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Implementation of Indoor Localization System

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Abstract

In this paper, a localization system for indoor objects is proposed. The proposed system consists of Beacons, LED Cells, Main Cell Controller (MCC), and Display. A Beacon is attached at each indoor object, and each LED cell has Beacon Scanner and VLC Transmitter. The Visual Light Communications (VLC) and Power Line Communications (PLC) methods are used to communicate the signals for localization of indoor objects. And the proposed system is designed, and implemented as a prototype. To certify that our propose d system can exactly localize a given indoor object, we take test for the implemented system as a p rototype. Here the location of the given indoor object is known. Test is done in two ways. The first is to check the operation of the detail of the system, and the second is the position recognition of i ndoor object. The second is the test of the implemented system to correctly detect the location of the indoor object with Beacon, while the object with Beacon is moved from location C to A. The experimental result shows that the system is exactly detect the moving locations. The system has the advantages of using previously installed power lines, and it does not need to use LAN lines or optical cables. The proposed system is usefully applied to indoor object localization area.

Key words: *Localization System, VLC, PLC, LED Cell, Beacon, MCC*

1. INTRODUCTION

Recent advances in information and communication technologies have led to active research in various areas on such as smart home and smart factory [1], [2], [3]. These technologies have also been applied to localization system for indoor and outdoor objects. The Global positioning system (GPS) is used for outdoor localization system [4], [5]. In this case, the GPS has applied to the localization systems to allow some amount of errors. When the GPS for indoor localization systems is used, it results in unacceptable amount of errors in calculating the location of objects unlike outdoor. The error is due to a number of factors such as its intrinsic error, the time delay of signal, and distortion by other obstacles in wireless communications [4],[5],[6]. As an alternative, several types of indoor location information systems are developed, which include Wi-Fi, Bluetooth, ZigBee, and Visual Light Communication (VLC) [7],[8],[9],[10]. These systems

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have some difficulty and complexity to implement in indoor environment such as wire lines. The case of the Wi-Fi system has the problem that the Wi-Fi Access Point (AP) may become extinct or the position of the AP could be changed. Bluetooth or Visual Light Communication has the shortcomings of short range for detection.

To compensate these kinds of problems, we propose and implement an indoor object location system using visible light communications, and power line communication. The implementation is accomplished as a prototype. The proposed system would be applied to indoor localization systems for wide-scattered indoor objects detection.

2. ARCHITECTURE OF PROPOSED SYSTEM

2.1 System Architecture

The proposed system can detect the localiztion of objects in indoor environment. For the wide range detection of indoor objects, the system uses the VLC and PLC methods. Figure 1 shows the architecture of the proposed system.

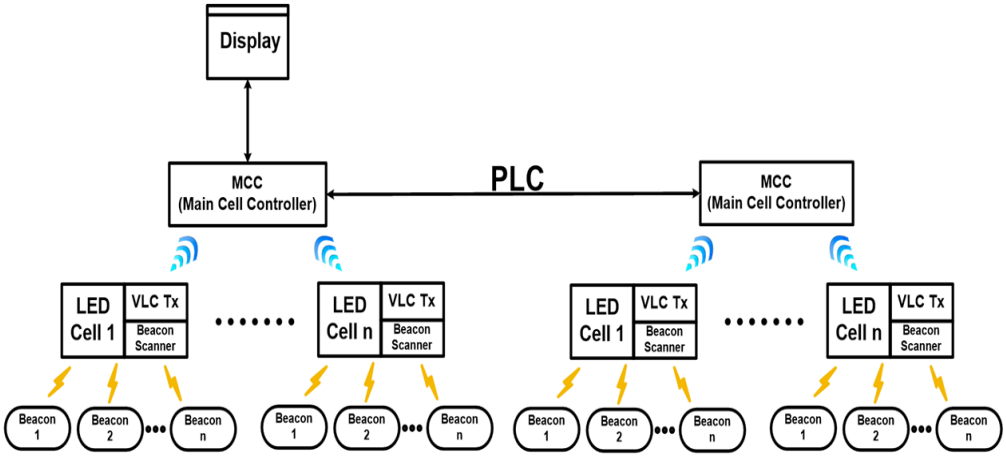

Figure 1. Architecture of proposed system

The proposed system consists of Dislay, Main Cell Controller (MCC), LED Cells, and Beacons. In this system, the esisting power lies are used for "**PLC**". A Beacon is attached at each indoor object, and each LED cell has Beacon Scanner and VLC Transmitter. The VLC transmitter includes the modulator for VLC and Micro Controller Unit (MCU). A LED cell covers many of the indoor objects.

2.2 Operation of Proposed System

Here we explain the system operation for convenience. Each object has its own Beacon, and each Beacon transmits its ID to LED cell, whose cell is located at same space belonging to the Beacon. The LED cell scans the transmitted information data from the Beacons around it. Then the LED cell sends the received Beacon's ID and its own ID to MCC by visible light communication method. The MCC receives the IDs of the LED cell and Beacon. Upon receiving the information, the MCCs communicate with Display by PLC. The information available on the Display is the IDs of beacons and the IDs of the LED Cells. Here the ID of Beacon corresponds to the location of object.

Figure 2 shows the detailed signal flow diagram of the proposed system to localize the object in indoor

environment.

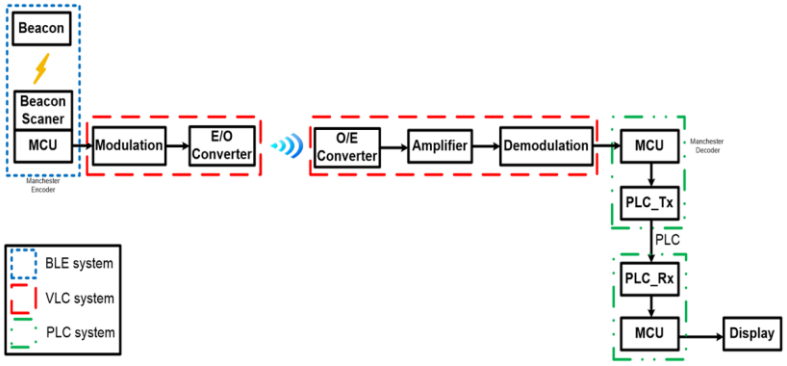

Figure 2. The signal flow diagram of the proposed system to localize the object in indoor environment

Each Beacon is made by HM-10 module with AT commands. Each Beacon radiates its ID, but the radiated signal does reach to near region because of limited power. Each LED cell receives all of the Beacon's IDs around it, and then the information of object IDs and it's cell ID are encoded by Manchester code in Micro Controller Unit (MCU) of the LED cell, and then the coded information data are modulated by ASK (Amplitude Shift Keying) method by using analog switch. The ASK-modulated signal is fed to E/O Converter, where the E means Electrical and the O means Optical. The E/O Converter functions to convert electronic signal to optical signal. After then the E/O output is sent to MCC. Here the VLC method is used to send optical signal to MCC.

The MCC receives the radiated signal from the LED cells, and the O/E converter of MCC transforms the optical signal to electrical type signal. The converted electric signal has a process of amplification because the signal has low level of power. After then, the demodulation process is done for the ASK-modulated signal, and results in original Manchester Code data. That is, the MCU of the MCC recovers original Manchester code from ASK-modulated signal through decoding process.

After then the Manchester coded signal is transmitted to Display unit by PLC method. Last, the Display shows the received information from the MCC to check the location of each indoor object.

3. IMPLEMENTATION OF PROPOSED SYSTEM

3.1 LED Cells

Figure 3 shows the designed circuit of the transmitter part of the proposed system as a PCB type.

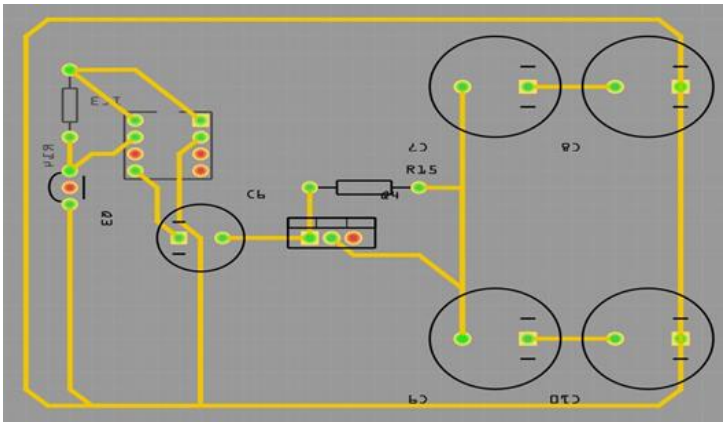

Figure 3. The designed circuit of the transmitter part of VLC as a PCB type

In Figure 3, HM-10 module was utilized for Beacon scanner with AT commands, and Arduino was used as an MCU for Manchester encoding from received Beacons' ID and current Cell's ID. That is, the HM-10 as a beacon scanner is used with AT commands, and Arduino was used as an MCU for Manchester encoding.

3.2 MCCs

Figure 4 shows the designed circuit of the receiver part of the MCC in proposed system as a PCB type.

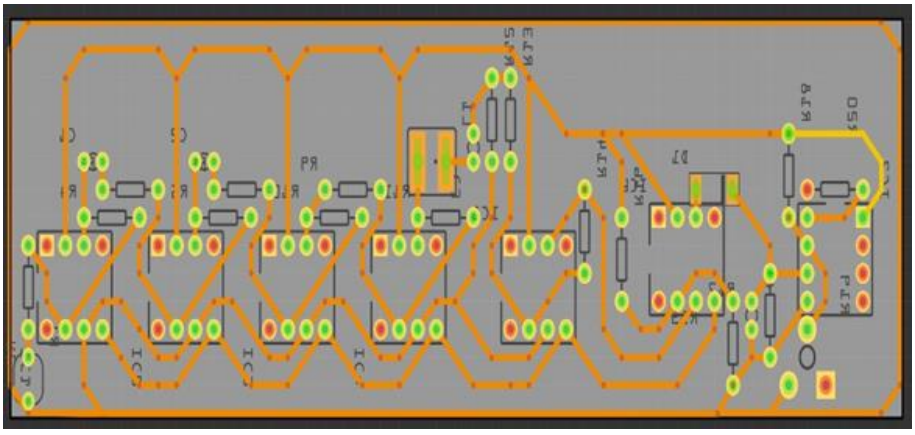

Figure 4. The designed circuit of the receiver part of MCC as PCB type

For the transmission of the IP's of the Beacons and LED Cells to Display, we designed the MCC and PLC module. Arduino is utilized to decode as Manchester-typed signal. After then, the Manchester-typed signal is sent to Display unit through serial communication by using Atmega128. For the communication of MCC to Display, we used the PLC method, the PLC is accomplished with already installed power lines.

3.3 Implementation of Entire System

Figure 5 shows the prototype of the proposed system to be implemented. The PC monitor is utilized as Display. And existing power lines are used for PLC.

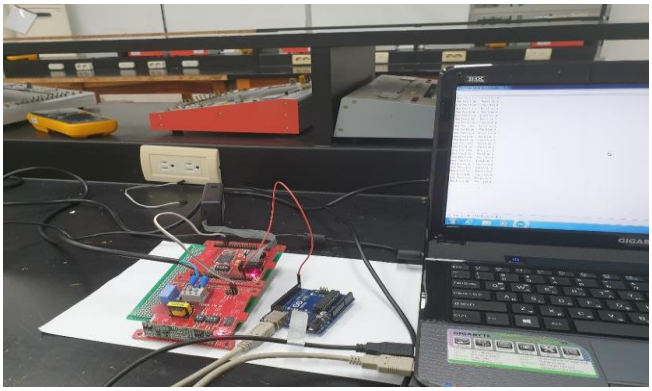

Figure 5. The entire proposed system to be implemented as a prototype

On the Display, the data for the indoor object location is shown.

4. EXPERIMENTAL RESULTS

We had taken a test to certify whether our system can localize a given indoor objet or not.

4.1 Test for Data Communications

Before checking the whole system, we had tried to take a test for data communications in part. The top signal of Figure 6 shows an example to be displayed on the oscilloscope screen, whose signal is encoded by Manchester code at the MCC, and the bottom signal of the Figure 6 shows the signal to be ASK-modulated for the original top signal, whose modulation is done by analog switch.

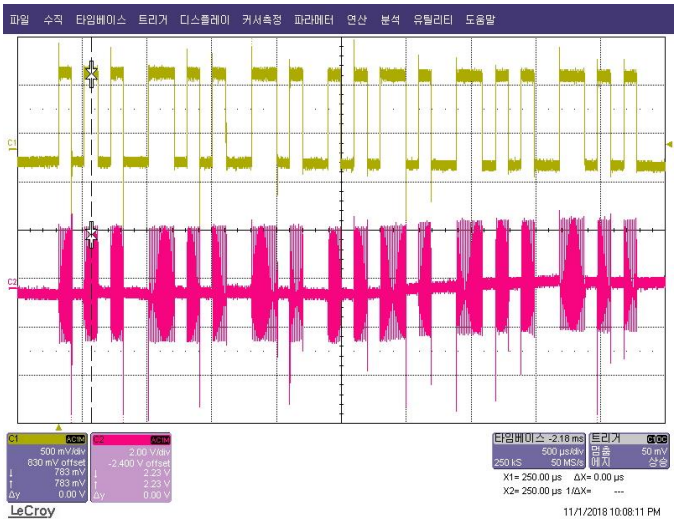

Figure 6. Signal to be encoded by Manchester code at the MCC (up), and ASK-modulated signal (down)

The top signal of Figure 7 shows the data signal before ASK modulation, which is same one of the top in Figure 6. And the bottom of the Figure 7 is the recovered data signal after ASK demodulation. Here we can certify that the lower part of the Figure 7 shows the same shape of the original upper one except for time delay of approximately 20 μsec. In the Figure 7, we know that the lower part of the Figure 7 is correctly recovered signal through ASK demodulation process.

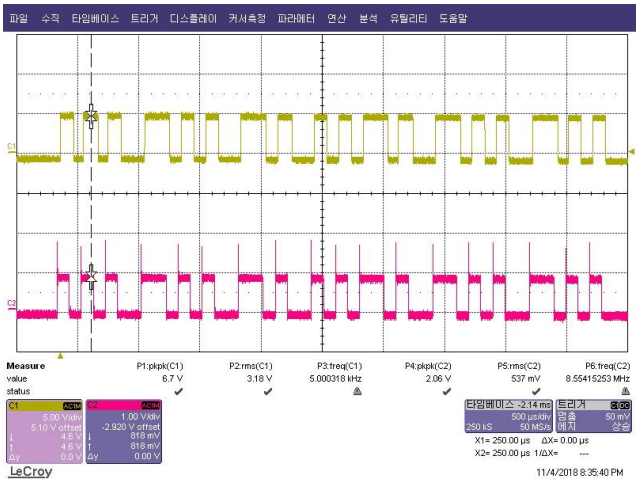

Figure 7. Original data signal (up) before ASK modulation, and the recovered signal through ASK demodulation process from ASK-modulated signal(down)

4.2 Test for Indoor Object Localization

For the test, the distance between MCC and LED cell is 2.7meter. The object with Beacon is initially positioned at C, and then moved to position A. Figure 8 shows the location information of the Beacon to be shown on the Display. This result shows that the location of the Beacon is moved from position C to A, and the result is exactly appeared on the Display screen of the system.

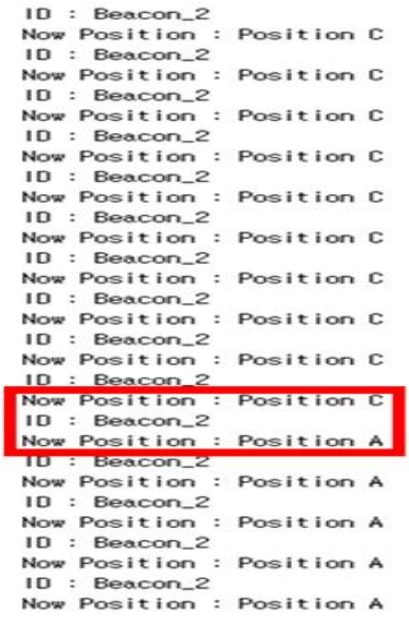

Figure 8. An example of experimental results

In conclusion, the known locations of the object with Beacon was tested for implemented system. The result shows that the location change of the object is correctly detected on the Display screen.

5. CONCLUSION

In this paper, we proposed an indoor object localization system, which consists of Display, MCCs, LED cells, and Objects with Beacon. The proposed system used a Beacon to check the location of indoor object. A Beacon is attached at each indoor object, and each LED cell has Beacon Scanner and VLC Transmitter. For the communication between Display and Beacon for localization of indoor objects, the Visual Light Communications (VLC) and Power Line Communications (PLC) methods were used. The proposed system was tested through the implementation as prototype. We took test in two ways. The first was the check of the operation of the detail of the system, which included modulation and demodulation process. And the second was the position recognition of a known indoor object. The second is that the implemented system is tested to correctly detect the location of the indoor object with Beacon, while the object with Beacon is moved from location C to A. The experimental result shows that the system exactly detected the movement of a known position of a given objet, while moving the location of the object with Beacon from position C to A. If the proposed system is applied at indoor-like environment, the location information of objects could be immediately identified.

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