IoT based Credit Payment Management (MCP) Monitoring System for the Caterpillar 305.5E2 Excavator

Faisal Backrie, Prihadi Murdiyat and Verra Aullia

Politeknik Negeri Samarinda, Indonesia
faisal.backrie@polnes.ac.id, pmurdiyat@polnes.ac.id, verraaulia@polnes.ac.id

Abstract. In heavy equipment sales, mainly by credit payment, leasing company or owner gives customer the trust to use heavy equipment or machines and pay off the credit by the project income they are working on. Agreement between the two parties is generally implemented as a contract involving day-to-day working hours, workplace limits, and service and maintenance periods. To monitor the condition of the machine while it is operating in the field, the owner generally communicates with the customer by telephone. This method has proven to be less effective, particularly when customers are dishonest. The Credit Payment Management System (MCP) is developed to allow the owner supervising the machine exploitation. The system consists of hardware and software, where the hardware main components are ESP32, GSM, GPS, and relays modules, while the software consists of the host program on ESP32, the application program on the mobile phone connected to Blynk IoT, and the McpPay application on the computer connected with the host program on ESP32. Evaluation after implementation shows that the system can serve its purpose. The position of the machine can be detected on the map. It will be automatically turned down when it is brought outside the contract area. Also, the machine will be shut down if the payment has not been made. In addition, owner and customer can expect maintenance due to the working hours reported by the machine. If the machine shut down, the customer may ask the owner to activate the machine when the agreement is reached.

Keywords: heavy equipment, credit payment management, ESP32, Blynk IoT, McpPay

1. Introduction

Heavy equipment is a special vehicle designed to assist human working in the fields of mining, construction, forestry, power plants, et cetera. As the heavy equipment is quite expensive, a company could buy it by credit payment, where the company (customer) pay the leasing company (owner) by the project income. By this way, customer and owner sign agreement with some conditions, for example, a machine can only be used in a specific region, payment must be orderly, and so on.

However, during contract implementation, credit payments may not run as they expect, hence, it may result losses to the owner. For example, when the project (construction and mining) is over, the customer may prefer to move the machine to other locations outside the work agreement, as they want to pay the credit normally. For this reason, the owner requires to find out the current condition of the heavy equipment, its current location, and its work time. Formerly, the owner makes phone call with the customer to obtain such information. However, there is possibility that the customer is dishonest and therefore cause losses to the owner.

With the presence of a digital platform, such a problem could be solved, where the owner could supervise the machine remotely and in real time. Credit Payment Management (MCP) is a digital system that offers ease in monitoring processes including searching, tracking, and payment progress, as well as providing communication between owner and customer.

MCP will automatically shut down the machine if the machine is operated outside the agreed area, or the credit due has not been paid. In this condition, customer is able to

M. U. H. Al Rasyid and M. R. Mufid (eds.), *Proceedings of the International Conference on Applied Science and Technology on Engineering Science 2023 (iCAST-ES 2023)*, Advances in Engineering Research 230,
https://doi.org/10.2991/978-94-6463-364-1_41

contact to owner to find out the solution. This flexibility gives customers the benefit in terms of payment change, credit time estimates, as well as new service plan to achieve goals and profits. For the owner, this system could minimize overtime credit payments, charge additional payment, offers additional schemes, as well as give predictive maintenance alert. These flexible services may increase customer loyalty.

2. Literature Review

2.1. Previous Research

Research in [1,2,3,4] study the utilization of free Global Position System (GPS) technology integrated with a Global System for Mobile Communication (GSM) sensor, microcontroller, the internet, and database storage. The results show that the system could be used to create a vehicle tracking and monitoring system with a fast and accurate digital map display. The system can also perform deadly control and activate the vehicle engine remotely through the Short Message Service (SMS). This gives a figure that location mapping of an object can be implemented by a low cost but useful system.

2.2. Heavy Equipment Basic Electric Circuit

A heavy gear unit is a combination of several systems that work together, where each system has its own components and functions. As similar with common heavy equipment, excavator 305.5E2 consists of engines, hydraulic, electrical and monitoring systems. The electrical system is required to do starting, charging, and to supply monitoring units. The basic set of electrical systems on heavy equipment is shown in Figure 1.

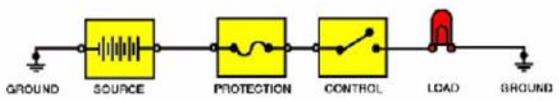

Fig. 1. Basic electrical circuit of heavy equipment [5]

Electrical systems are divided into power supply/power supply, conductor/transmitter, circuit protection/network protection component, control/switch, and load/output component. In the elaboration of the concept of Management Credit Payment, the electrical system, particularly the starting system, is used to turn on and off the engine. To combine the MCP hardware with the heavy equipment, several considerations should be taken in account to avoid problems and thus the existing systems still work properly although the MCH has been added.

3. Research Method

3.1. Hardware Management Credit Payment

Figure 2 shows the block diagram of the MCP board installed on the Caterpillar 305.5E2 excavator. The GPS module determines the location of the coordinates with the help of several satellites. The GPS output data are in a string type where every character forms an 8-bit ASCII code. The data are accepted by ESP32 microcontroller through serial communication with a certain baud rate. Such data are processed by microcontroller to obtain geographical coordinates (latitude, longitude), time and speed.

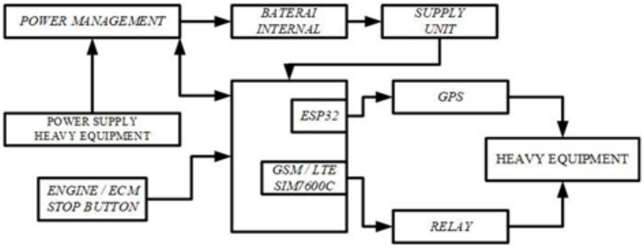

Fig. 2. Diagram block of MCP hardware

The data are sent to the server via a GPRS device executed by the GSM module using the HTTP protocol. In this process, the GSM module can also receive commands from the server to perform tasks such as shutting off the heavy equipment machine. If the stop button of heavy equipment ECM is pressed once in 1 second, the microcontroller on ESP32 will order the GPRS device to send an emergency message to the server. Hence, the server will display off condition and at the same time shut down the machine.

The internal battery serves as a backup power supply when the main supply from heavy equipment is removed. The supply unit reduce the voltage obtained from internal battery to a lower voltage required by the system. Power management is designed to work as an indicator of the internal battery capacity. In addition, it can also act as an internal charger to automatically charging the internal battery if its voltage is too low.

3.2. The Installation of MCP Board Relay on The Caterpillar 305.5E2 Starting System

The installation of MCP board relay on the heavy equipment is shown in Figure 3. It can be seen that the cables on pin S and B are disconnected to put relays to control the electric supply. This allows the owner to control the machine operated by customer to achieve condition on the contract.

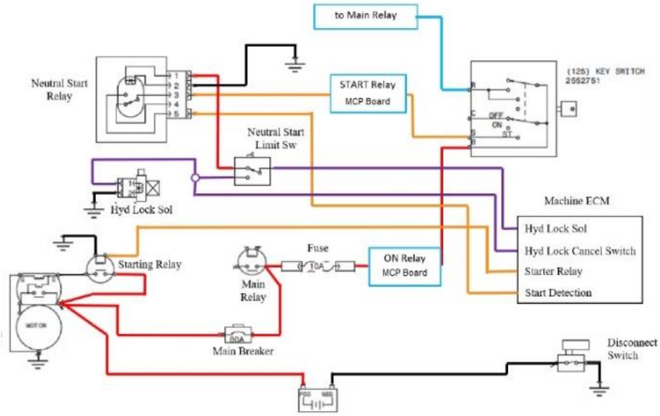

Fig. 3. Block diagram of hardware management credit payment

3.3. MCP System

The block diagram of MCP system is shown in Figure 4. MCP board consisting modules of ESP32, GPS, relays, GSM/LTE is placed on a box installed near excavator ECM unit. The location of excavator measured by the GPS module is sent to a webserver through 4G LTE network. Other data sent by the ESP 32 are the conditions of relays. All those data saved in webserver could be accessed by the owner through the application built from Blynk IoT platform installed on their mobile phone. The application could work on mobile phone as it is built based on Android operating system. Throughout the application, the owner is allowed to monitor the excavator location and relay condition, as well as control the relay. In addition, ESP32 includes hosting program that could be access by personal computer through WiFi.

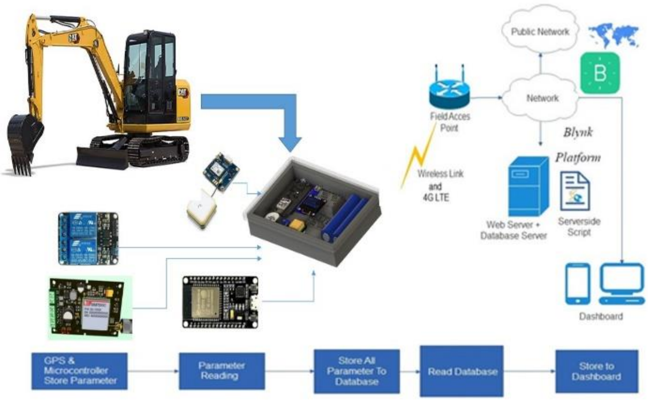

Fig. 4. Diagram of MCP system

3.4. Placement of MCP Board on The Excavator

In the excavator unit 305.5E2, as shown on Figure 5, the MCP board is placed next to the ECM board. The MCM board is mounted on the mounting case of the excavator ECM excavator.

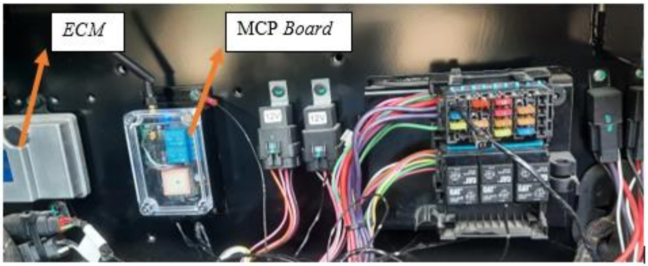

Fig. 5. Placement of MCP board in the excavator

4. Results and Discussion

To figure out the performance of MCP system installed in excavator 305.5E2, several tests are undertaken. The testing involves the owner and customer to ensure that the system could work according to the required workflow and there are no impediments in terms of technical and workflow.

4.1. MCP Process Monitoring Interface on Blynk Cloud

Figure 6 and 7 display data appearing on Blynk Cloud browser page that are recorded when the MCP board is installed in excavator and activated.

Fig. 6. Several functions appear on Blynk cloud browser

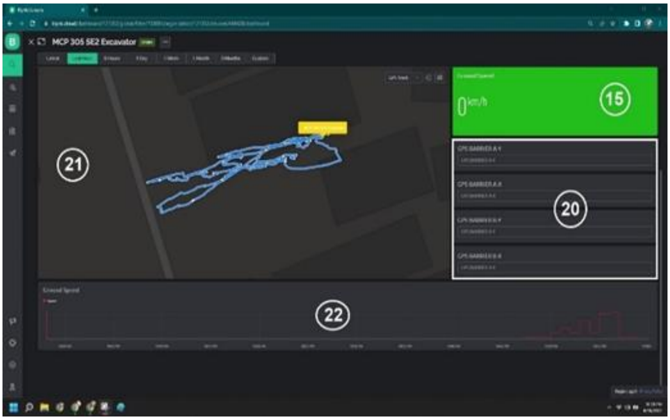

Fig. 7. Other functions appear on Blynk cloud browser

Functions displayed on the Blynk cloud browser are as follows:

1. **Hours**, determines how long the machine has been in use, and hence could be make maintenance schedule accordingly.
2. **On Relay**, shows the switch that the owner could use to turn off the engine for emergency maintenance. The customer will not be aggrieved by this function as the credit time will be saved and used as an ECM bypass line when the machine crosses the real-time border of the designated area.
3. **Start Relay**, works to turn the machine on after it was turn off when the costumer is too late to pay credit. It also displays the position of relay in real-time.
4. **SMS Trigger**, shows the owner's switch for turning on SMS notifications to the customer.
5. **Day**, allows owner to know current date.
6. **Month**, allows owner to know current month.
7. **Year**, allows owner to know current year.
8. **Machine Status**, allows owner to know the machine state (on or off); if it is red, the machine is shut down.
9. **Overdue Day**, displays credit expire date that can be immediately modified to a new credit agreement date.
10. **Overdue Month**, displays credit expire month that can be immediately modified to a new credit agreement month.
11. **Overdue Year**, displays credit expire year that can be immediately modified to a new credit agreement year.
12. **Saved Day**, allows owner to view credit date that have been saved on the MCP board
13. **Saved Month**, allows owner to view credit month that have been saved on the MCP board
14. **Saved Year**, allows owner to view credit year that have been saved on the MCP board
15. **Ground Speed**, displays excavator speed in real time (km/h).

16. **Realtime GPS (latitude)**, displays excavator location latitude.
17. **Realtime GPS (longitude)**, displays excavator location longitude.
18. **Model Machine Owner**, shows heavy equipment model that is being tracked.
19. **Menu Device**, allows owner to access heavy equipment data online for credit time requirements.
20. **GPS Barrier Locking Area**, displays the area border where the heavy equipment has been agreed to work. The MCP will notify information such as notifications, location, SMS, and even the machine's inability to run if the device leaves the area set by the owner.
21. **Realtime MAP**, allows users to observe the location of the heavy equipment in real time. The location of the machine is indicated by a model label, and the machine's serial number is highlighted in yellow.
22. **Grafik Ground Speed**, display the graph of the heavy equipment speed in real time.

The test is provided by using a computer and mobile phone that has been integrated into the Blynk server. This method examines the machine's location (GPS latitude and longitude) and displays the machine's journey on a real-time map. The machine's status looks to be operational with a green indicator, as well as when it is being tested for functionality and when it is being turned on remotely. All of the test give a flawless performance.

4.2. Excavator 305.5E2 Battery Voltage and Current Measurement

The purpose of battery voltage measurement is to make sure that the heavy equipment unit's starting mechanism operates properly with and without the MCP Board. The test takes four measurements. The battery voltage reading is anticipated to be within the range of 12.79 to 12.90 Volt. The result is shown in Figure 8 and 9.

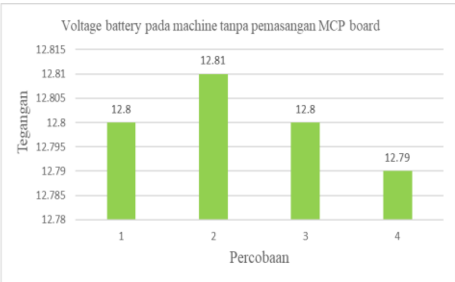

Fig. 8. Excavator battery voltage without MCP board

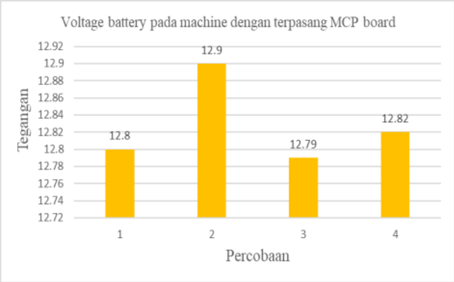

Fig. 9. Excavator battery voltage with MCP board installed

Four trials of voltage measurement found that the voltage is to be within a small margin of the specification, between 12.79 and 12.90 volts. It shows that the MCP board installation does not interfere the excavator supply voltage.

Furthermore, the current measurement of the excavator battery is undertaken to find out the capability of battery capacity to provide current for MCP board. The result of four trials is shown in Figure 10 and 11.

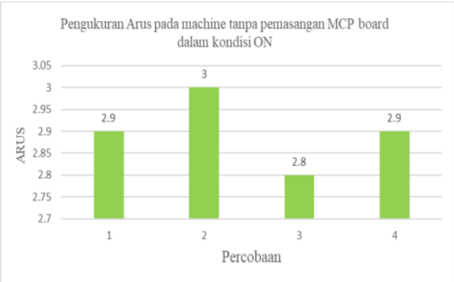

Fig. 10 Excavator battery current without MCP board

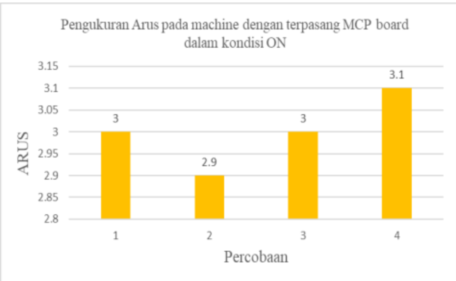

Fig. 11 Excavator battery current with MCP board installed

Four trials of current measurement found that the current does not significantly change, and thus it shows that the MCP board installation does not interfere the excavator supply current.

4.3. Evaluation of Transmit and Receive Response

The evaluation aims to demonstrate that the MCP board is capable to support its features to work well when owner and customer are communicating over WiFi and the Internet. The data on the graph can also serve as a benchmark when the MCP Board encounters an obstacle, and can be used to determine the speed of its communication in order to make it real time.

Figure 12 illustrates the measurement outcome of the time difference when stored time/units of dead condition with time continued/resumed. Ideally, the lower the error value and the smaller the differential value, the less the customer will likely be charged in losses. Customer losses occur when the response system falls short of a predetermined level, preventing notifications of the machine's location and its operation.

Fig. 12. Sort saved time and resume

Figure 13 depicts the reaction time measurement result for the owner's request to remotely shut down the machine (remote engine shutdown). Ideally, the quicker the owner application's relay time response trigger (1-3 seconds), the quicker the unit can be protected. When the machine's time has passed, the owner has the right to remotely switch the machine off in a safe manner. The engine shutdown technique must be adjusted to occupational health and safety. The machine does not typically restart once the contact lock is turned off and then turned back on because of the mechanism that keeps the contact key positioned on.

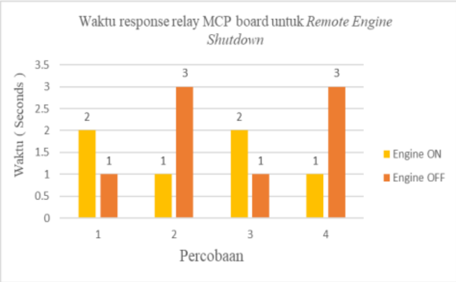

Fig.13 MCP board response relay time

Figure 14 displays the reaction trigger time measurement of the MCP board necessary to provide feedback in the form of an email to the owner. The timeliness of the data transmission time decreases the risk of the unit being overdue and even breaking down because the owner needs this data once the unit's maintenance period has passed. The more quickly the unit can be picked up, the more the unit's potential can be credited back. The pickup alert will convey the location of the unit in real time.

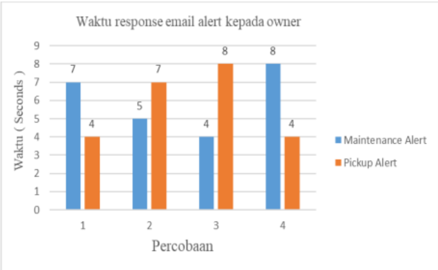

Fig.14 Time response email alert to owner

After for trials, it has been determined that the email of the owner's response time for maintenance alerts and pickup alerts is 4 to 8 seconds. A beneficial outcome of installing the MCP board is that the machine can send emails in a reasonable amount of time.

4.4. RSSI Measurement

When deciding the place of MCP boards installation in the excavator, it is important to take into account the received signal strength indicator (RSSI) parameter for WiFi connection between the MCP board and the owner's mobile phone and computer. The transfer of location and Alert data by the MCP board to the user of the mobile phone cannot function effectively if the RSSI value is below a certain threshold. An MCP board device at the right height and position will produce a high RSSI.

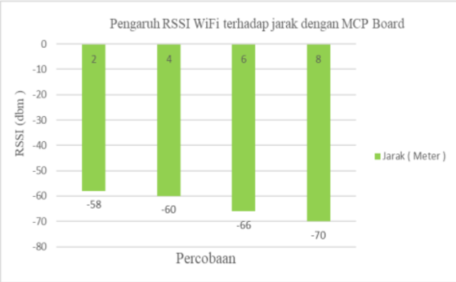

Fig. 15. Influence of WiFi RSSI on distance

The measurement results in Figure 15 showing RSSI between (-58) and (-70) at a range of 2 – 8 meters states that it is acceptable. However, the communication between MCP board and the owner phone or computer may be more difficult for the further distance.

4.5. Evaluation of GPS data receive response

GPS sensors are used by the MCP board to locate large trucks in the field. According to the sensor's specifications, its accuracy is up to 2.5 meters. Four data retrievals are made for the given location to test the GPS accuracy on the MCP board. Then, the position on Google Maps was compared to the location information displayed by the MCP board. Two test locations—indoors and outdoors—that may impact GPS accuracy are chosen. According Figure 16, it can be seen that the owner may not misplace the location of the excavator in outdoor as the difference between the location displayed by MCP Board and the location on Google Map is small.

Fig. 16. GPS deviation from actual position in the outdoor

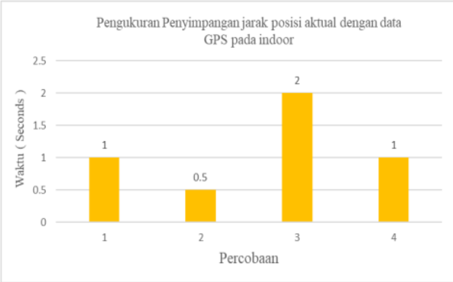

Fig. 17. GPS deviation from actual indoor position

In 4 trials, the measurements of the indoor GPS variation ranged from 0.5 to 2 seconds. The GPS's latitude or longitude position is the deviation. The MCP board must be mounted on the machine in an outside environment; if it is indoors, the GPS reception will be slowed.

5. Conclusion

As the result of the design and implementation of the MCP on Caterpillar 305.5e2 heavy-duty excavator unit, the conclusion is as follows:

1. Android-based Blynk IoT and MCPPay applications are sufficient to access MCP Board.
2. The MCP system allows setting of the boundary of the working area according the contract between owner and customer. The excavator will be shut down automatically when passing the boundary.
3. In accordance with the service maintenance interval plan, the owner will be notified when the unit needs interval maintenance while it is in use.
4. By using the Blynk IoT or Blynks Cloud application and email notifications during the credit period, the owner are able to supervise the location of the in real time while the unit is in use.
5. The MCP board could work well and uses relatively little power when installed in a large machine.
6. RSSI readings made at a distance of 2 to 8 meters and between (-58) and (-70) dBm.
7. The MCP Board must operate in accordance with the occupational health and safety to avoid accident as the engine is shut down.

Acknowledgment

Authors would like to express gratitude and appreciation to The Director of Politeknik Negeri Samarinda for the research financial support to realize the system, as well as the

Center of Research and Community Service of Politeknik Negeri Samarinda for the conference participation financial support.

References

[1] M. A. Fatah, "Implementasi mobile tracking and security system berbasis mikrokontroler Atmega162 GPS dan SMS", *Jurnal Online Mahasiswa (JOM) Bidang Teknik Elektro*, vol. 1, no. 1, 2016.

[2] K. Guravaiah, R.G. Ivyavignesh, and R. L. Velusamy, "Vehicle monitoring using internet of things," in *Int. Conf. on Internet of Things and Machine Learning 2017 (IML 2017),* Liverpool, United Kingdom, October 17-18, 2017.

[3] U. Lestari and S. Kristiyana, "Rancang bangun mobile tracking application module untuk pencarian posisi benda bergerak berbasis short massage service (SMS)," in *Sem. Nas. Tek. Informasi dan Komputasi (SENASTIK)*, 2013, pp. 30–31,

[4] P. Sokibi and A. Widjaja, "Implementasi perangkat IoT (Internet Of Things) sebagai sistem pemantau dan pengendali kendaraan," *Jurnal Bit*, vol. 15 no. 1, 2018.

[5] Training Center Dept. Trakindo Utama, *Fundamental Electric, 1st Ed*, PT. Trakindo Utama, Cileungsi, 2003.