Design and implementation smart parking based-on Visible Light Communication

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Design and implementation smart parking based-on Visible Light Communication

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Abstract. In general, the parking doorstop system used in Indonesia, still using a cable or bluetooth to connection to a button or switch for open and close the parking doorstop. To record the identity of the vehicle still using manual paper, and to enter and leave the vehicle still using the operator. This results in a quite solid vehicle queue. The parking system above is not reliable for a faster parking system. So this research will utilize Visible Light Communication technology by utilizing the characteristics of several photodiode sensors and lighting to send and receive text data from Visible Light Communication (VLC). In this parking system will utilize vehicle lights in the form of Light Emitting Diode (LED) lights, and use Pulse Width Modulation (PWM) communication from the sender with a frequency of 490 hz with time efficient. In this research, vehicle that will be used is a motorcycle. The results of the study for receiving and sending data using PWM modulation which can still be read and received correctly are at a distance of 220cm during the day with a value of 245 and 290cm lux at night with a value of 163 lux. receipt of data from the sender that is equal to 0.28 seconds. In this study the data transmission angle was changed and obtained the recipient response value at vulnerable distances of 50 to 90cm with effective data that is at an angle of 5 degrees.

1. Introduction

The need for information with correct data quality is becoming an important thing at this time [1,2]. Wireless network technology that is easily connected to the network wherever the user is, is becoming the technology of choice and is very fast growing nowadays. Wireless technology applications are no longer limited to data communication, where the sender and receiver exchange information over long distances. But it has begun to spread to Visible Light Communication (VLC) technology [3].

VLC is a wireless communication technology that uses visible light to modulate information [4,5]. VLC can be done by using an LED headlamp as a transmitter, including the use of LED tail lights which are currently only used for lighting on the road can be added to the feature with VLC [6-8]. Activities in and out of vehicle parking are vulnerable to causing long queues, thus requiring technology that is able to make the queue not long [2]. The use of RFID using Barcodes makes someone to prepare cards and do tapping, so it requires quite a long time. Motorcycle LED lights that are used as street lighting can be designed for the use of Visible Light Communication (VLC) which can send motor identity data and send "open" and "close" commands to the photodiode on the receiver with On-Off Keying modulation [9,10].

In this research, the design of a motorbike vehicle data identity transmission system and the "open" and "close" command using PWM that can send data 8 bits at a time and can also adjust the pulse width, by applying Visible Light Communication (VLC) technology and implement it on the front and rear LED lights of the motor. After the data and commands from the transmitter have been received by the receiver, the parking gate will open then the motorbike will be allowed to enter.

2. Design and implementation system

2.1. System design

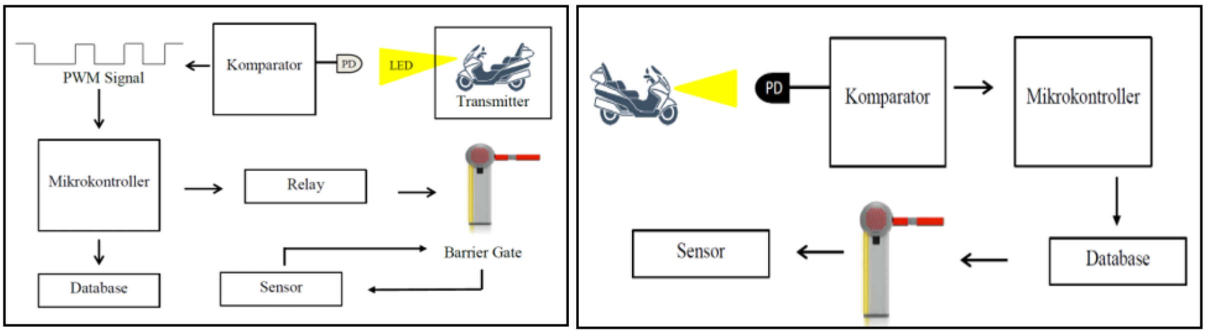

Figure 1. Transmitter and receiver block diagram.

The principle of work on the transmitter there are two photodiode to detect light from the headlights of the motor from the transmitter, then the comparator is tasked to strengthen photodiode, after that the data enters the microcontroller, and the data received is data text that will enter the database, after all data enter the database a microcontroller that is connected to a DC barrier gate motor with a relay connector as a mechanical switch, then the microcontroller will be ordered to open the bar park, then after the motor passes the barrier gate, the boom sensor will detect that on that area the motorbike has passed and the parking bar will automatically be closed [11,12]. While on the transmitter there are LED motorcycle front lights and rear LED motorcycle transmitter lights [13-15]. The working principle of this system is a microcontroller processing text data that has been programmed into a microcontroller in binary form with pulse width modulation output (PWM), and the data is superimposed on the light coming from the motor LED lights, the motor LED lights which insert the signal information in the form of text data and a command stating the motor identity and the "open" command on the front motor LED lights are transmitted wirelessly and received by the receiver at the photodiode at the barrier gate, then the parking gate will open and on the rear motor LED lights sending the "close" command to the receiver, so the parking doorstop will be closed [16-19].

2.2. Hardware and software system design

In the transmitter section, the motor LED lights are used as sending text data superimposed on the light.

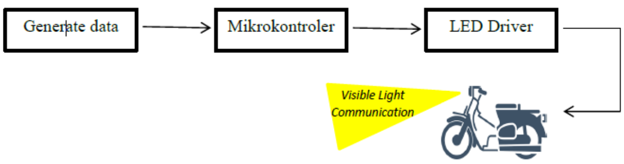

Figure 2. Transmitter block diagram.

In the transmitter using 2W LED Motorcycle lights as many as 2 pieces. The LED light emitted by the motor LED lights functions as a transmission medium for sending text-based data to the receiver. Arduino pro mini gets 12v from the motor battery, with the help of the LED driver as the current controller so that Arduino gets a supply from the motor battery. The installation is Pin 10/11 on the Arduino pro mini connected to a resistor of 1K then connected to the gate foot on the mosfet, the ground

Arduino pro mini is connected to the source foot on the Arduino pro mini, then the drain foot on the mosfet is connected to (-) on the LED lights motor, and in part (+) motor LED lights are connected to the motorcycle battery with a switch as a safety device.

While on the receiver, the photodiode is used as a receiver of the text data that is sent from the transmitter.

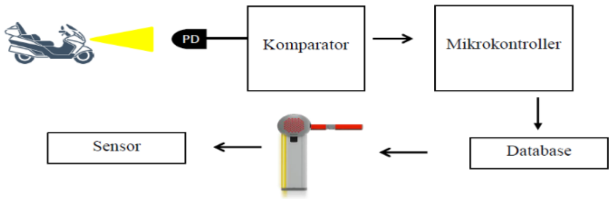

Figure 3. Receiver block diagram.

In the receiver using 2 photodiodes. Photodiode in pairs are as a transmission medium for receiving text-based data from the transmitter. Arduino Uno and Pro Mini get a supply of 5V laptop, with the help of a comparator as an amplifier on the receiver to receive text data sent by the transmitter. The installation is pin 3 on Arduino Uno through a comparator on the analog pin A0.

In the receiver's data storage the author uses the SD Card module as the storage media, the installation is on Pin D11 pro mini connected to the pin MOSI on the SD Card module, then on the D12 Pro Mini Pin is connected to the MISO PIN on the SD Card module, then on the D13 pro mini Pin is connected to the SCK Pin on the module SD Card, then on the D4 Pro Mini Pin it is connected with the CS PIN on the SD Card module, and for 5V (VCC) power in the Arduino Pro Mini connected to the VCC on the SD Card Module.

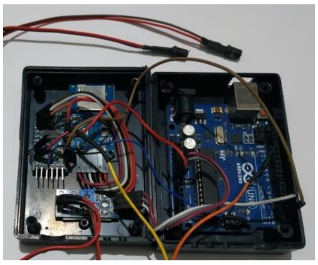

Figure 4. Receiver circuit.

Figure 5. Transmitter circuit.

2.3. *Testing scenarios*

2.3.1. Test the delivery of binary numeric data to be converted to char. In this test the parameter is the level of transmitter success in sending binary numbers. Then it will be converted into several characters and will be sentences. The sentence is in the form of motorcycle identity text data.

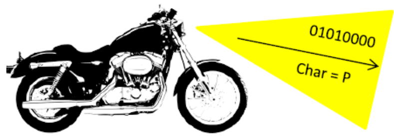

Figure 6. Binary text data transfer testing scheme converted to char.

2.3.2. Delivery delay testing. Transmission delay is the estimated duration of data sent from the transmitter to the receiver. In this measurement, it is measured how long the text data sent per character to get to the recipient and put together into a sentence, that is the motor identity data sentence using Stopwatch found on the Smartphone.

2.3.3. Tx – Rx distance testing. This measurement will be carried out starting at a distance of 10 cm to the farthest distance that can be responded by the system. Measurements were made in outdoor conditions (day and night) with a closed roof and indoor conditions.

2.3.4. Light intensity testing. Testing is done by adjusting the position of the photodiode sensor and the motor LED lights on keep it from 10 cm to the farthest by seeing whether the light is emitted from the transmitter is still detected in the receiver, then the test data taken is the value lux from measurement distances, receiver response per-distance, and effectively detected data from a certain distance value.

2.3.5. Angle of light reception testing. Angular testing, for knowing at what angle the data can be received perfectly at the receiver, because vehicles that will enter the parking lot are not always in a straight line with the position photodiode that is mounted on the parking lot, testing is done on two conditions, i.e. during the day and night with outdoor conditions covered by a roof, receive angle taken is at an angle of 5o, 10o, 15o, with the distance between the sender and receiver i.e. 50cm, 60cm, 70cm, 80cm, 90cm, 100cm per test angle and have the lens mounted on the lamp motorcycle vehicles and at the photodiode.

3. Measurement and analysis

Here we present a number of measurements and analysis in this research including:

3.1. Binary character conversion delivery test

Table 1. Testing of binary converted characters.

Biner	Char	State	Biner	Char	State
01010000	P	Sent	00100000	(space)	Sent
01101100	l	Sent	01000100	D	Sent
01100001	a	Sent	00100000	(space)	Sent
01110100	t	Sent	00110110	6	Sent
00100000	(space)	Sent	00110100	4	Sent
01101101	m	Sent	00110010	2	Sent
01101111	o	Sent	00110000	0	Sent
01110100	t	Sent	00100000	(space)	Sent
01101111	o	Sent	01010110	V	Sent
01110010	r	Sent	01000010	B	Sent
00100000	(space)	Sent	01001101	M	Sent
00111101	=	sent			

Table 1 show that the transmission of binary data converted characters sent from the Transmitter to the Receiver. The receiver will respond to the text data into a sentence and the parking doorstop will open. In this table shown that there are 23 data bits "1" and "0" in the transmitter, each binary converted character that will be sent to the receiver, each character above will be united in the receiver and will become a sentence, namely "Plat motor = D 6420 VBM ".

The data sent by the Motor LED are bits "1" and "0", amounting to 8 different bits for each character that is converted on the receiver. Bits 1 and 0 can be registered bits in the ASCII table. Then there are 184 bits that will be sent to the recipient who will later convert 23 different characters, then each character will be put together and become a sentence. The sentence that will later be used as information and entered into the database shows that the motor with the data "Plat motor = D 6420 VBM" has entered the parking areas.

3.2. Delay time testing

The following is a Delay Delivery table per 8 bits to the receiver using PWM modulation:

Table 2. Delay time testing.

Biner	Char	Delay (s)	Biner	Char	Delay (s)
01010000	P	0,68	00100000	(space)	0,43
01101100	l	0,45	01000100	D	0,16
01100001	a	0,17	00100000	(space)	0.43
01110100	t	0,32	00110110	6	0,16
00100000	(space)	0,43	00110100	4	0,16
01101101	m	0,16	00110010	2	0,37
01101111	o	0,16	00110000	0	0,21
01110100	t	0,32	00100000	(space)	0,43
01101111	o	0,16	01010110	V	0,22
01110010	r	0,25	01000010	B	0,13
00100000	(space)	0,43	01001101	M	0,16
00111101	=	0,16	Average Delay		0,28

Each delivery delay to the receiver has various delay times, depending on the receiver when receiving 8 character bits sent by the transmitter until the receiver converts 8 bits per character into a character. In delay time testing obtained that the fastest delivery is the character "B" 0.13 s, while the late is "(Space)" is 4.7s. An average delay of 0.28 cm is obtained from calculations of all delay data sent.

3.3. Distance testing

In this test, 30 measurements are carried out by measuring the distance of transmission from the sender to the recipient sending text data. This test will be carried out at a distance of 10 cm between the transmitter and receiver to the maximum distance. This test is carried out on two conditions, namely indoor and outdoor. For outdoor measurements are taken during the day and night. Test distances are taken from the average value of each distance to produce maximum measurements.

Table 3. Distance testing (indoor).

No. Test	Dist (cm)	State	Data	Lux	No. Test	Dist (cm)	State	Data	Lux
1	10	respond	ok	40672	16	160	respond	ok	14929
2	20	respond	ok	38810	17	170	respond	ok	12954
3	30	respond	ok	36681	18	180	respond	ok	11429
4	40	respond	ok	34486	19	190	respond	ok	9187
5	50	respond	ok	32701	20	200	respond	ok	8076
6	60	respond	ok	30199	21	210	respond	ok	6870
7	70	respond	ok	29007	22	220	respond	ok	4991
8	80	respond	ok	28179	23	230	respond	ok	3542
9	90	respond	ok	26003	24	240	respond	nok	2012
10	100	respond	ok	24562	25	250	respond	nok	1289
11	110	respond	ok	22959	26	260	respond	nok	996
12	120	respond	ok	21956	27	270	respond	nok	723
13	130	respond	ok	19100	28	280	respond	nok	409
14	140	respond	ok	17997	29	290	No respond		-
15	150	respond	ok	16885	30	300	No respond		-

Table 4. Distance testing (outdoor - day).

No. Test	Dist (cm)	State	Data	Lux	No. Test	Dist (cm)	State	Data	Lux
1	10	respond	ok	2700	16	160	respond	ok	208
2	20	respond	ok	2160	17	170	respond	ok	170
3	30	respond	ok	1898	18	180	respond	ok	144
4	40	respond	ok	1684	19	190	respond	nok	144
5	50	respond	ok	1236	20	200	respond	nok	143
6	60	respond	ok	947	21	210	respond	nok	137
7	70	respond	ok	801	22	220	respond	nok	127
8	80	respond	ok	617	23	230	respond	nok	118
9	90	respond	ok	588	24	240	respond	nok	114
10	100	respond	ok	434	25	250	respond	nok	105
11	110	respond	ok	361	26	260	respond	nok	92
12	120	respond	ok	302	27	270	No respond		-
13	130	respond	ok	276	28	280	No respond		-
14	140	respond	ok	253	29	290	No respond		-
15	150	respond	ok	232	30	300	No respond		-

Table 5. Distance testing (outdoor - night).

No. Test	Dist (cm)	State	Data	Lux	No. Test	Dist (cm)	State	Data	Lux
1	10	respond	ok	42501	16	160	respond	ok	15112
2	20	respond	ok	40327	17	170	respond	ok	13030
3	30	respond	ok	38742	18	180	respond	ok	11470
4	40	respond	ok	35325	19	190	respond	ok	9144
5	50	respond	ok	33024	20	200	respond	ok	7926
6	60	respond	ok	31923	21	210	respond	ok	6432
7	70	respond	ok	29190	22	220	respond	ok	5578
8	80	respond	ok	27005	23	230	respond	ok	4790
9	90	respond	ok	26647	24	240	respond	ok	3597
10	100	respond	ok	24570	25	250	respond	nok	2643
11	110	respond	ok	22985	26	260	respond	nok	1384
12	120	respond	ok	21879	27	270	respond	nok	1006
13	130	respond	ok	19774	28	280	respond	nok	786
14	140	respond	ok	18156	29	290	respond	nok	587
15	150	respond	ok	16708	30	300	norespond	-	450

In distance test, 3 experiments were carried out on 3 conditions Indoor, Outdoor-day and Outdoor-night. The 3 conditions are effective for doing experiments because the value of other light lux is not too high, at 84 lux indoor, at 586 Lux outdoor daytime, and at night outdoor only 17 lux. On sending data on the indoor reception the response is 280 cm with effective data received within 230 cm, on the Outdoor Day the reception response is 260 cm with the effective data received within 180 cm, and on the Outdoor night the reception response is 290 cm with effective data received is 240 cm apart.

4. Conclusion and suggestion

4.1. Conclusion
On the transmitter system the average delivery delay is 0.28 seconds per character. Meanwhile, to send data from an LED motor that managed to send data with a distance of 230 cm in indoor conditions, 180 cm in the daytime outside, and 250 cm at night outdoors. At the PWM Transmitter signal output, bit 0 has a Duty Cycle percentage value of 40% with a High value of 102, while bit 1 has a Duty Cycle percentage value of 80% with a High value of 204. The farthest distance that can still be measured and has a good response to the recipient is during the day is 220cm, and at night is 290cm. The most effective reception angle is at a distance of 50cm to 90cm with good reception and data response at an angle of 5 degrees.

4.2. Suggestion
The motor LED lights face straight toward the photodiode, so the receiver can receive data correctly and The photodiode placement in the vehicle parking bar must be straight with light emitted from motor vehicle lights.

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