system parameters. The system designed in this paper mainly monitors the following key sensors on core drilling rigs, as shown in Table 1.

Table 1. Key monitoring parameters

Monitoring Target	Range	SensorOutput
Liquid level	35kPa	4-20mA
Cylinder inlet pressure	40MPa	4-20mA
Cylinder outlet pressure	40MPa	4-20mA
Power head inlet pressure	40MPa	4-20mA
Power head outlet pressure	40MPa	4-20mA
Return oil	6MPa	4-20mA
Pilot oil	6MPa	4-20mA
Pump 1	40MPa	0-10V
Pump 2	40MPa	0-10V
Pump 3	40MPa	0-10V
Oil temperature	-50~100℃	0-10V
Feed angle	±90°	CAN
Power head displacement	4000mm	0-10V
Rotation speed	/	NPN

3. Hardware Design

The smart controller is the core unit for data collection in the core drilling rig condition monitoring system. It's part of the system's sensing layer and mainly handles tasks like connecting sensor signals, collecting and processing data, and transmitting it. Structurally, the controller uses a modular and slot-based design, putting the common and basic functions on the controller's baseboard, while allowing flexible expansion with additional modules. Considering the complex on-site conditions of core drilling rigs and the diverse measurement and control needs, this design not only boosts the system's flexibility and adaptability but also makes maintenance, replacement, and function upgrades much easier.

3.1 Baseboard Design

The main control chip of the baseboard is the STM32F407VGT6. This chip is based on the ARM Cortex-M4 core, with a clock speed of up to 168MHz. It features abundant peripheral interfaces and powerful data processing capabilities, capable of meeting the real-time acquisition and processing requirements of multiple sensor signals[7]. The baseboard integrates related interface circuits such as USB, Bluetooth, Ethernet, and SD card. Considering the large amount of sensor data from the core drilling rig, as well as the need for future upgrades and application expansion, the design extends the

ISSN: 2414-1895 DOI: 10.6919/ICJE.202608_12(8).0013

data acquisition module to the baseboard through a slot. The baseboard mainly handles data processing and data communication. The block diagram of the baseboard design is shown in Figure 1.

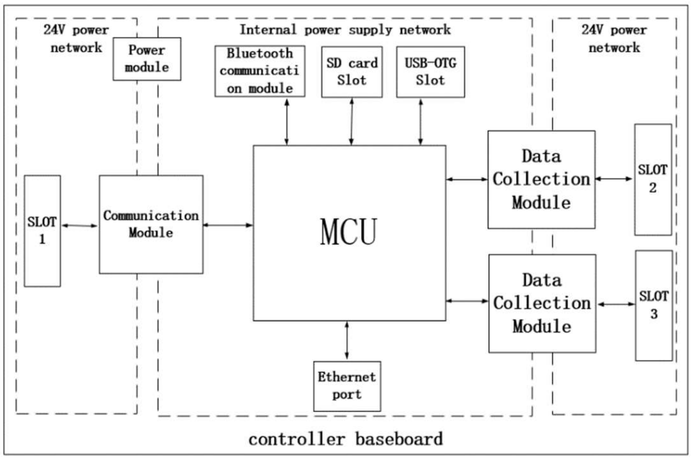

Figure 1. Baseboard Design Diagram

3.2 Communication Module Design

The main function of the communication module is to achieve communication with the host computer, display real-time data on the Kinco F150E, and support an extended LoRa module for remote transmission. The design block diagram of the communication module is shown in Figure 2.

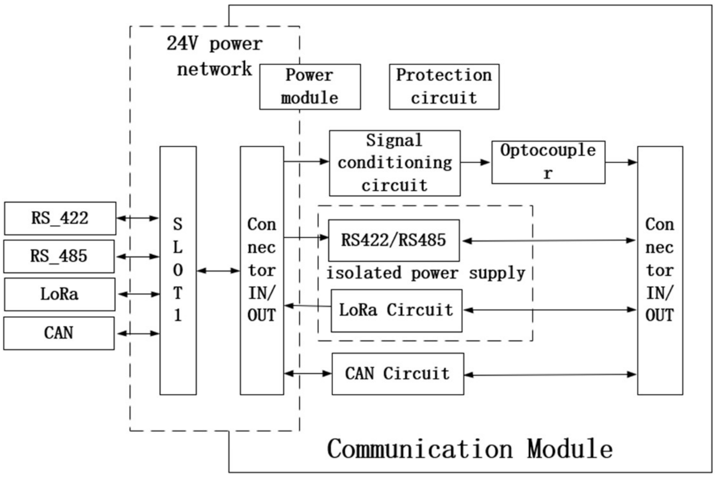

Figure 2. Communication Module Design

3.3 Data Collection Module Design

For monitoring the key parameters of the core drilling rig sensors, proportional conversion and protection need to be carried out according to the input range of the ADC in the data acquisition module. The ADC uses the ADC128S102 as an external analog-to-digital conversion chip. This chip is a 12-bit,8-channelsingle-endedinput,successive approximation ADC[8] with a rated sampling rate of 500ksps to 1Msps, which can meet the sampling requirements well and communicates with the motherboard via an SPI interface. Also, considering the strong electromagnetic interference and complex power supply conditions on industrial sites, the acquisition circuit has been fully equipped with anti-interference and isolation measures. The design block diagram of the data acquisition module is shown in Figure 3.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202608_12(8).0013

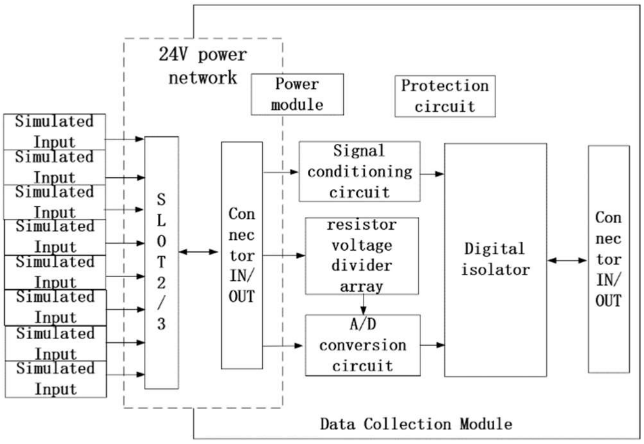

Figure 3. Data Collection Module Design

4. Software Design

The parameter design process based on sensor data is as follows: taking feed force/lifting force as an example, first define a struct variable to receive the pressure measured by the pressure sensor at the power head's inlet and outlet. Then, convert the analog signal obtained by the sensor into the actual pressure value through a linear transformation, and finally calculate the feed force or lifting force using a formula.

The controller software design includes peripheral initialization, CAN communication programs, storage programs, serial communication programs, and configuration programs for various functional modules. FreeRTOS real-time operating system is embedded for task scheduling and kernel object management, ensuring the real-time performance and reliability of data acquisition, processing, and communication tasks. The software design block diagram is shown in Figure 4.

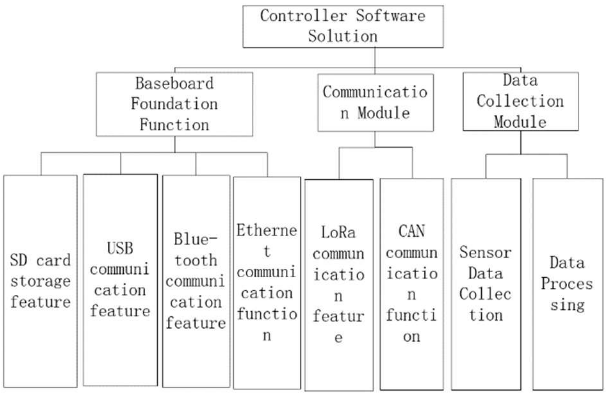

Figure 4. Data Collection Module Design

5. HMI Design

Industrial touchscreens are commonly used human-machine interface devices in the field of industrial automation, combining data display and touch operation functions.

5.1 Touchscreen Configuration Software Design

The Kinco touchscreen uses its self-developed Kinco DTools configuration editing software, which has a fairly rich library of components. When editing the configuration interface, you can simply drag the needed components from the library window onto the interface. These components also support custom sizes, colors, and styles. Additionally, in the extended properties, you can set the range for the dashboard and the upper and lower alarm zones for dangerous values. The design is shown in Figure 5.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202608_12(8).0013

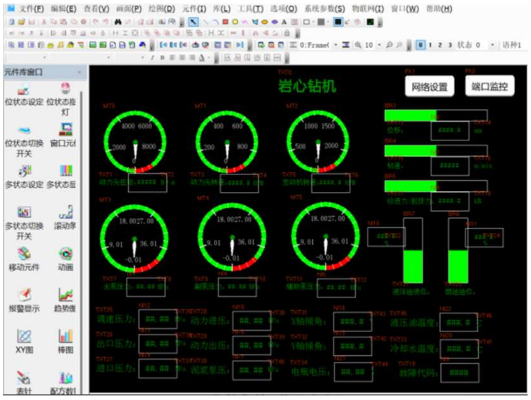

Figure 5. Data Collection Module Design

5.2 Kinco Communication Design

The Kinco F150E touchscreen [9] supports CANOpen bus communication and CAN free port communication. This design uses CAN free port communication. Users can develop custom CAN bus protocols according to their actual needs. The protocol program manages the sending and receiving of CAN communication data through the system's underlying standard interface library, and also provides predefined function callbacks, allowing developers to write message parsing and handling logic in C. The communication process is shown in Figure 6.

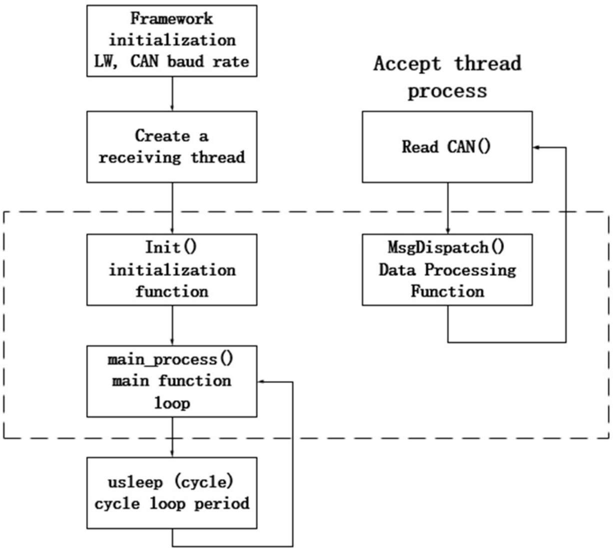

Figure 6. Kinco Communication Flowchart

6. Conclusion

Based on the STM32F4 and Kinco F150E, a solution was designed for a core drilling rig parameter monitoring system to improve the intelligence level of drilling equipment. The monitoring system software was designed to process sensor signals and handle relevant communication data sending and receiving, enabling the monitoring and display of various parameters during the operation of the drilling equipment. By setting up a test platform, it was verified that this system can monitor the drilling rig's parameters in real time and provide fault alerts, meeting the requirement to monitor the relevant parameters of the core drilling rig during operation.

References

[1] Zeng, Z. W., & Ye, W. C. (2026). Analysis of geological exploration and safety technology in geological prospecting engineering. World Nonferrous Metals, 7, 160–162. https://doi.org/10.3969/j.issn.1002-5065.2026.07.054

[2] Tang, X. R., Liu, F. B., & Fan, L. F. (2025). Fully hydraulic geological core drilling rig. Drilling Engineering, 52(6), 154–155. https://doi.org/10.12143/j.ztgc.2025.06.021

[3] Sun, F. Y., & Chen, J. J. (2025). Design of core drilling rig monitoring system based on CODESYS. Plant Maintenance Engineering, 9, 14–16. https://doi.org/10.16621/j.cnki.issn1001-0599.2025.05.05

[4] Lu, C. D., Gan, C., Chen, L. F., et al. (2023). Research progress and development prospects of intelligent control in geological drilling process. Coal Geology & Exploration, 51(9), 31–43.

[5] Zhang, X. X., Liang, B. W., & Zhang, X. L., et al. (2023). Research progress on intelligent drilling equipment and technology. Coal Geology & Exploration, 51(9), 20–30.

[6] Tang, X. R., Liu, F. B., & Fan, L. F. (2025). Fully hydraulic geological core drilling rig. Drilling Engineering, 52(6), 154–155. https://doi.org/10.12143/j.ztgc.2025.06.021

[7] STMicroelectronics. (2024). STM32F407xx datasheet: Arm® Cortex®-M4 32b MCU+FPU, 210DMIPS, up to 1MB Flash, 192KB RAM, USB OTG HS/FS, Ethernet, 17 TIMs, 3 ADCs, 15 comm. interfaces & camera [Datasheet]. https://www.st.com/resource/en/datasheet/stm32f407vg.pdf

[8] Texas Instruments. (2015). ADC128S102: 8-Channel, 500-ksps to 1-Msps, 12-Bit A/D Converter (Document SNAS298G) [Datasheet]. https://www.ti.com/lit/ds/symlink/adc128s102.pdf

[9] Kinco Automation (Shanghai) Co., Ltd. (2023). F150E waterproof dedicated human-machine interface [Product datasheet]. https://www.kinco.cn/productdetail/f150ew38.html