The analysis of power consumption saving by Contents Adaptive Brightness Control driving

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Abstract

In this paper, Contents Adaptive Brightness Control(CABC) driving method is presented. Application of this techique to display panels confirm the driving like the CABC theory. In addition, we discuss the relation between CABC driving and the power consumption saving. As we operated the panel has CABC software program, we got this experimental data. As a result, it was found that power consumption saving effect by CABC driving.

Introduction

IT device market cosists of Smart phone, Tablet, Note, Monitor recently. Especailly, Mobile market such as Smart phone, Tablet has become increasingly saturated. Mobile Set companies establish a various of strategies to make their product differentiation. Among diverse strategies, mobile set companies attaches importance to power consumption saving. The reason why power consumption saving is important for mobile is the characteristic of mobile. Mobile is portable device because of this, power consumption saving is highly significant for portable mobile so that it operates for long time without battery charge. Display module(Panel+Backlight unit)'s power consumption saving is the one of the important factor from the point of view of mobile set. Display module's power consumption saving method is controled by T-con(Timing controller) & TED IC(Timing controller Embedded Driver IC) softwares. There are many T-con or TED IC's sofewares such as PSR(Panel Self Refresh), APS(Advanced Power Saving), sDDRS(Seamless Display Refresh Rate Switch) and CABC(Contents Adaptive Brightness Control). The above softwares can reduce panel logic consumptiom current or BLU(Back Light Unit) consumption current. Explain CABC in detail, T-con or TED IC collects pixel data while display drives. After T-con or Ted IC alalyzes gathering data, T-con or TED IC transmits matching data that is reflected in analysis result to panel and BLU. Therefore, the diaplay module can save power consumption through CABC software. The purpose of this study was to examine the relationship betwween CABC driving and power consumption saving.In this paper, we did experimental work by Tablet Module and eDP T-con. It is founded that the display module can save 0.3W~1.0W by using CABC driving. From our results, we conclude that CABC driving has a effect on power consumption saving. In section 1 we recall CABC driving principle. In sections 2 and 3 we derive the relation between CABC driving and the power consumption saving in icture or Moving video. Section 4 deals with CABC Side effect. In section 5 experimental data and analsis results are discussed.

Materials and Methods & Result

At first, We explain CABC driving principle briefly. CABC is the abbreviation for Contents Adaptive Brightness Control. CABC software gathers panel's pixel data and analyzes it. CABC transmit to panel and BLU the data that CABC analyzes. That is, CABC is power consumption saving through BLU dimming. However, the panel doesn't have visual fault due to BLU dimming. Therefore, CABC transmits to panel image enhancement data. As expaln in deail, CABC block in T-con analyzes orginal screen data(left screen) using histogram. After analyzing the data, CABC selects the mode throgh classified algorithm in CABC. Up to mode, BLU Brightness decreases and panel receives image enhancement & compensation data. Performing rhe above procedure, the processed screen sames as the original screen visually but power consumption declines.

Mobile set transmits EEPROM register value that includes the information about CABC on/off and mode set-up to T-con through AUX(Auxiliary) channel. T-con's CABC performs a received value. CABC transmits pixel's RGB data to panel and BLU PWM vaule to LED driver IC after CABC analyzes panel's RGB data, as shown in Figure 1.

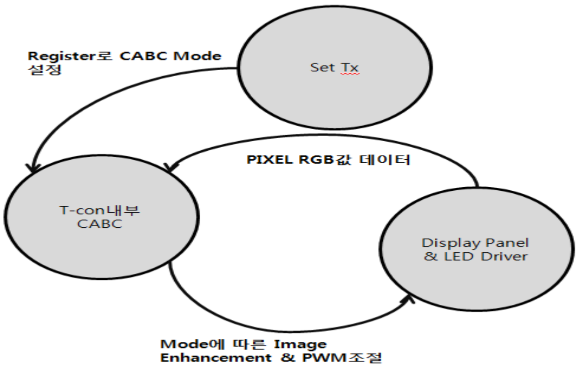


Fig. 1. CABC driving diagrammatic

Table 1 is a sort of CABC mode. CABC mode divides MIE, MANBR, PSBR basically. At first, MIE(Mobile Image Enhancement) mode has four inner mode. MIE mode performs automatic dimming. In this case, Mobile set transmits analysis data(Histogram data) with T-con and then selects what the mode uses. After this connects, Module drives automatically. Second, MANBR(Manual Brightness is fixed dimming through EEPROM data written. Third, PSBR(Photo Sensor Brigtness) is dimming through outer brightness. Fig 1, Fig 2 is MIE Mode's explanation, we obtain this experiment data using MIE.

Type	Dimming Method	Mode(Mode #)	Function
MIE	Auto Dimming	OFF(0)	CABC off
		UI(1)	Visual Quality priority Power Consumption Saving
		STILL(2)	Middle of UI and MOV
		MOV(3)	Power consumption saving priority
MANBR	Manual Dimming		Dimming control by EEROM
PSBR			Using outer brightness by sensor

Table. 1. A sort of CABC Mode

There are four modes in MIE type. Off mode is that we don't use the CABC. UI mode is that Visual quality is prior to power consumption saving. That is, UI conserves the visual quality over minimum dimming. STILL mode is that the middle of UI mode and MOV mode. MOV mode is that power consumption saving priority. Therefore, there is maximum dimming in MOV mode. MOV is mainly used in the movie. The table below is experiment condition, as shown in Table 2. We tested that we had written the EEPROM in T-con to set MIE mode because we didn't have a mobile set.

Module	Tablet Module, PLS, Vin 3.3V, Vbl 12V), 5pcs
T-CON	eDP T-con
Experimental condition	Case 1. Picture(Off Mode versus UI Mode) Case 2. Video(Off Mode versus MOV Mode)

Table. 2. CABC Experimental condition

Case 1 of Experimental condition, we compare OFF Mode with UI Mode in picture.

There are screens of the experiment 1. We choose computer's basic screen, bright screen, dark screen for pixel data compensation and BLU dimming.

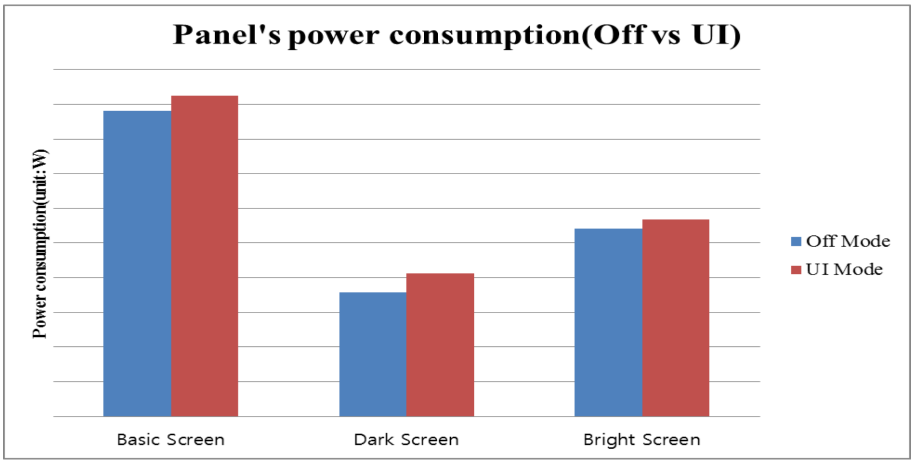


Fig. 2. Compare panel's power consumption (OFF mode verus UI mode)

Figure 2 shows the results of measuring the panel's power consumption when OFF mode and UI mode. Measuring result indicated that UI mode power consumption increased more than 0.009W off mode in basic screen. In case of dark screen, UI mode power consumption increased more than 0.012W OFF mode. Finally, UI mode power consumption increased more than 0.008W OFF mode. In conclusion, the result of experiment 1 suggest that UI mode panel's power consumption increases more than OFF mode because the pixel data is enhanced by BLU dimming.as theory. In additional, we found power consumption increment in dark screen higher 0.004W than power consumption increment in bright screen. Because BLU emits light more dark in dark screen, the pixel data is enhanced to preserve original image screen.

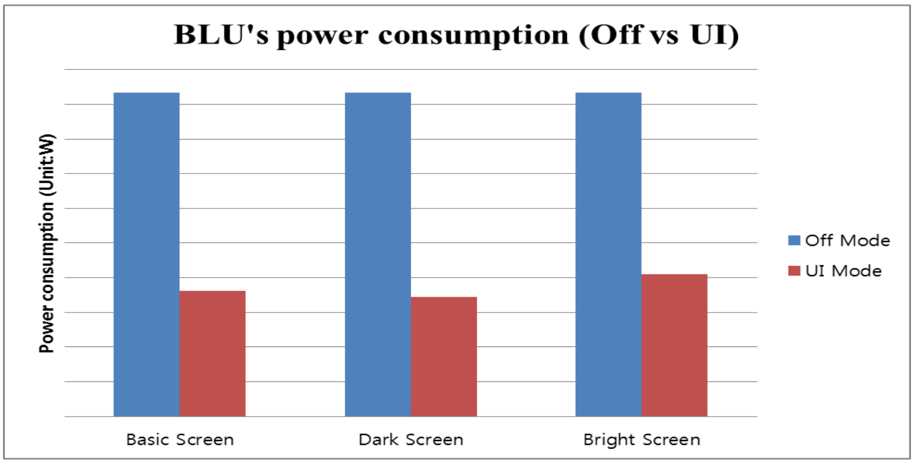
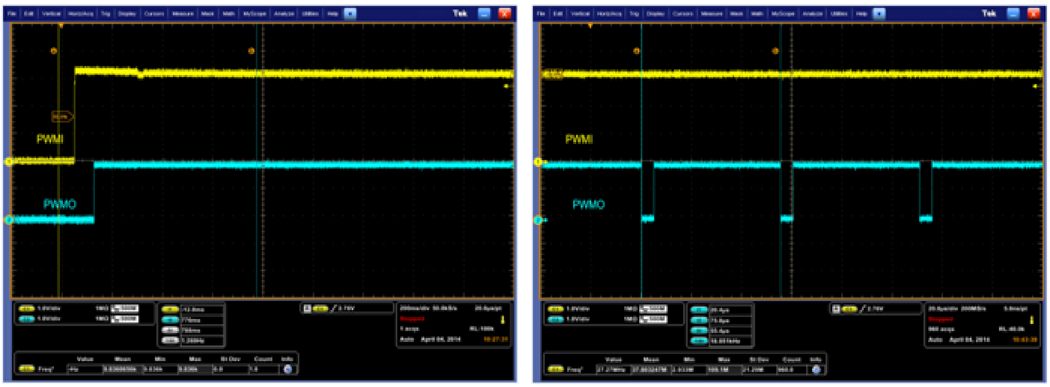


Fig. 3. Compare BLU's power consumption (OFF mode verus UI mode)

Figure 3 shows the results of measuring the BLU's power consumption when OFF mode and UI mode. Measuring result indicated that UI mode power consumption usually decreased more than 0.3W off mode. In addition, BLU's power consumption in dark screen less than in bright screen. That is, this data indicates BLU emits light more dark in dark screen. We confirmed how CABC drives. At first, CABC analyzes panel's pixel data and then transmits the data that control PWM to LED driver. As show in Figure 4, T-con receives PWMI signal (PWM Input data) to Mobile set and T-con sends LED Driver the PWMO (PWM Output data) signal. PWMO signal is different in OFF mode and UI mode. The high signal of PWMO means BLU light on. That is, BLU emits light constantly in case of OFF mode. On the other hand, BLU turns on and off according to PWMO signal frequency in case of UI mode. Therefore, BLU's power consumption can save during turn off. We found how CABC drives and match the theory through measuring result.



< Off Mode >　　　　　　　　　　< UI Mode >

Fig. 4. PWMI and PWMO signal in OFF mode and UI mode

Case 1 of Experimental condition, we compare OFF Mode with MOV Mode in video.
The used video is the Window7 basic video (30 seconds) in this experiment. It consists of dark screen and bright screen.

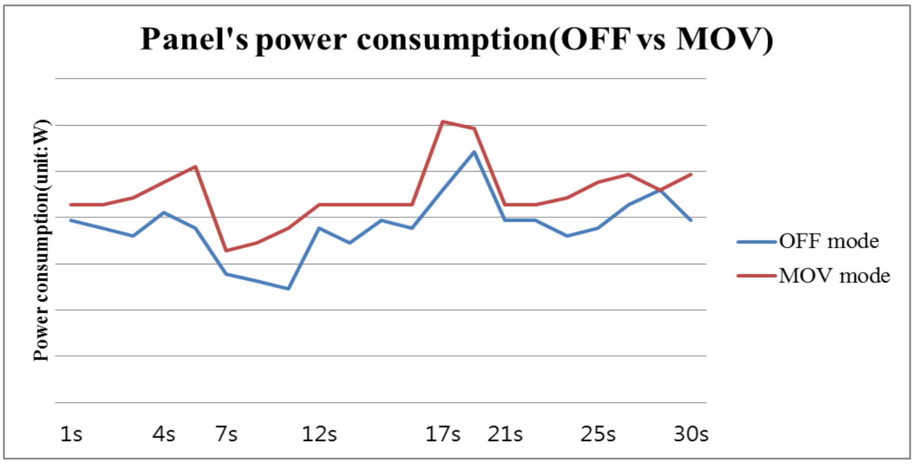


Fig. 5. Compare panel's power consumption (OFF mode verus MOV mode)

The video shows the results of measuring the panel's power consumption when OFF mode and MOV mode. Measuring result indicated that MOV mode power consumption increased more than approximately 0.01W ~0.02 off mode in basic screen. This result is similar to the result of experiment 1. To compensate the pixel data, MOV mode consumes panel's power. Especially, we have to take note on 7~20 seconds screen. The true seal screen (7~11s) almost consist of dark screen. The seagull screen (12~16s) also consist of dark screen. On the other hand, the rat screen is almost composed of bright color. When the screen changes from dark to bright, we found that the MOV mode's variation is more rapidly increase than OFF mode. That is, this data indicates to charge the pixel data to enhance the image.

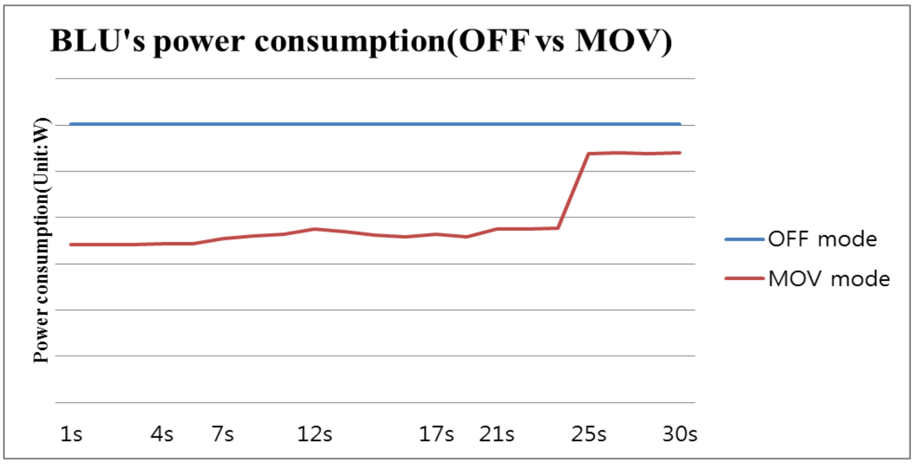


Fig. 6. Compare BLU's power consumption (OFF mode verus MOV mode)

Figure 6 shows the results of measuring the BLU's power consumption when OFF mode and MOV mode. This result is also similar to the result of experiment 1, panel's power consumption increases and BLU's power consumption decreases. However, there is a difference between experiment 1 result and experiment 2 result. MOV mode's BLU power consumption reduce more approximately 0.2~0.9W than UI mode's. That is, we found that UI mode is image quality priority and MOV mode is saving power consumption priority as explained in the theory. We also measured PWMI signal and PWMO signal in MOV mode. As show in figure 7, the period of PWMO high signal in bright screen is longer than them in dark screen. This principle is that CABC analyzes each frame and matches classified screen in CABC IP and then controls the BLU on period.

<7s~11s screen> <21s~23s screen> <24s~30s screen>

Fig. 7. PWMI and PWMO signal in MOV mode

We had measured PWMO signal when video played. As a result, BLU on ratio and power consumption is the proportional relationship, as shown in figure 8. In other words, BLU on period is long to seem bright in bright screen but BLU on period is short to seem dark in dark screen. In conclusion, we found that CABC can save power consumption as BLU on control.

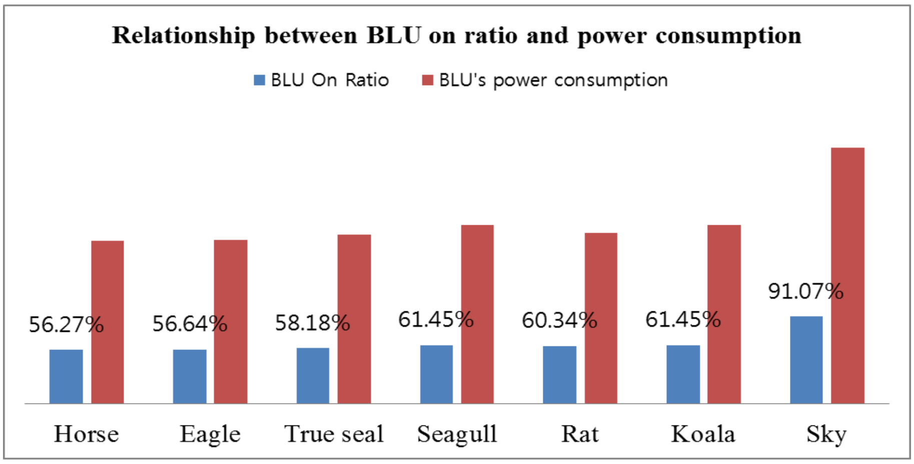


Fig. 8. BLU on ratio and power consumption

Discussion & Conclusion

The purpose of this paper is to measure the power consumption whether CABC turn on or off. Through the data, we want to confirm matching the theory. As a result, first of all we found that the case of CABC on reduces more 0.3 ~ 1.0W than the case of CABC off as explained in the theory. Second, CABC IP in T-con analyzes each frame and then enhances image data and control BLU on period. Third, we found that UI mode is image quality priority and MOV mode is saving power consumption priority. In conclusion, the results obtained show that if we use CABC technology, LCD module can save power consumption and we found how much efficiently power consumption reduces.

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References

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