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June 2015

FAN8841
Dual Half-Bridge Piezoelectric Driver with Step-up DC-DC Converter

Features

Step-up DC-DC Converter

- Integrated Step-up Power Switch up to 36 V
- Wide Operat

Typical Application

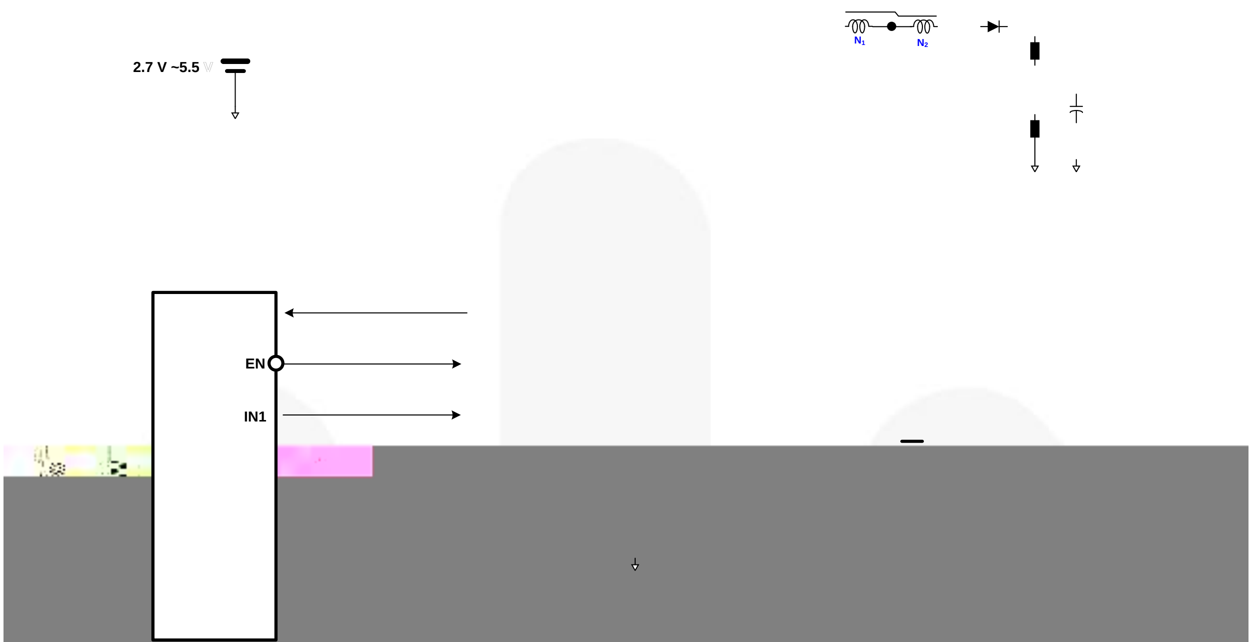

Figure 1. Typical Application Circuit for Piezo Actuator Driver

Block Diagram

Figure 2. Block Diagram

Pin Configuration

Figure 3. Pin Assignment

Pin Definitions

Pin #	Name	Description
1, 2	PGND1	Power Ground 1. It is connected to the source of the step-up switch.
3	V_{DD}	Power supply of step-up DC-DC converter.
4	SGND	Signal Ground. The signal ground for step-up DC-DC converter circuitry.
5	ZCD	The input of the Zero Current Detection
6	FB	Step-up DC-DC converter output voltage feedback input.
7	COMP	Output of the transconductance error amplifier.
8	OCP	Sets Step-up DC-DC converter current limit
9	FO	Fault Output.
10	EN	Enable pin to turn on and off the overall system. (Active Low Shutdown Mode2 284.57 3(t)11(h)

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended.

Electrical Characteristics

V_{DD}=3.0 V, V_{DRV}=60 V, and T_A= -40°C to +125°C. Typical values T_A=25°C, unless otherwise specified.

Symbol	Parameter	Conditions

Electrical Characteristics

V_{DD}=3.0 V, V_{DRV}=60 V, and T_A= -40°C to +125°C. Typical values T_A=25°C, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Current Limit Comparator Section						
I_{OCP}	OCP Trip Current	R_{OCP}=3.3 KΩ, V_{DD}=3.3 V	1.85	2.00	2.15	A
		R_{OCP}=22 KΩ,V_{DD}=3.3 V	0.9	1.0	1.1	A
t_{CS_BLANK}	Comparator Leading-Edge Blanking Time(8)		80	130	180	ns
Step-up Output Control Section						
I_{CON}	Internal Current Source for V_{CON} Pin	T_A=25°C	9.0	10	11	µA
V_{CON+}	Positive Going Threshold Voltage(8)			1.0		V
V_{CON-}	Negative Going Threshold Voltage(8)			0.1		V

Step-up Switch.48 refW52.0

Typical Performance Characteristics

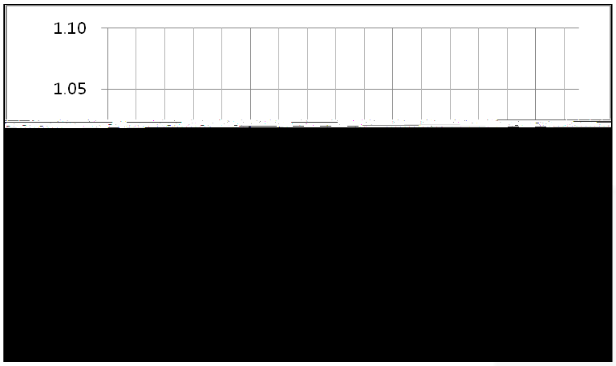

Figure 5. Reference Voltage vs. Temperature

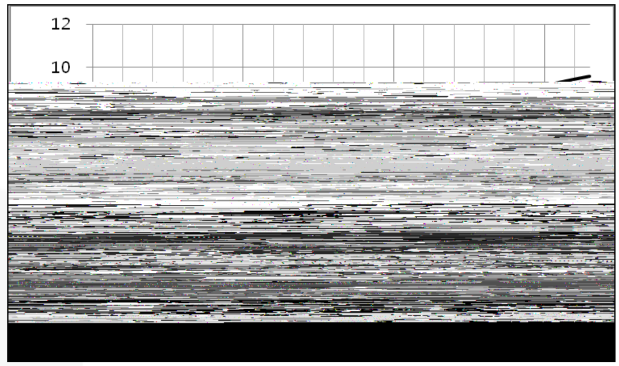

Figure 6. Shutdown Current for V_{DD} & V_{DRV} vs. Temperature

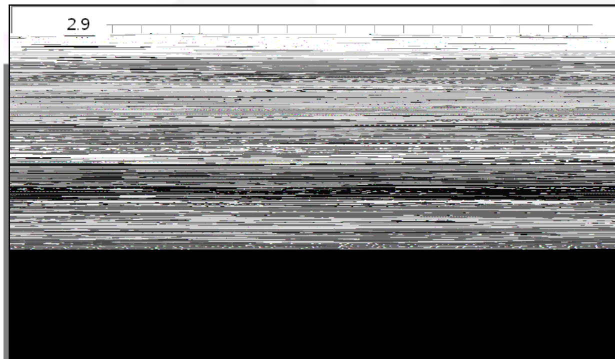

Figure 7. V_{DD} Threshold vs. Temperature

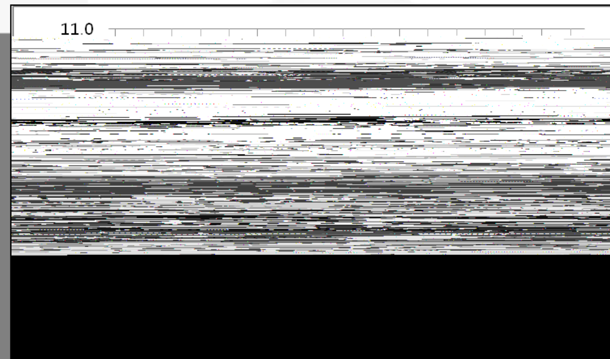

Figure 8. V_{CON} Current vs. Temperature

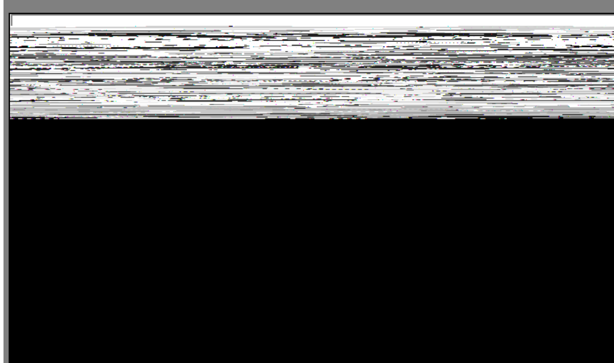

Figure 9. Quiescent Current for V_{DD} & V_{DRV} vs. Temperature

Figure 10. OCP Current vs. Temperature

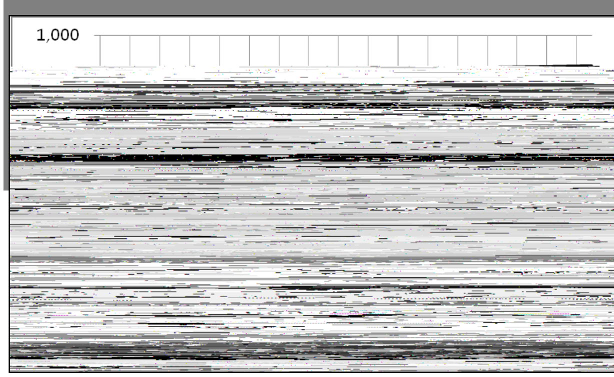

Figure 11. Operating Current for V_{DD}, V_{DRV}, & V_{IN}

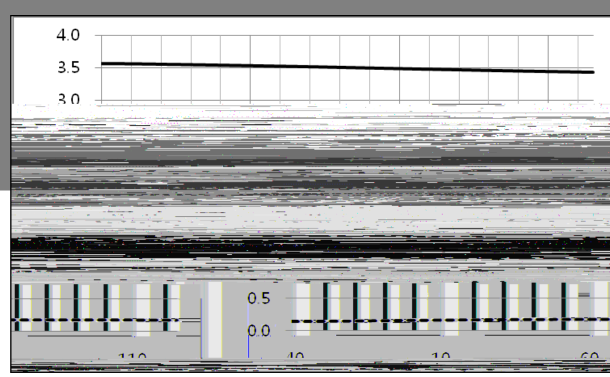

Figure 12. ZDC Clamp Voltage vs. Temperature

vs. Temperature

Typical Performance Characteristics (Continued)

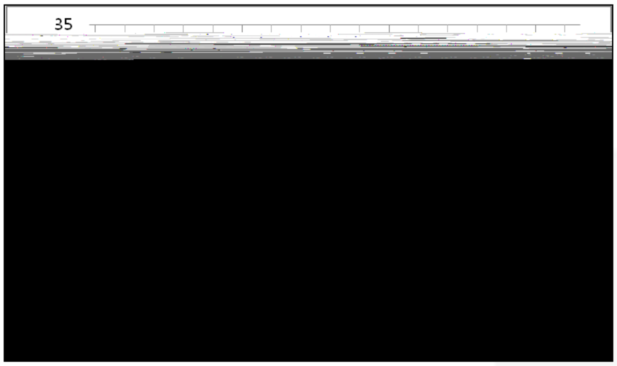

Figure 13. Maximum On-Time vs. Temperature

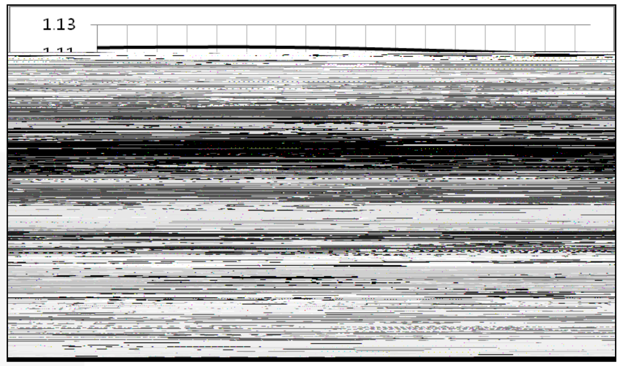

Figure 14. OVP (FB) vs. Temperature

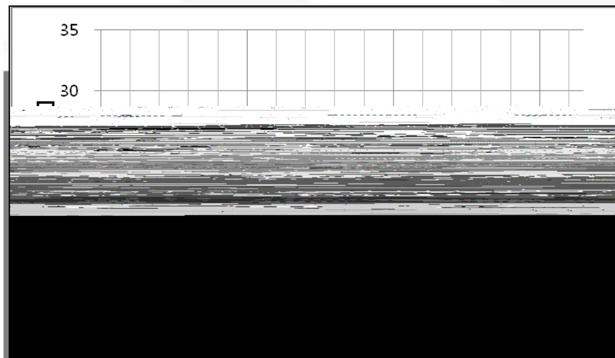

Figure 15. Restart-Time vs. Temperature

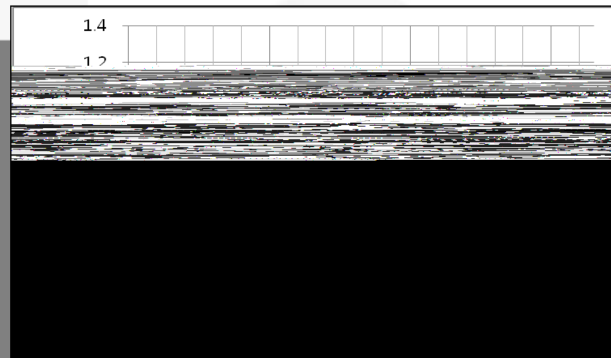

Figure 16. INPUT Threshold vs. Temperature

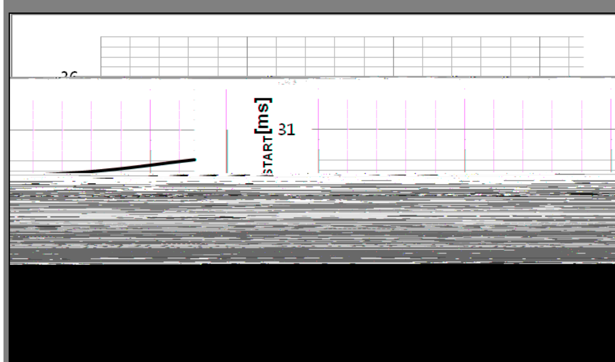

Figure 17. Soft-Start Time vs. Temperature

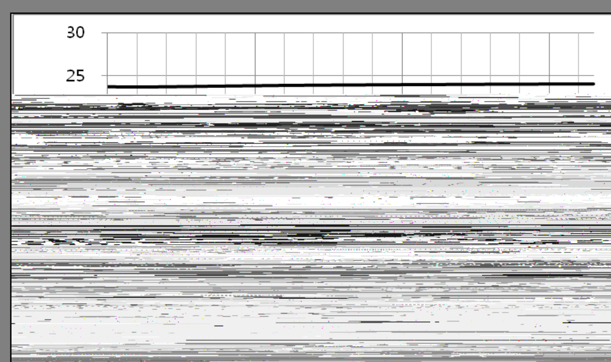

Figure 18. INPUT Logic Current vs. Temperature

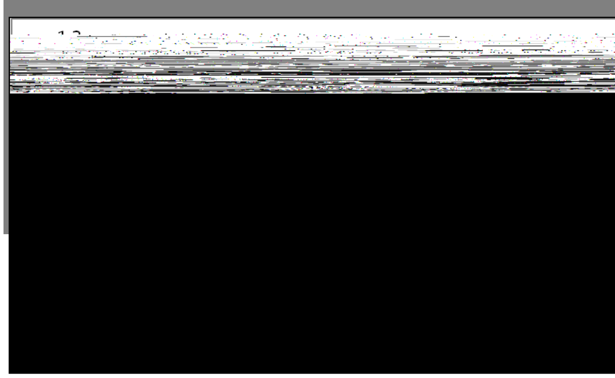

Figure 19. Enable(EN) Threshold Voltage vs. Temperature

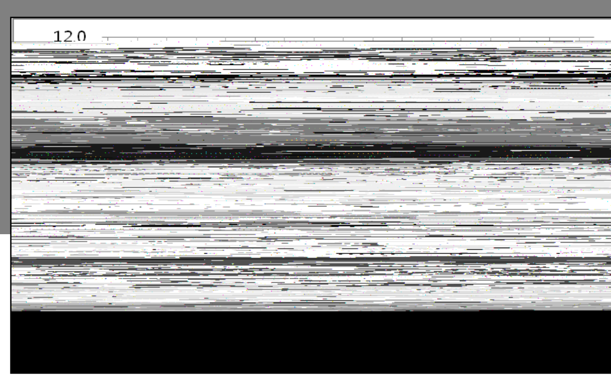

Figure 20. V_{DRV} UVP Threshold Voltage vs. Temperature

Typical Performance Characteristics (Continued)

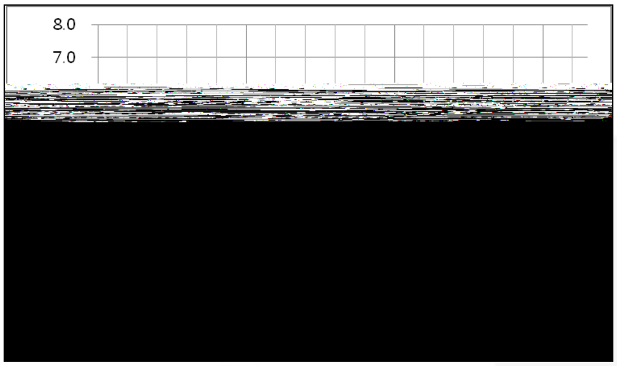

Figure 21. Half-Bridge Switch R_{DSON} vs. Temperature

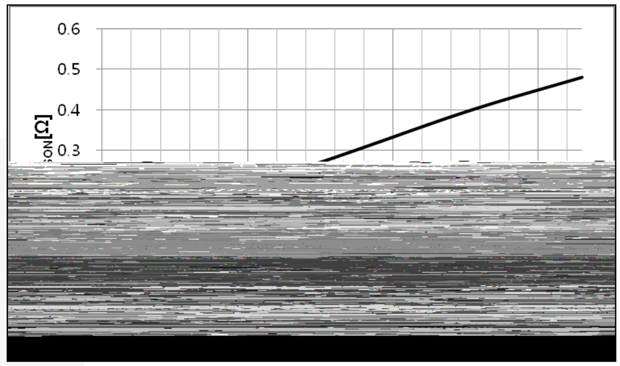

Figure 22. Boost Switch R_{DSON} vs. Temperature

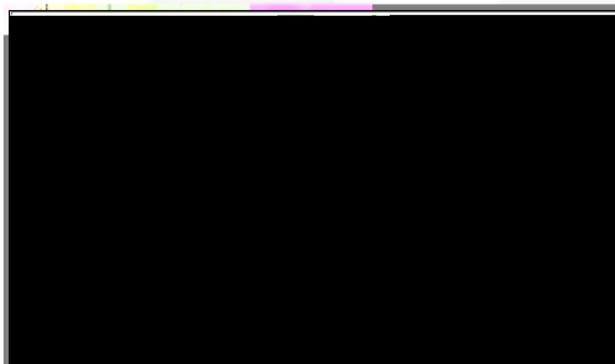

Figure 23. OUT1/2 Delay vs. V_{DRV}

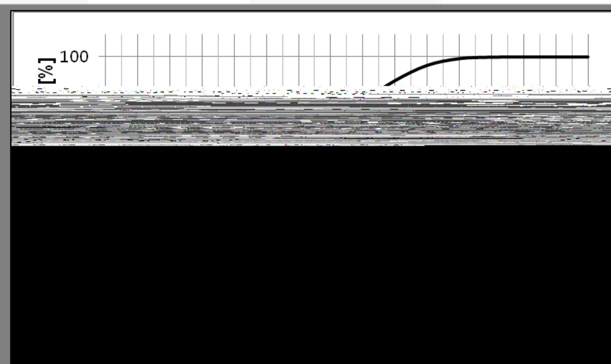

Figure 24. % of OUT Amplitude vs. V_{CON}

Figure 25. I_{OCP} vs. R_{OCP}

Functional Description

The FAN8841 has a basic PWM controller for Step-up DC-DC converter topology in Critical Conduction Mode (CRM) and integrated Dual half–bridge drivers. To increase efficiency of the DC-DC converter, FAN8841 has a Zero Current Detection (ZCD) function for CRM control. It can reduce Step-up DC-DC converter switching loss at MOSFET turn on time. The FAN8841 Step-up DC-DC converter supports output voltage up to 36 V with the use of a commercial inductor since the absolute maximum voltage of internal switching FET V_{DS} is 40 V. If the use requires a driving voltage higher than 36 V, it is recommended to use a coupled inductor, since the internal half-bridge absolute maximum voltage is 75 V.

The device architecture is that of a current mode controller with an internal sensing resistor connected in series with the NMOS switch. The voltage at the feedback pin tracks the output voltage at the cathode of the external Schottky diode. The internal error amplifier amplifies the difference between the feedback voltage and the internal reference voltage. I

V_{DRV} Under-Voltage Protection

The driving voltage of the internal dual Half-bridge is received from the V_{DRV} pin. The internal 5 V LDO for driving the internal gate driver is also received from the V_{DRV} pin. For supplying a stable power to the internal gate driver, V_{DRV} has an under-voltage protection function. If the V_{DRV} voltage is less than 11 V typically, during normal operation, the internal gate driver is turned off. When the V_{DRV} voltage exceeds 12 V typically, the internal gate driver is turned on.

Over-Voltage Protection (OVP)

The FAN8841 features a unique V_{DRV} monitoring to maximize the safety when the feedback voltage is higher than the specified threshold voltage. The OVP comparator shuts down the output drive block when the voltage of the FB pin is higher than 1.1 V.

At the normal operating condition, Fault Out signal maintains on V_{DD} voltage, but the abnormal over-voltage has occurred at V_{DRV}, Fault Out signal goes low during typ. 20 µs.

Application information

Setting the Output Voltage

The internal reference is 1.0 V (Typical) and it controlled by the V_{CON} voltage. The output voltage is divided by the external resistor divider, R_{FB1} and R_{FB2} to the FB pin. The output voltage is given by:

$$V_{DRV} = V_{REF}\left(1 + \frac{R_{FB1}}{R_{FB2}}\right) \quad (2)$$

Figure 27. Feedback Circuit

Inductor Selection

To prevent the absolute maximum voltage in the operating condition, the switching voltage V_{LX} should be lower than 36 V, as shown in Figure 28.

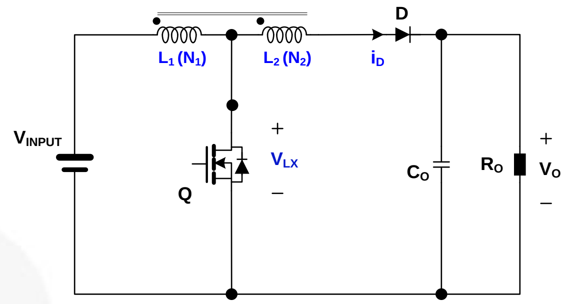

Figure 28. Schematic of Coupled Inductor Boost Converter

V_{LX} is determined by the output voltage, input voltage and coupled inductor turn ratio. The V_{LX} voltage is calculated as follows:

$$V_{LX} = V_{INPUT} + \frac{V_O - V_{INPUT}}{n + 1} = \frac{V_O + nV_{INPUT}}{n + 1} \quad (3)$$

Therefore, the turn's ratio can be easily obtained as the following equations:

$$n = \frac{V_O - V_{LX}}{V_{LX} - V_{INPUT}} \quad (4)$$

To determine the turn's ratio, the input voltage variation has to be considered as well.

The inductor parameters are directly related to the device performance, saturation current and DC resistance. The lower the DC resistance, the higher efficiency. Usually a trade-off between inductor size, cost and overall efficiency is needed to make the optimum choice.

The inductor saturation current should be rated around 2 A at maximum power in the FAN8841. If to use a low saturation current inductor under 2 A due to inductor size, it is possible using the OCP level control.

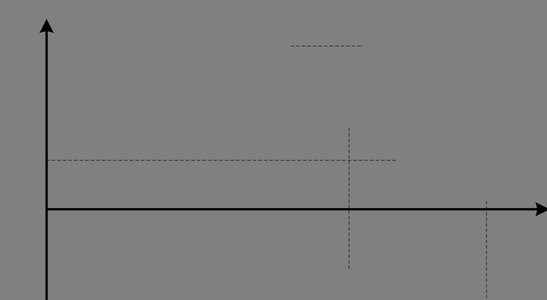

Figure 29. Current Waveform

In CRM operation, the inductance can be obtained from the slope of the inductor current, as shown in Figure 29. During FET turn off period, the inductor current flows through the diode. The diode peak current is expressed as follows:

$$I_{D,PK} = \frac{2I_{OUT}}{1 - d} \quad (5)$$

And then, the peak current of the main switch is obtained as follows:

$$I_{PK} \quad \frac{2I_{OUT}(1 \quad n)}{1 \quad d}, \text{ or } I_{PK} \quad \frac{V_{INPUT}}{L_1} dT_S \tag{6}$$

The inductance value obtained as follows:

$$L_1 \quad \frac{V_{INPUT}\, dT_S}{I_{PK}} \quad \frac{V_{INPUT}\, d(1 \quad d)T_S}{2I_{OUT}(1 \quad n)} \tag{7}$$

If a user wants a commercial inductor at output voltage under 35 V condition, n(turns ratio at using coupled inductor) should be substituted the value zero, (turns ratio at using coupled inductor).

Output Capacitor Selection

The value of the output capacitor can be selected based on the output voltage ripple requirements. Without consideration of the effect of Equivalent Series Resistance (ESR) as output capacitors, the output voltage ripple in a peak-to-peak manner is obtained as follows:

$$_{ripple\,pp} \quad \frac{\quad {}_{OUT} \quad {}_{S}}{C_O} \tag{8}$$

where $V_{ripple,pp}$ is the output voltage ripple in peak-to-peak manner. Therefore, the output capacitance can be selected with the given output voltages ripple specification as follows:

$$C_O \quad \frac{2d \quad \frac{(1 \quad d)^2}{2} \quad I_{OUT} \quad T_S}{2V_{ripple,pp}} \tag{9}$$

Diode Selection

The external diode used for the rectification is usually a Schottky diode. It's average forward current and reverse voltage maximum ratings should exceed the load current and the voltage at the output of the converter respectively.

A care should be taken to avoid any short circuit of V_{OUT} to GND, even with the IC disabled, since the diode can be instantly damaged by the excessive current.