The Design of IC Driver for AMOLED Display

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Abstract. AMOLED LCD and AMOLED brightness of the device does not require a backlight controlled by the current flowing in the OLED. Therefore, each pixel AMOLED behavior depending on the current-driven power, so the amount of current that can be controlled according to the user's needs is required. This paper examined the AMOLED display IC driver block for design and simulation. An IC driver block was designed and simulation conducted for an AMOLED display which supplies power as selected by users.

Keywords: AMOLED, IC, Driver, IP

1 Introduction

AMOLED possesses excellent qualities of thin structure, vivid color reproduction, light viewing angles, quick response speed, high luminance, and high contrast versus low power usage, for the elements to self-radiate, so requires no back lighting, unlike the LCD.[1]

Since OLED brightness is determined by electric current, and each AMOLED pixel is activated by the current driven method, AMOLED requires power whose current may be adjusted according to the demands of the user.

Accordingly for this paper, an IC driver block was designed and simulation conducted for an AMOLED display which supplies power according to user settings. The IC driver design focused on the regulation of output power, due to the OLED characteristic for diode electric current according to voltage, to be activated by pulse-skipping mode (PSM) under low loads, and 1.5 MHz pulse-width modulation (PWM) for medium/high loads. For output voltage regulation within 1%, for relatively high frequency of 1.5 MHz and efficiency, was designed as a synchronous rectifier type. Mobile applications were considered for achieving true shutdown by limiting current to under 1μA for turn-off. The soft-start and the thermal shutdown functions protect the IC by preventing in-rush current during IC enable.[2][3]
2 The Design and Simulation of IC Driver for Dual Power Management IP

The most important element to be addressed with regard to LED operation of LCD backlighting system is the loss of electric power. Unless this is not kept minimized, the problem of heat generation may weaken the system competitiveness to a large degree. This study aims to design an LED driver that controls the output of the boost converter for the optimization of voltage at both sides of the constant current source for LED string operation, in order to maximize the power consumption efficiency of an LED backlight device.

Figure 1 is a functional block diagram of dual power management IP. Among the functional blocks in Figure 2, the driver block applies to the gate driver and synchronous driver, ringing-killer driver blocks. Step-up converter power switch uses a 5V 0.5Ω CMOS. Synchronous switch uses a 5V 0.8Ω CMOS. Ringing-killer switch uses a 5V 1Ω CMOS. Each switch was designed for non-overlap to prevent shoot-through. The power switch in particular was designed to reduce leading edge current spike by soft switching for turn-on, and hard switching for turn-off.

![Fig. 1. Functional block diagram](image)

2.1 Gate Driver

Dual power management IP has a planned voltage output of 4.9V, with power switch element using a 5V 0.5Ω CMOS. Size of the power switch was designed for a width of 14mm and length of 500nm. To operate a power switch of this size, there must be a gate driver with sufficient sourcing/sinking capacity to allow rise & fall in desired time. Also, to reduce peak currents occurring during switching on the gate driver, a non-overlap circuit was selected. With the block designed for rising time of 10nsec and falling time of 3nsec, in order to reduce the leading edge peak current, turn-on uses soft switching and turn-off uses hard switching. Figure 2 in turn shows
the results of simulation from the circuitry design as shown on Figure 3. The simulation conditions were set for \( V_{in} = 3.7V \), and input pulse rising/falling time = 2nsec.

![Simulation Results](image)

**Fig. 2.** Delay and current waveform measured of power switch driver

### 2.2 Ringing-killer Driver

Ringing oscillations destroy the power switch, or may be the source of EMI increase to surrounding elements. A circuit is necessary to prevent ringing oscillation in correcting these problems. For this purpose, this IC used the ringing-killer block to prevent ringing oscillations. When the current built up on the inductor is delivered through the synchronous rectifier as output power to reach 0A, by making the inductor unit voltage to be 0V, inductor induced ringing oscillations can be prevented. Figure 3 is the block diagram of the ringing-killer driver.

![Block Diagram](image)

**Fig. 3.** Block diagram of ringing-killer driver

The ringing-killer switch used a 5V 2Ω CMOS. The driver unit switch was not large in size, so was activated using the inverter.
Fig. 4 show simulation results from the designed ringing-killer circuit.

![Simulation result of ringing oscillation with ringing-killer driver](image)

**Fig. 4 Simulation result of ringing oscillation with ringing-killer driver**

### 3 Conclusion

In this this paper, an IP driver block was designed and simulation conducted for an AMOLED display which supplies power as selected by users. The IP driver design focused on the regulation of output power, due to the OLED characteristic for diode electric current according to voltage, to be activate by pulse-skipping mode (PSM) under low loads, and 1.5 MHz pulse-width modulation (PWM) for medium/high loads. The IP driver was designed to eliminate ringing effects appearing from the discontinue mode (DCM) of the step-up converter. Ringing effects destroy the power switch within the IC, or increase EMI to the surrounding elements. The IP driver design minimized this through a ringing killer circuit. Mobile applications were considered to enable true shut-down capability by designing the standby current to fall below 1uA for disable.

### References