An Efficient LSDM Lighting Control Logic Design for a Lighting Control System

Sung-IL Hong, Chi-Ho Lin

Schools of Computer, Semyung University, 65- Semyung-ro, Jecheon, Chungbuk, Korea

megadriver@hanmail.net, ich410@semyung.ac.kr

***Abstract*—in this paper, we propose an efficient LSDM lighting control logic design for a lighting control system. The proposed LSDM lighting control logic is designed according to the operating conditions by dividing them into the signal control part for the I/O data bus and the timer/counter part for the clock signal control. Also, the control logic is transmitted to the MCU through a data bus based on the environmental information provided by each sensor node. The power dissipation rate of the proposed LSDM lighting control logic was measured in order to demonstrate the efficiency of the applying the control system. In addition, it was demonstrated that the proposed design is effective for the reduction of overall power consumption.**

***Keyword*—Control logic, LSDM, Lighting control, Signal control, Power dissipation, MCU**

I. INTRODUCTION

THE field of lighting design in the 21st century is being developed based on intelligence and automation technology, because the LED lighting device performance was improved quickly in recent years. The LED lighting device needs control logic for LED emitting. The LED lighting is commonly used in lighting devices by configuring to one module the multiple LED. The power consumption of LED affects the life of the LED lighting device by changing the internal temperature of the LED through the operation of the control logic. Also, the LED lighting control system should be provides exceptional identification skills and high color rendering by considering the energy savings [1-6].

The existing lighting device is not made as a complicated control circuit design, in order to implement the simple on-off function according to operation of the sensor. But, the existing lighting control logic for the LSDM (LED streetlight dot-matrix module) control has problems when operating by using each different device drivers and control programs. The lighting control logic for LSDM is sensitive device that directly affects the light output of LED, reliability, efficiency, and life. Also, the LED lighting device is required to be designed by using MCU, because many features can be controlled and operated [7-8].

The current flowing through the LED determines the brightness, and the internal power consumption will change the internal temperature of the LED. Therefore, the lighting control logic is a sensitive device that is related to LED's brightness, reliability, efficiency, long-lasting life, etc., because the operating temperature affects the life of the LED. There have been various studies performed on LED lighting control logic to develop optimal performance of the system configuration or the circuit. However, these researches are incomplete when considering the technology needed to reflect optimal design with modeling of the LSDM lighting control logic.

The existing street lighting control system has been operated by design providing the ability to distinguish objects only to pedestrians or motorists than the light functionality. As a result, the lighting device control system needs to be designed to ensure the safety of pedestrians via a signal placed above the road, using a variety of add-ons. For troubleshooting in this study, we propose the design of an efficient LSDM lighting control logic for a lighting control system using the MCU by considering the compatibility of the devices and the scalability.

II. LSDM LIGHTING CONTROL LOGIC

A. LSDM Control Logic

The ATmega128 is downloaded to your system by compiling the lighting control program created for the control of LSDM with the kernel, the device drivers, and the file systems. The LSDM lighting control logic is used to control the LSDM by configuring the decoders, the drivers, the latches, and the shift registers.

Figure 1 shows the configuration of the LSDM lighting control systems. In this paper, efficient control logic for the LSDM operation is designed by configuring the LSDM as signal controller, timer, and counter parts. The LSDM control signal can be sent to the LSDM lighting control by operating the control logic with the program execution. The LSDM lighting control logic was designed by dividing the controls into the signal control part for the I/O data bus and the timer/counter part for the clock signal control according to operating conditions.

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Sung-IL Hong is with the School of Computer, Semyung University, 65 Semyung-ro, Jecheon, Chungbuk, 390-711, Korea. e-mail: (megadriver@hanmail.net).

Chi-Ho Lin is with the School of Computer, Semyung University, 65 Semyung-ro, Jecheon, Chungbuk, 390-711, Korea. e-mail: (ich410@semyung.ac.kr).

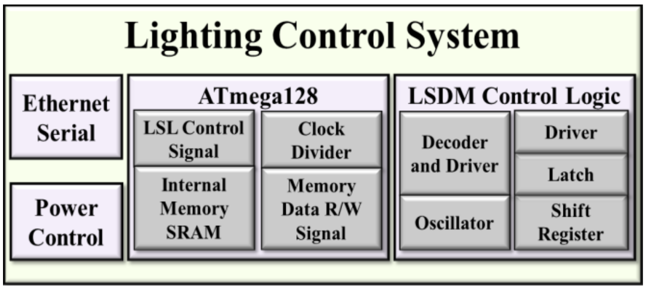


Fig. 1. LSDM Lighting control system

Figure 2 shows the configuration of the LSDM lighting control logic. The control logic is used as a decoder for selected lighting line by considering expansion of the LSDM. The I/O of the lighting control data uses the latch for control. Also, the control logic outputs the lighting data as LSDM uses the driver vertically and horizontally. The oscillator is designed to provide clock synchronization on all circuits using the internal oscillator circuit of ATmega128. To enable this the signal is received from ATmega128 for data output by repeating the latch process after a certain period of time. The R-Data and G-Data are used with the data for lighting of the LSDM. The A0 to A2 of 3-bit address lines are designed to be the line selection of LSDM by serial connection of up to maximum of eight. It outputs the lighting line selection signal of LSDM, because the LSDM I/O data signal controller can be controlled by selecting the LSDM connected as serial by adding a 3-bit decoder. In this case, the LSDM will light up by shifting the lighting data values using a shift register. The anode and the cathode driver are output as LSDM by receiving the lighting data signal of the rows and columns.

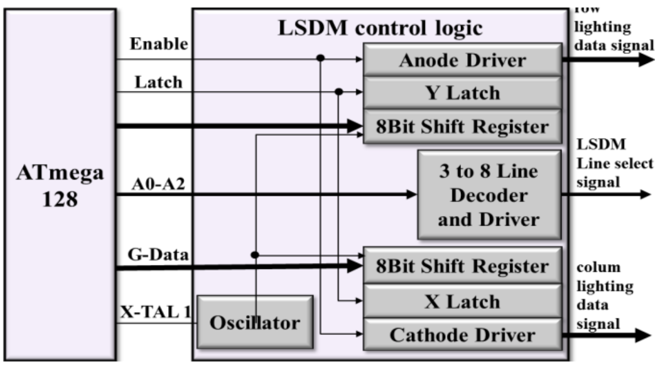


Fig. 2. LSDM lighting control Logic

B. I/O Data Signal Control

The I/O data signal flow of the control logic for LSDM control is entered through LSDM control logic, and the data output pin is determined depending on the address of the ATmega128. It uses address from 0x2500 to 0x2800 for the LSDM control, and stores in the internal memory by applying simultaneously to the data, address, and clock. If the data are read in the control logic of LSDM, the signal and data from ATmega128 is entered into the LSDM, according to the clock and latch signal. When the data is output into the control logic of LSDM, it is entered into the LSDM data when RW output signal is 1. The LSDM input data signal control part is selected and the control is used as the serial connecting LSDM by adding the 3-bit decoder that can be extended, because I/O pins are not simply I/O functionality. It outputs the line selection signal for lighting of LSDM. In this case, the LSDM input data signal control part will light up the LSDM by shifting the lighting data value using the shift register. The anode and the cathode driver will output to LSDM, the lighting data signal of the rows and columns through the shift register and the latch. Figure 3 shows the control flow of LSDM I/O data signal.

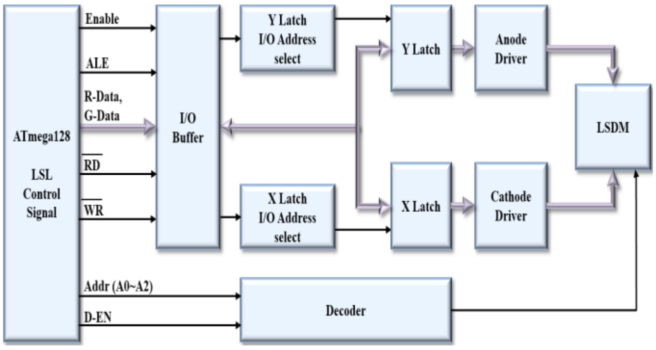


Fig. 3. LSDM control signal flow

Figure 4 shows the configuration default value of the optimization register. The control logic is used the output port C from port A on ATmega128 for data processing. It uses port G for controlling using address latch signal and R/W strobe signal for memory. The signal of the R/W signal roughly accesses the memory to the I/O buffer, and the address latch etc. in order to light up the LSDM. A port that is used at the I/O of the lighting data signals for LSDM lighting control can be the individual bits control when used as general-purpose I/O ports. Therefore, it is to be read/written as lighting data of LSDM using the PORTx data register (Data Register) that corresponds to the output and the DDRx (Data Direction Register) that sets the direction of I/O.

	bit	7	6	5	4	3	2	1	0
DDRx		DDx7	DDx6	DDx5	DDx4	DDx3	DDx2	DDx1	DDx0
	read / write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
	initial value	0	0	0	0	0	0	0	0

	bit	7	6	5	4	3	2	1	0
PORTx		Px7	Px6	Px5	Px4	Px3	Px2	Px1	Px0
	read / write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
	initial value	0	0	0	0	0	0	0	0

Fig. 4. LSDM lighting signal control registers

The data for controlling the flow of input and output signals of the LSDM is set to the direction and output of the input and output data, depending on the settings of the DDRx and the PORTx. In the DDRx register sets the input or output when each bit value is 0 or 1 using the 8-bit from 0 to 7. The PORTx register stores the value of the logical output port and verifies DDRxn bit setting contents of the PORTx register. Also, it is designed to load the status value of the corresponding port pin using the PINxn (Port Input Pins Register) bit register. In this case, the PINxn register bits are synchronized in order to optimize the input and output values in order to avoid the intermediate situation lasting phenomenon, whether the bit value is 0 or 1. Table 1 shows the values that the PORTx data register are used for processing of data signals for the lighting control on LSDM.

TABLE 1. PORT$_X$ DATA REGISTER VALUE

DDRx	PORTx			
	~row[1]	~row[2]	~row[3]	~row[4]
0xff	0xff	0xdd	0x01	0xee
	0x01	0x55	0xff	0xaa
	0xff	0x55	0x80	0xaa
	0x80	0x55	0xff	0xaa
	0xff	0x55	0x01	0xaa
	0x01	0x55	0xff	0xaa
	0xff	0x55	0x80	0xaa
	0x80	0x77	0xff	0xbb

The DDRx register value is set to 0xff to be used as the row-by-row lighting control data, with the PORTx register output used as bit-by-bit. It was designed to allow controlling according to the periodic pulse outputs by specifying an output data value of PORTx register.

C. The Timer/Counter for Controlling of LSDM Clock Signal

The LSDM lighting control system requires a periodic pulse output in order to control the LSDM and ATmega128 due to the synchronization. The LSDM control logic behavior cuts off the clock supply using sleep mode individually, providing a separate clock to each part to reduce the power consumption in the timer/counter part. The LSDM control logic behavior avoid fast-paced change of frequency for stable operation of the control logic when you use a separate clock. The timer/counter initial state is designed to be used by changing to other content appropriate for the user environment using the ISP or parallel programmer. The LSDM control logic uses the XTAL divide control register (XDIV) by setting the initial value to 0x90 for the continued use of the same frequency and to reduce the power consumption. Figure 5 shows the default setting values of the XDIV for the control of demultiplying.

Bit	7	6	5	4	3	2	1	0	
	XDIVEN	XDIV6	XDIV5	XDIV4	XDIV3	XDIV2	XDIV1	XDIV0	XDIV
Read/write	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	
Initial value	1	0	0	0	0	1	0	0	

Fig. 5. The XDIV default setting value

The clock source used in the LSDM lighting control logic is 16MHz. Therefore, a clock source has a set value to activate clock frequency, which is set to match the control program during behavior of the control logic. A frequency is set dividing 128 for the use of the control logic.

D. LSDM Control Algorithm

In this paper, the LSDM control algorithm to be used in the LSDM lighting control logic is designed to control the appropriate use of the LSDM to ensure low cost. The LSDM control algorithm is converted to the digital signal of the analog signal using the illuminance sensor, and it can be a pattern control according to the changes in the brightness of the light. . If the convert value of the ambient light is less than the default value, LSDM is continuously illuminated. If the converted value is large than the default value, LSDM will turn off by shutting down all processes automatically to avoid unnecessary energy consumption. This method will improve the energy efficiency of LED lighting device.

Figure 6 shows the control algorithm for the behavior state of the LSDM, controlled by a pre-set time schedule. The control algorithm flow for the LSDM control is defined by the type of I/O data, and transmitted to the MCU using the data bus by starting illuminance measurement and motion detection through installed sensor on lighting device. The control system from MCU can calculate the illuminated level depending on the set control method by correction of the I/O data, and decide whether to the level is maintained by comparing the results. The LSDM control algorithm determines whether to adjust level by comparing with the existing measurement values with the data according to the illumination measurement and motion detection. Therefore, the lighting control system was applied to the control algorithm for an efficient LSDM control.

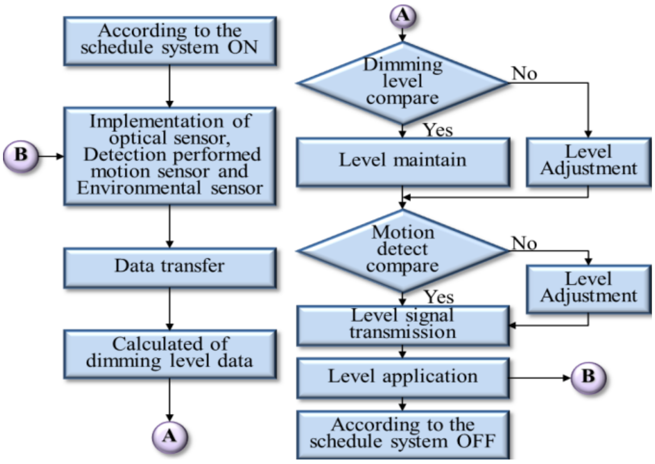


Fig. 6. LSDM control algorithm

III. THE EXPERIMENTAL RESULT

In this paper, a proposed LSDM lighting control logic measured the power of dissipation rate of the control logic on the lighting status by checking the control status, using LSDM lighting control data value of input and output from lighting control system. The Lighting control data confirmed data input for LSDM control that applies to the changes at any time by user needs.

The existing LSDM lighting control logic replaces the street lighting device from the lighting method using sodium lamps and metal halide lamps to LSDM. In addition, the used LED module does not require an MCU, because to light up by placing as the line forms or an array form. The lighting control method is simply implemented with an on/off function by measuring the illuminance. For this reason, the street lighting will be used in the case where lighting shows excessive brightness in comparison to the illuminance of the surrounding, avoiding unnecessary power consumption. The proposed LSDM lighting control logic is lighting control based on factors such as the temperature, humidity, illuminance, vehicle, and pedestrian traffic around streetlights, because the MCU is used so that we can adjust the brightness using PWM (Pulse Width Modulation) or change the lighting pattern by placing the LED module in the form of a matrix.

In this paper, we designed control logic for controlling the LSDM of efficient lighting control system, and the control program was written to operate in device driver and LSDM. The drivers and written programs were preferences using minicom and RS232C communication through the serial port in order to download to the lighting control system. In addition, an environment was set up of the host PC and trivial file transfer protocol (tftp), and transmits. We used this for the cross compiler, because the compiler should behave differently in the host PC and the generated executable file behavior system. The boot loader was compiled for configuring the lighting control system, and the download. Also, we were compiling with the kernel, the file system, and the device drivers and we created a lighting control program. The host PC checked the status of lighting control by downloading the program into the lighting control system through ethernet or serial.

Figure 7 shows the experimental environment of the host PC and the lighting control system had serial connection. It was configured so that it can control behavior of LSDM through the network on client PC in other places. The LSDM controlled lighting by applying the dynamic driving method constructed as 8x8 dot type.

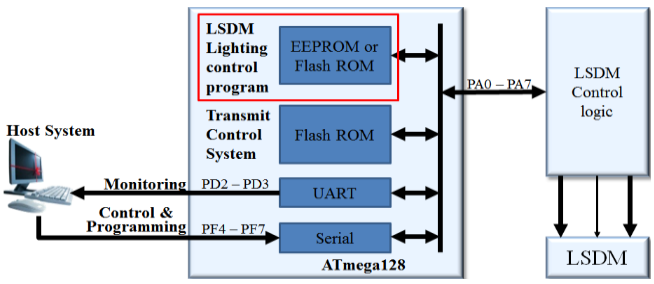


Fig. 7. Experiment environment

The experimental environment of figure 7 confirmed the lighting control status by efficiently controlling the LSDM control logic through I/O LSDM lighting signal data values by operation of LSDM lighting control program.

The lighting control data was confirmed by the data input for controlling the LSDM, because it was applied so that it can be efficiently changed at any time according to the user needs. Figure 8 shows the timing diagram of the lighting control data of the LSDM lighting control logic entered through PORTx of the ATmega128 with application of the LSDM lighting control algorithm. The lighting control data represents the value of the ~row[1] in the register-values for the control signals of Table 1, and the data were entered sequentially from ~row[1] to ~row[4].

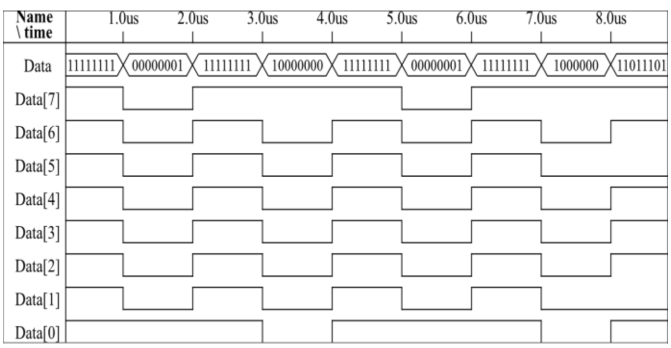


Fig. 8. LSDM control data

Figure 9 shows the time chart of the experimental results on the LSDM lighting control logic operation state of lighting control system that based on the control data entered from the ATmega128 by the LSDM control algorithm.

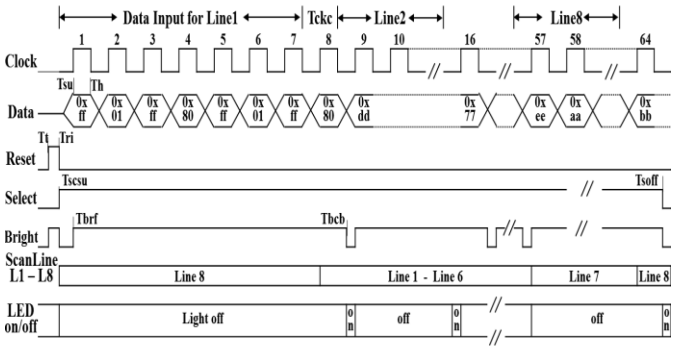
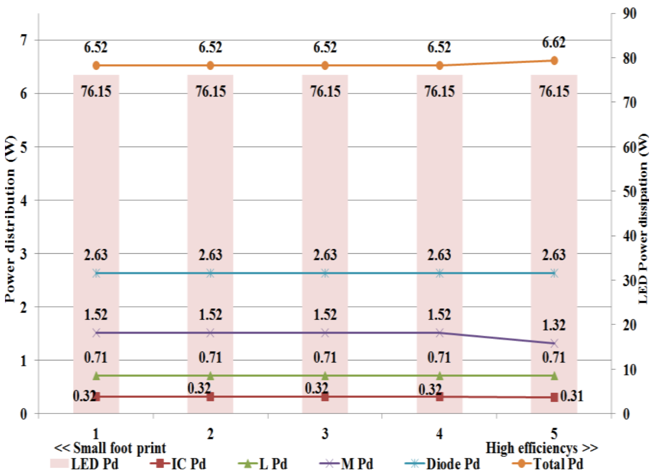


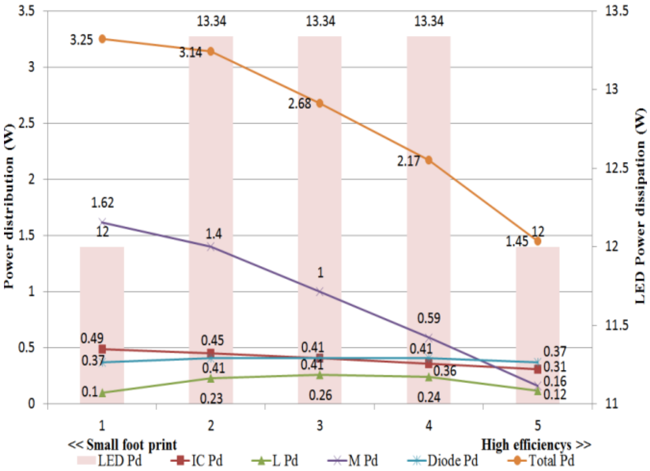
Fig. 9. LSDM operation timing chart

The ATmega128 enters the clock signal to the LSDM for data input and display, and enters the data through the PORTx for LSDM lighting. In addition, the reset signal is entered as "H" in order to counter the value initialized. In this case, the LSDM is not deleting the stored data even though the reset signal is input as "L". If the selected input signal is "H", the data input control is displayed with the data input. If the data input is "L", it is displayed by the set that disables the stored data. The brightness of the LSDM are controlled by determining the pulse width of the "tckc" when the selected signal for lighting control is entered as "H", because it can control the brightness by adjusting the pulse width on the PWM. The LSDM control logic receives a signal to check the on/off status using a dynamically-driven, and it could obtain off results of LSDM while the signal is being input.

Figure 10 is a graph showing measured results of the power dissipation rate by comparing the footprint and the efficiency. For the measured result of the average value of power dissipation rate, IC power dissipation (IC Pd) were increased 0.086W, but LED power dissipation (LED Pd) were decreased 12.80W as 63.34W from 76.15W. The total power dissipation (Total Pd) were decreased 4.01W as 2.53W from an average of 6.54W. The result of comparison to the power dissipation rate of control logic obtained effective results of power dissipation reduction and the power dissipation rate of the proposed control logic was reduced by 61.19% when compared with the conventional control logic.



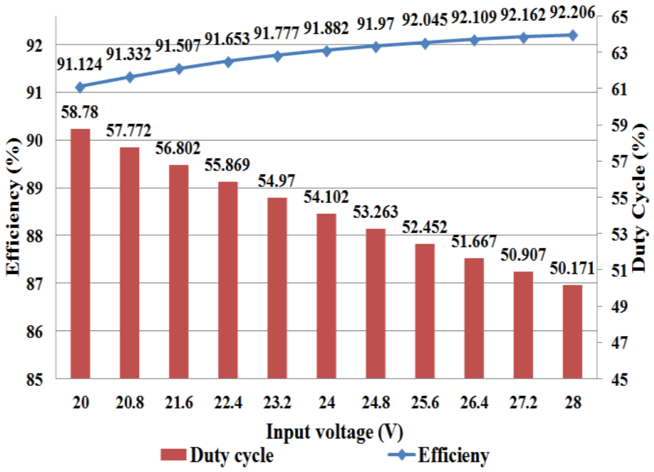
(a) Power dissipation existing lighting control logic



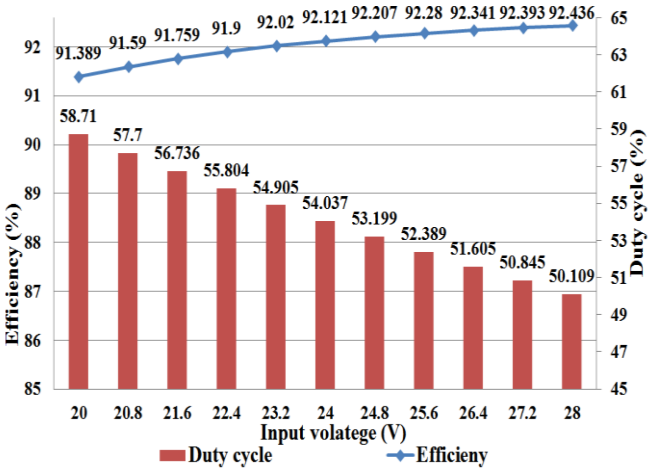
(b) Power dissipation proposed lighting control logic

Fig. 10. Power dissipation

Figure 11 shows the measured results of efficiency and the duty ratio for LSDM operation state by comparing the input voltage when applying the LSDM lighting control algorithm.



(a) Existing lighting control logic



(b) Proposed lighting control logic

Fig. 11. Efficiency and duty cycle

In Figure 11(a), the efficiency of the existing control logic could be obtained at an average efficiency of 91.79% by measured to increasing 1.08% that it measured the 91.124%, when the minimum input power is 20V; and it is measured at 92.206% when the maximum input power is 28V. The duty cycle could obtain an average duty cycle of 54.25% by measured to decreasing 14.64% that it measured the 58.78% when the minimum input power is 20V, and measured at 50.171% when the maximum input power is 28V. In figure 11(b), the efficiency of the proposed control logic was obtained at an average efficiency of 92.03% by measured to increasing 1.14%, it measured at 91.389% when the minimum input power is 20V, and at 92.436% when the maximum input power is 28V. The duty cycle was obtained at an average duty cycle of 54.18% by measured to decreasing 14.65%, it was measured at 58.71% when the minimum input power is 20V, and at 50.109% when the maximum input power is 28V.

Figure 12 shows the comparative results of development costs for efficiency by comparing the area occupied of the existing control logic and the proposed control logic. The BOM (Bill of Materials) cost of the control logic was estimated by the primarily considering efficiency than the area occupied.

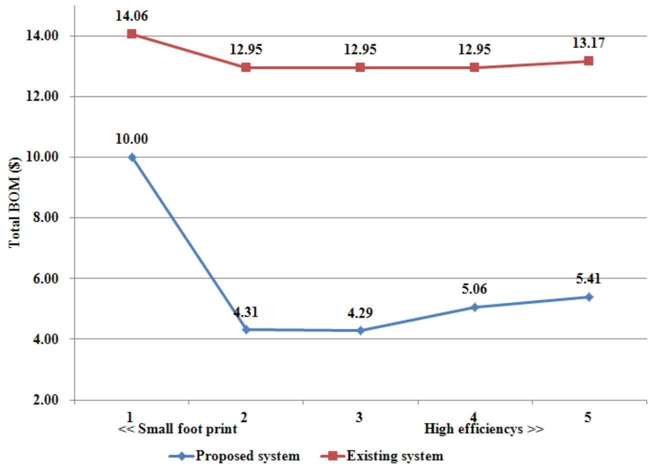


Fig. 12. Total BOM cost of system

IV. Conclusion

In this paper, we proposed an efficient LSDM lighting control logic design for a lighting control system using the LSDM control algorithm. In this paper, a proposed LSDM lighting control logic was measured to power dissipation rate of the control logic on LSDM lighting status, by downloading the LSDM control algorithm into the control logic through serial port. LSDM control algorithm is able to efficiently control the lighting control system by the lighting control signal data value of input and output into LSDM lighting control logic.

As a result of checking the lighting control status, we analyzed the results by measuring the efficiency and the duty ratio for the input power. The efficiency of the proposed LSDM lighting control logic was obtained at an average efficiency of 92.03% by measured to increasing 1.14%. The duty cycle was obtained at an average duty cycle of 54.18% by measured to decreasing 14.65%. As a result, the proposed LSDM lighting control logic was proved to be more effective than the existing control logic for improving the overall efficiency of the lighting control system. The LSDM lighting control logic based on MCU makes it possible to utilize lighting control with real-time monitoring when configuring the sensor network using zigbee communication method.

In the future, LED street lighting control system must be applied to the LSDM lighting control logic to increase the utilization of the proposed LSDM lighting control logic, and more research must be carried out for the establishment of an efficient street lighting management system.

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Sung-IL Hong received B.S and M.S. degrees in sciences and education from Semyung University in 2007 and 2009, respectively. Since August 2009, he enters to the Ph.D course. His current research interests include SoC CAD, ASIC Design, CAD Algorithms, SoC Design, RTOS and Embedded Systems. Now, he studies the lighting control systems and remote control & management system.

Chi-Ho Lin received B.S and M.S. degrees in Engineering from Hanyang University in 1985 and 1987, respectively. He also received Ph.D degree in Engineering from Hanyang University in 1996. Since March 1992, he has been with the school of computer in the semyung university as the professor. His current research interests include SoC CAD, ASIC Design, CAD Algorithms, SoC Design, RTOS and Embedded Systems. Now, he studies the lighting control systems and remote control & management system.