IDEC Chip Design Contest

Design of Dual-Mode DC-DC Buck Converter with Dead Time Controller for OLED displays

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1. Introduction

- Demand for OLED display in mobile device is rapidly increasing.
- Battery-driven device requires high efficiency.
- Body-diode conduction loss due to dead time reduces power efficiency.

This paper proposes dual-mode DC-DC converter with a dead time controller for OLED display to increase power efficiency.

2. Circuit Design

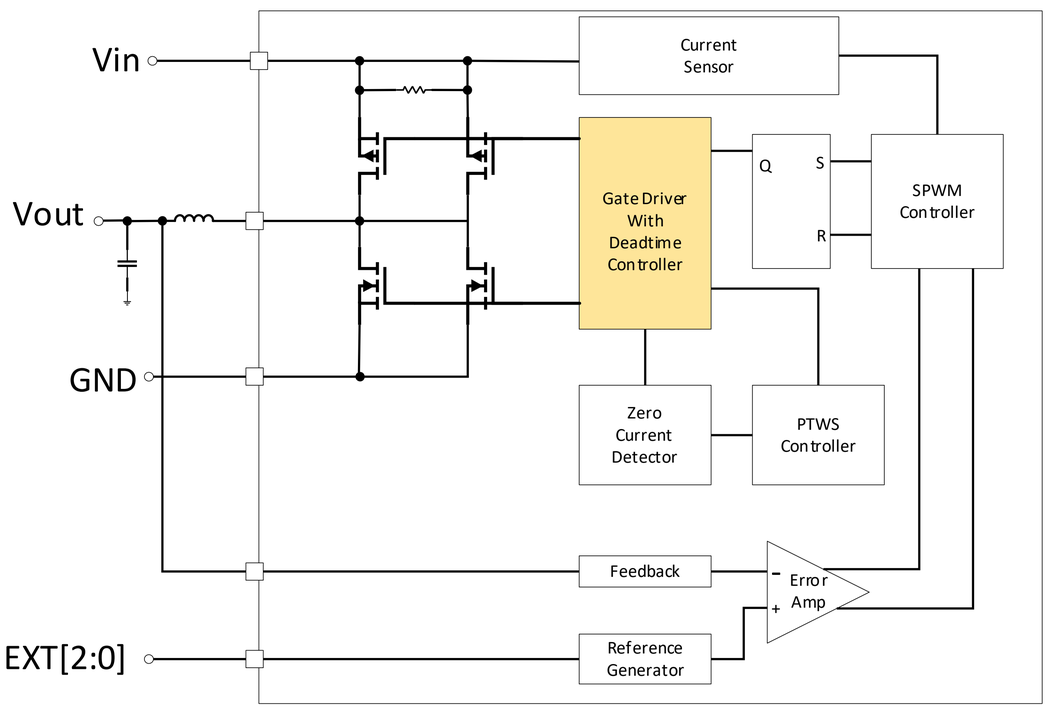

Fig 1. Block diagram of proposed DC-DC buck converter.

Buck converter : SPWM-PWM dual mode, Dead time controller
→ Increase power efficiency.

2.1. Dead time controller

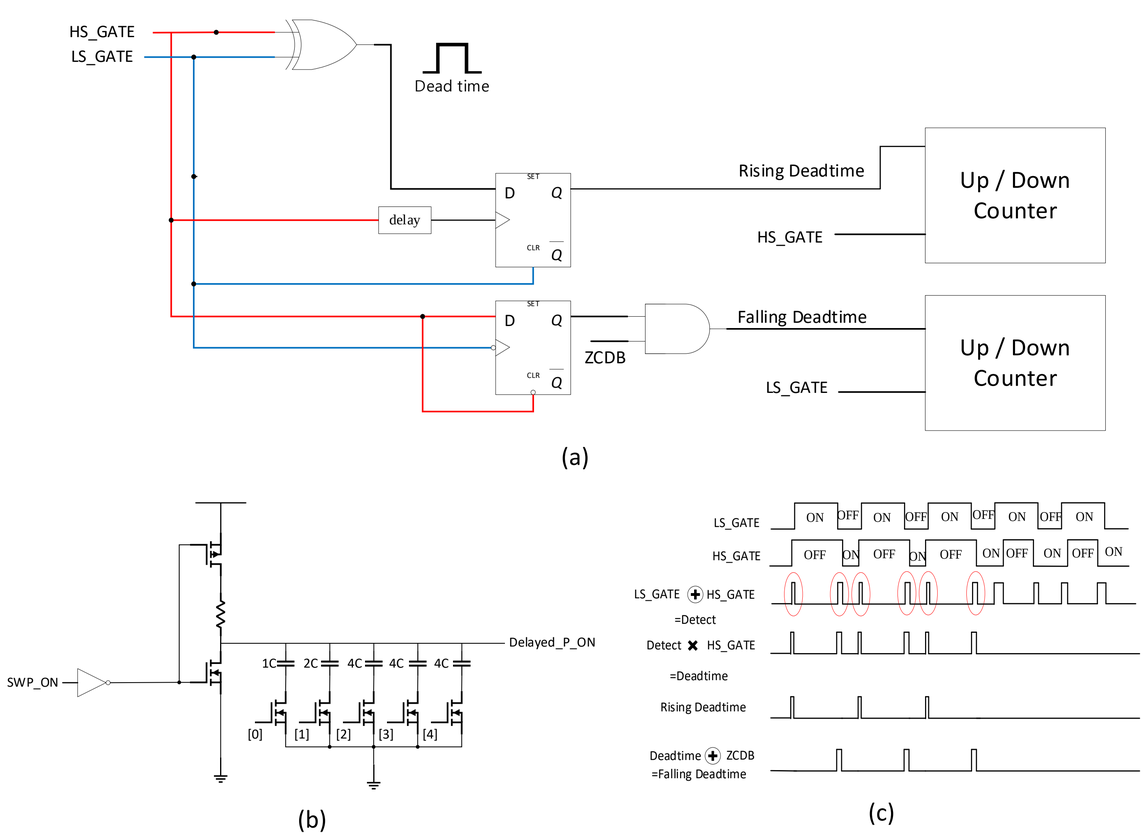

Fig 2. (a) Dead time detector, (b) Delay circuit of dead time controller, (c) operation of dead time controller.

2.2 SPWM-PWM controller

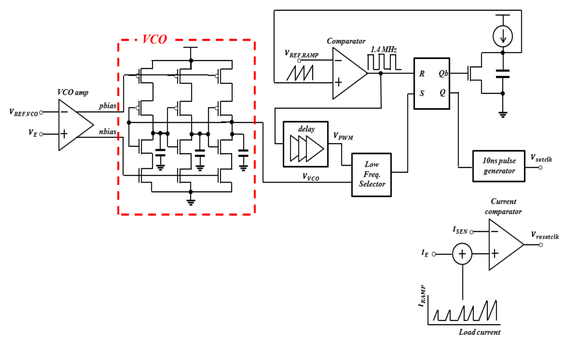

Fig 3. SPWM-PWM controller.

- Light load : set-time variable PWM
  : set-time varies in proportion to load current
- Heavy load : PWM
  : pulse width varies in proportion to load current

- Buck converter is controlled using a SPWM-PWM dual.
- Dead time controller
  - Dead time detector : Generates a pulse if the dead time does not exist.
  - UP/DOWN Counter : Counts the pulse generated by Lx level sensor.
  - Delay Circuit : Changes RC delay by varying capacitance according to delay [3:0].

  → Due to dead time controller, the dead time is optimized less than 2ns and power efficiency was increased by 1.8%.

3. Results

Item	Summary
Process	0.18 µm CMOS
Input voltage	3.3 V ~ 3.7 V
Output voltage	1.8 V
Load Current	5 mA ~ 180 mA
Frequency	0.15 MHz ~ 1.28 MHz
Output ripple	< 5mV
Chip size	0.76 mm X 1.7 mm

Table 1. Summary of proposed DC-DC converter.

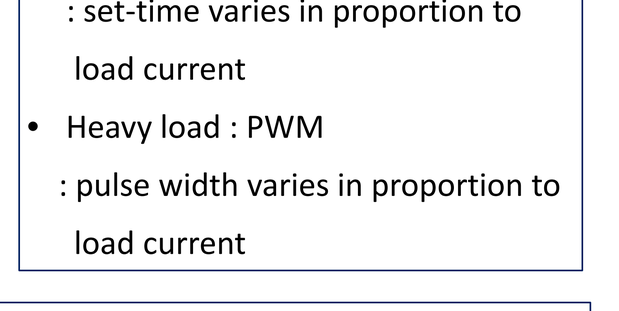

Fig 6. Chip layout.

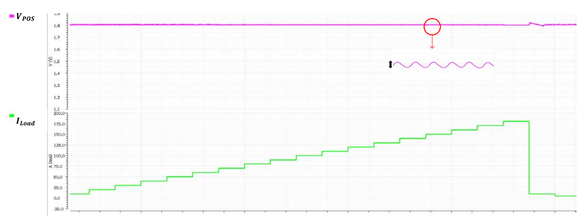

Fig 7. Output voltage with ripple according to load current.

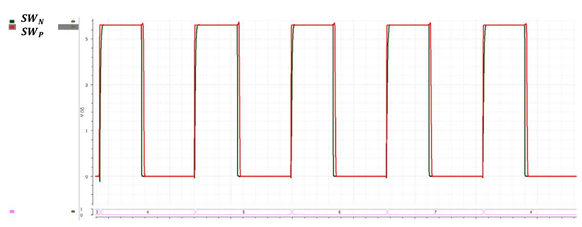

Fig 8. Power transistor switching voltage and dead time.

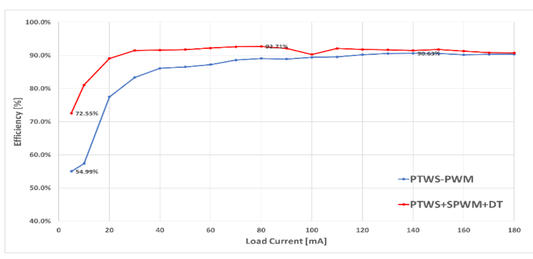

Fig 9. Power Efficiency.

Dead time is reduced less than 2ns both under light load and heavy load due to dead time controller.

@ V_{IN} = 3.3, V_{OUT} = 1.8 V

4. Conclusion

- A DC-DC buck converter for OLED displays was designed - V_{OUT} : 1.8 V
- The dead time controller reduced dead time less than 2 ns.
- Adopting the dead time controller, power efficiency was improved by 1.8%.
- The fabricated chip shows voltage drop due to narrow metal width which connect between chip core and pad, so it works abnormally.
  - This paper includes only simulation results because of above reason.

ISD&T Integrated Systems Design & Test Lab.
Chungbuk National University

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