LV56351HA

DC/DC Boost converter for BS/CS antennas

Application Note Ver.2.0

ON Semiconductor®

http://onsemi.com

1. Overview

LV56351HA integrates 1ch DC/DC boost converter and 1ch LDO. It is suitable as the power supply for BS/CS antennas of LCD/PDP TV and BD recorders that require automatic recovery without IC destruction and malfunction when the output is short-circuited.

2. Function

DC/DC boost converter

- Soft-start time: 2.8ms
- Frequency 425kHz operation
- Pulse by pulse over-current limiter
- Short circuit protector

LDO

- Over-current limiter (Fold back)

ALL

- Under-voltage lockout
- Thermal shut-down protector
- Power good

3. Block diagram and Application circuit

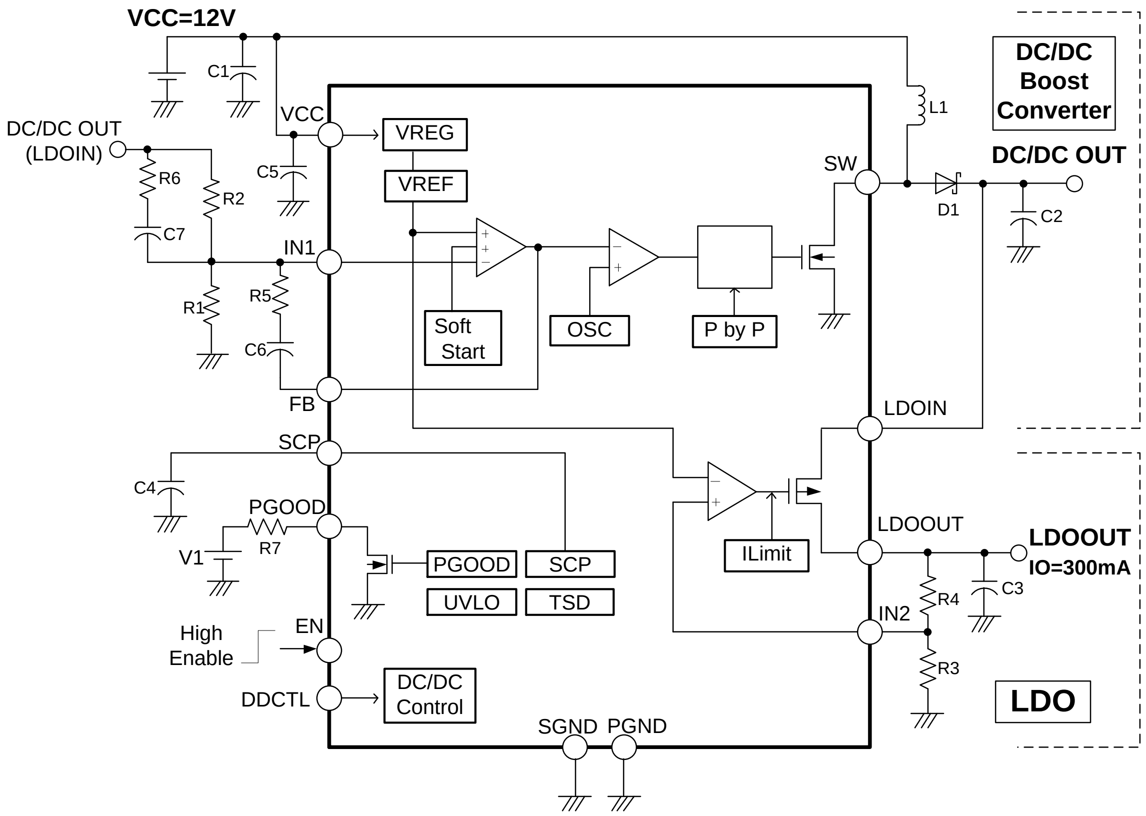


Figure 1: Block diagram and Application circuit

4. Evaluation Board

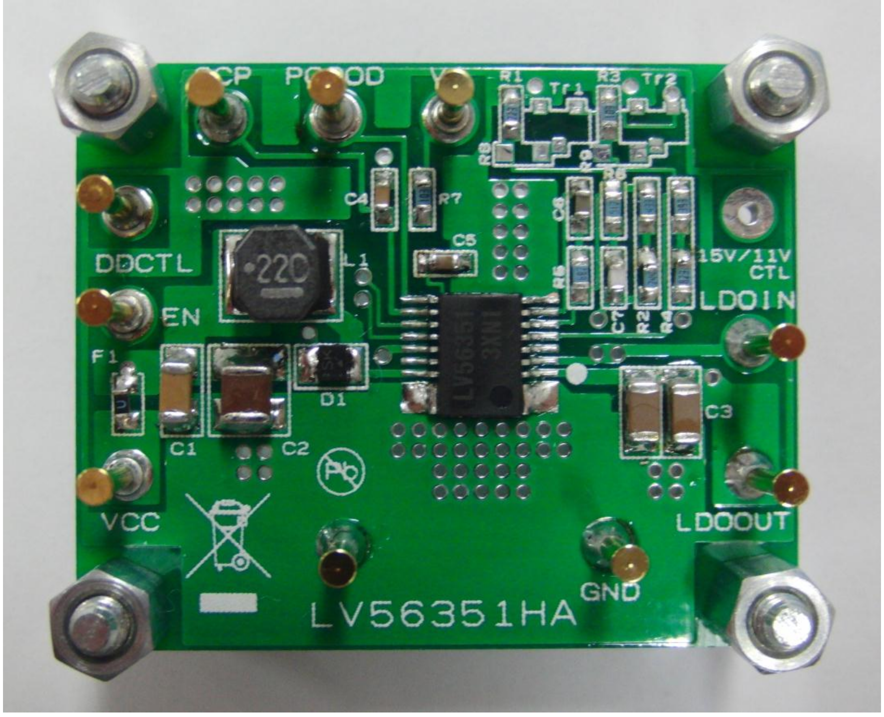


Figure 2: Evaluation Board

4.1 Performance summary

VCC input	12V
LDOOUT output	16.5V
Oscillation Frequency	425kHz
EN input	High(2V): IC ON Low(0V): IC OFF
V1 input	2V
DDCTL state *	Open or Low(0V)

*About DDCTL: When DDCTL pin is Open or Low, Evaluation Board operates normally. If DDCTL pin is high, DC-DC converter operation is compulsorily stopped and only LDO operates. When DDCTL becomes Open or Low from High, LDO stops temporarily and DC-DC boost converter starts with soft start and then LDO restart.

4.2 Schematic

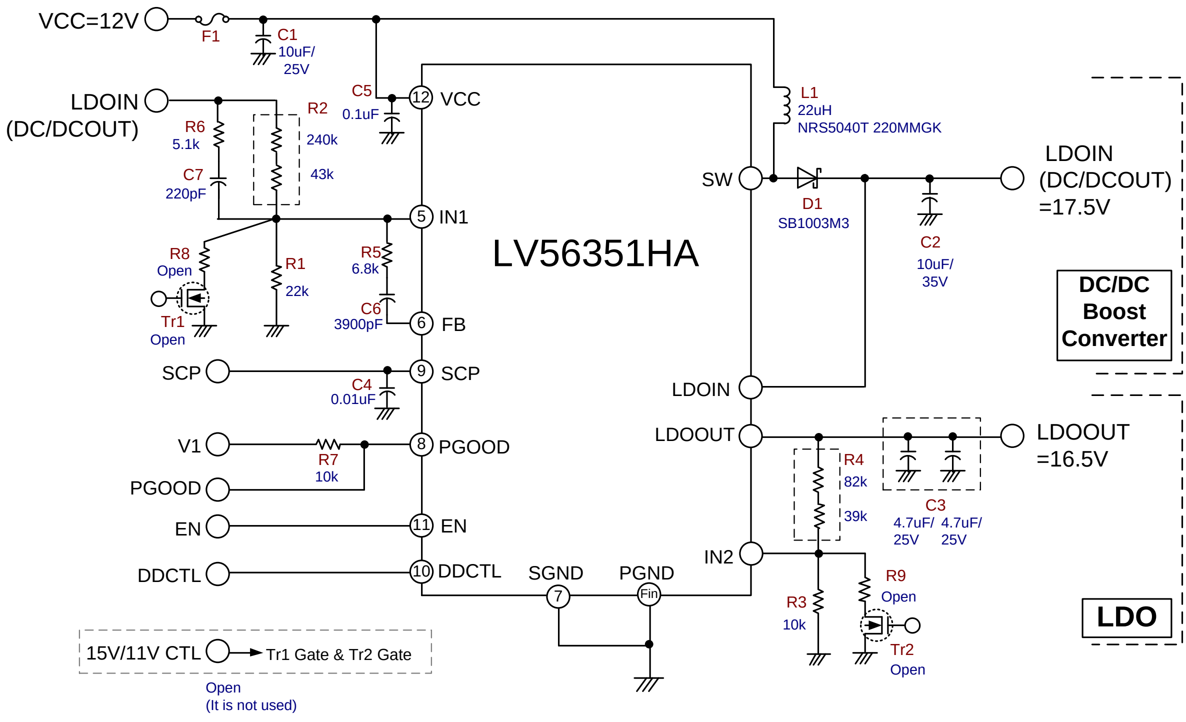


Figure 3: Schematic of Evaluation Board

4.3 Bill of Materials

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number
C1	1	Capacitor,Ceramic,B	10uF/25V	10%	1206	MURATA	GRM31CB31E106K
C2	1	Capacitor,Ceramic,X7R	10uF/35V	10%	1210	MURATA	GRM32ER7YA106K
C3	2	Capacitor,Ceramic,B	4.7uF/25V	10%	1206	MURATA	GRM31CB31E475K
C4	1	Capacitor,Ceramic,B	0.01uF/50V	10%	0603	MURATA	GRM188B11H103K
C5	1	Capacitor,Ceramic,B	0.1uF/50V	10%	0603	MURATA	GRM188B31H104K
C6	1	Capacitor,Ceramic,SL	3900p/50V	5%	0603	MURATA	GRM1881X1H392JA01J
C7	1	Capacitor,Ceramic,CH	220pF/50V	5%	0603	MURATA	GRM1882C1H221J
D1	1	Diode,Schottky	30V/1A	-	MCPH3	ON Semiconductor	SB1003M3
F1	1	Fuse Resistor	3.15A	-	0603	KOA	TF16AT3.15TBK
L1	1	Power Inductor	22uH	20%	4.9x4.9	TAIYO YUDEN	NRS5040T 220MMGK
R1	1	Chip Resistor	22k	1%	0603	KOA	RK73H1JTTD223
R2	1	Chip Resistor	240k	1%	0603	KOA	RK73H1JTTD244
	1	Chip Resistor	43k	1%	0603	KOA	RK73H1JTTD433
R3	1	Chip Resistor	10k	1%	0603	KOA	RK73H1JTTD103
R4	1	Chip Resistor	82k	1%	0603	KOA	RK73H1JTTD823
	1	Chip Resistor	39k	1%	0603	KOA	RK73H1JTTD393
R5	1	Chip Resistor	6.8k	1%	0603	KOA	RK73H1JTTD682
R6	1	Chip Resistor	5.1k	1%	0603	KOA	RK73H1JTTD512
R7	1	Chip Resistor	10k	1%	0603	KOA	RK73H1JTTD103
R8	-	DNP	DNP	-	-	-	DNP
R9	-	DNP	DNP	-	-	-	DNP
U1	1	DCDC and LDO Driver	-	-	HSSOP-14	ON Semiconductor	LV56351HA
Tr1	-	DNP	DNP	-	-	-	DNP
Tr2	-	DNP	DNP	-	-	-	DNP

4.4 Test Procedure

Suggested equipment:

- Current limited DC Power Supply (e.g. ADVANTEST R6243 DC Voltage Current Source/Monitor) ···· 2pcs
- Digital Multimeter (e.g. ADVANTEST R6452 Digital Multimeter) ············ 2pcs
- Multifunction Generator (e.g. NF WF1974) ············ 1pc
- Electronic Load (e.g. FUJITSU ACCESS LIMITED Electric Load EUL-150αXL) ············ 1pc
- Oscilloscope (e.g. LeCroy WaveRunner) ············ 1pc

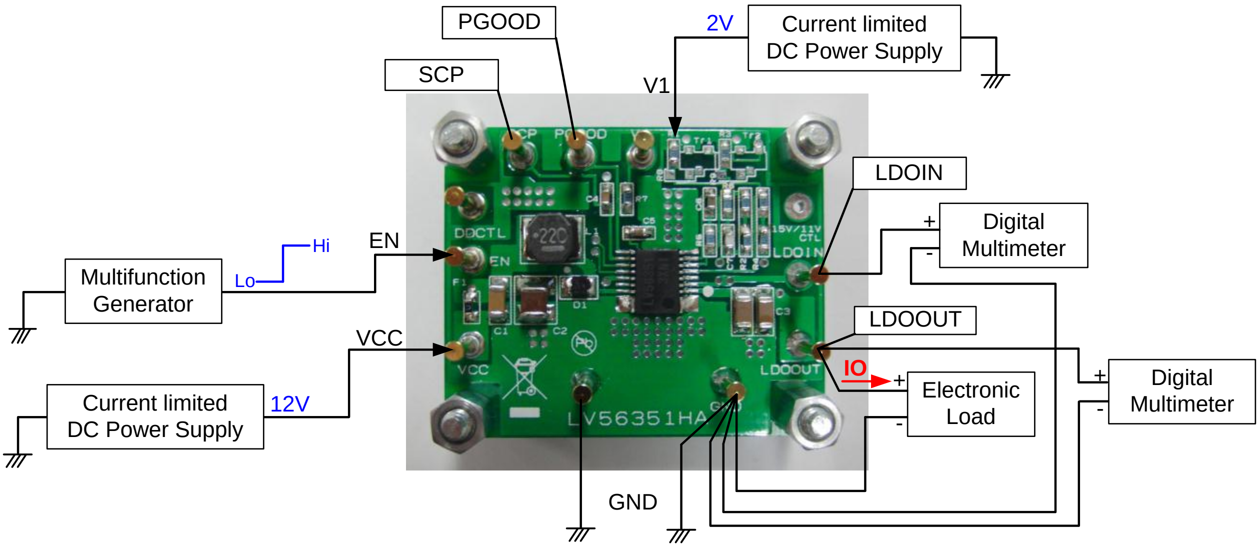


Figure 4: Test setup

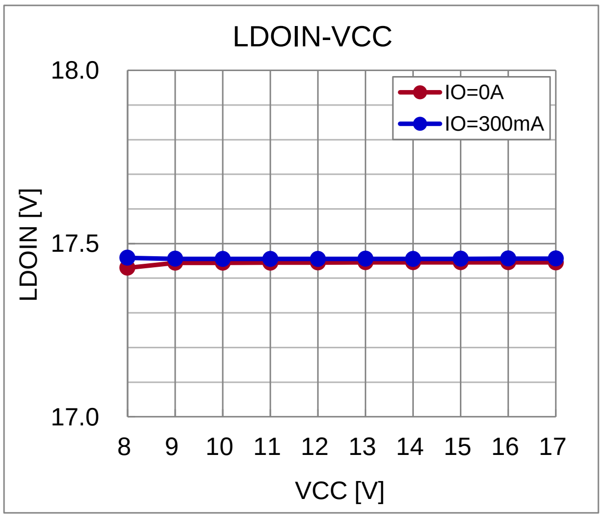
Procedure:

(1) Connect the test setup as shown in Figure 4
(2) Apply 12Vdc to VCC.
(3) Apply 2Vdc to V1.
(4) Apply Low level (0V) signal to EN.
(5) Check that LDOIN=0[V] and LDOOUT=0[V].
(6) Apply IO(load)=0[A] to LDOOUT.
(7) Apply High level (2V) signal to EN.
(8) Check that LDOIN=17.5[V] and LDOOUT=16.5[V]
(9) Set IO to desired level, 0[mA] – 300[mA], and measure LDOOUT voltage and LDOIN voltage.
(10) Apply Low level signal to EN.
(11) Turn off IO(load).
(12) Turn off VCC, V1, and EN.

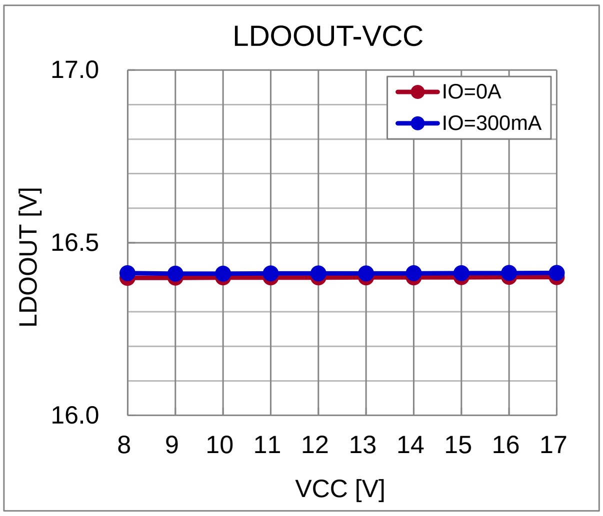
4.5 Reference data (Ta=25˚C, VCC=12V, V1=2V)

• Line Regulation (Load from LDOOUT)

LDOIN (DC-DC boost converter output)

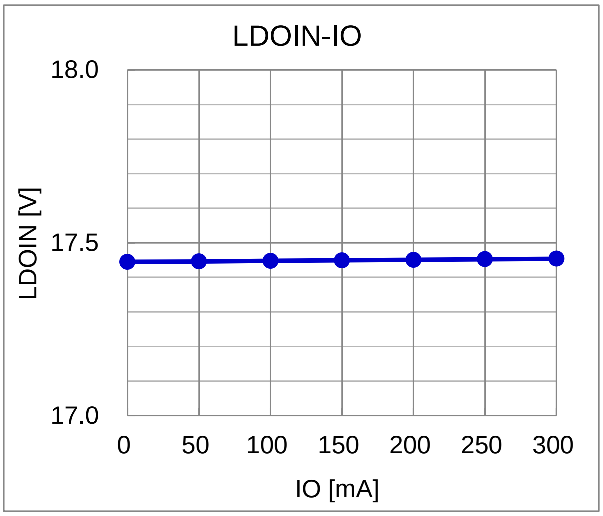


LDOOUT

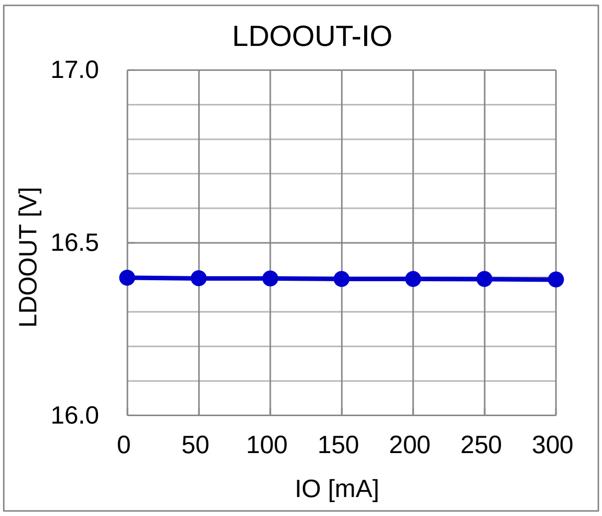


• Load Regulation (Load from LDOOUT)

LDOIN (DC-DC boost converter output)

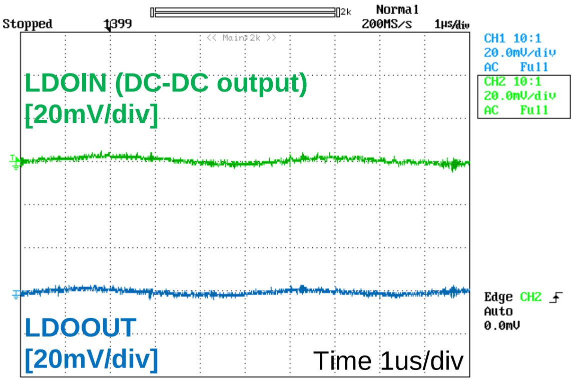


LDOOUT

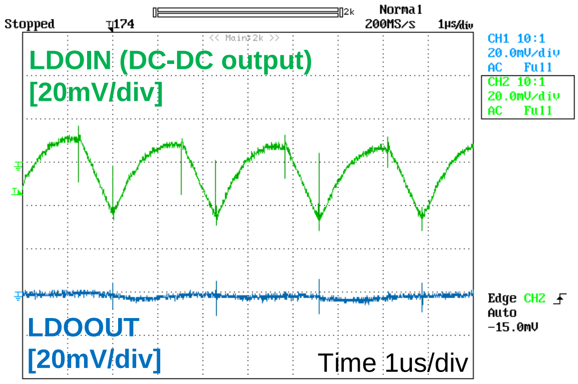


• Output waveform

IO=0A(LDOOUT load)



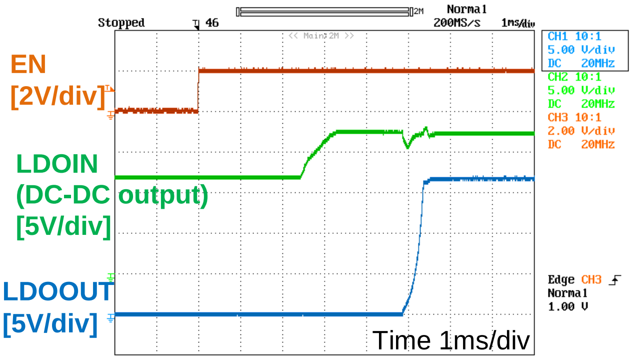
IO=270mA(LDOOUT load)



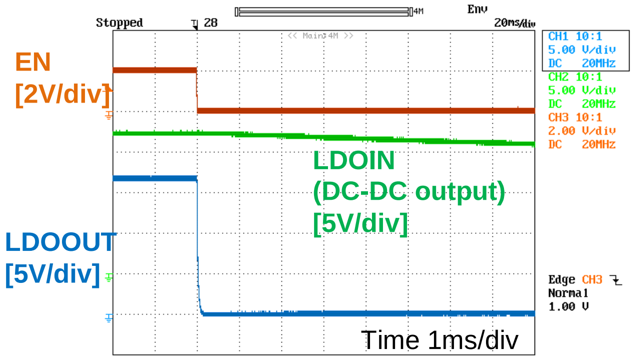
• Start-up and Stop waveform

VCC=12V, IO=270mA(LDOOUT load)

Start-up

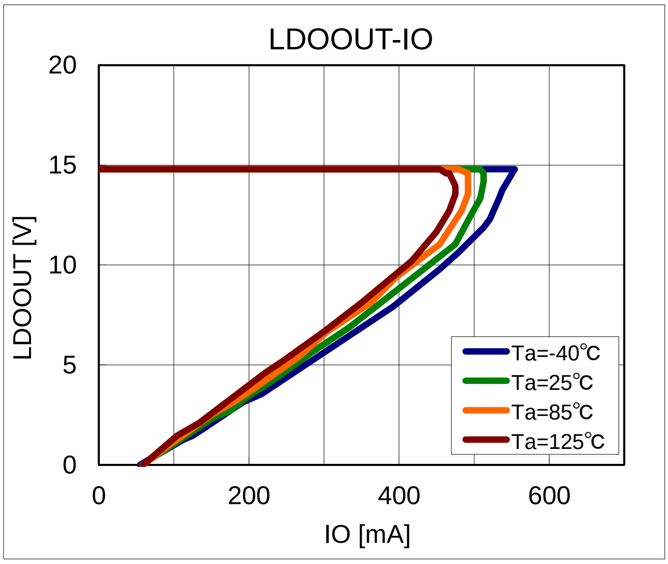


Stop



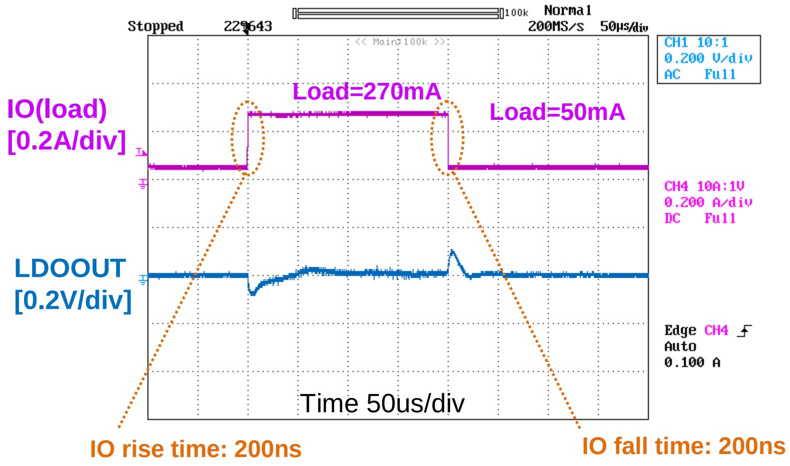
• LDO current limit operation

[Output setting: LDOIN=16V, LDOOUT=15V]

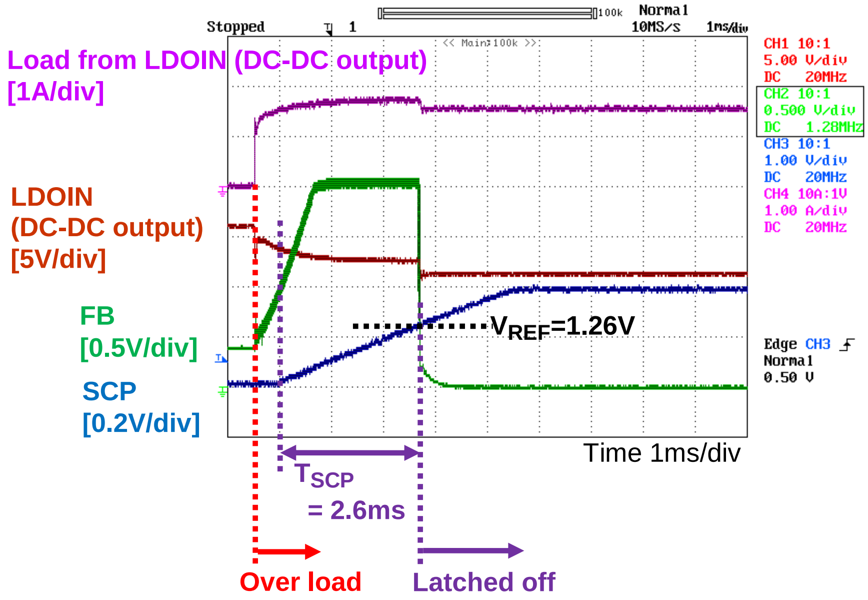


- Load transient response (Load from LDOOUT)

LDOOUT load =50mA↔270mA

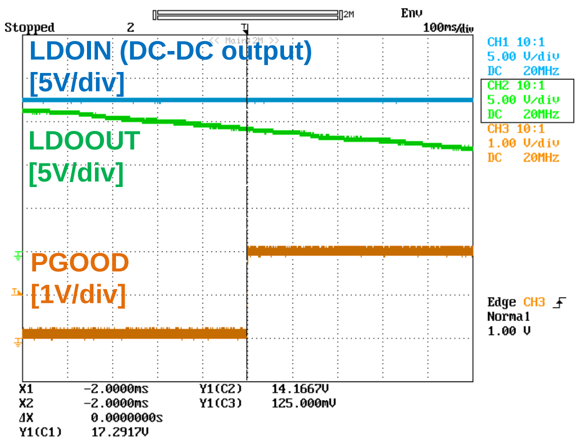


- Short Circuit Protection (SCP) (Over load from LDOIN (DC-DC output))

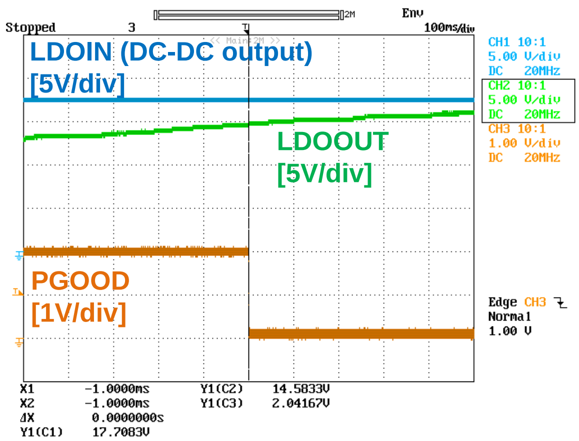


- PGOOD operation

PGOOD→ High (Output fault)

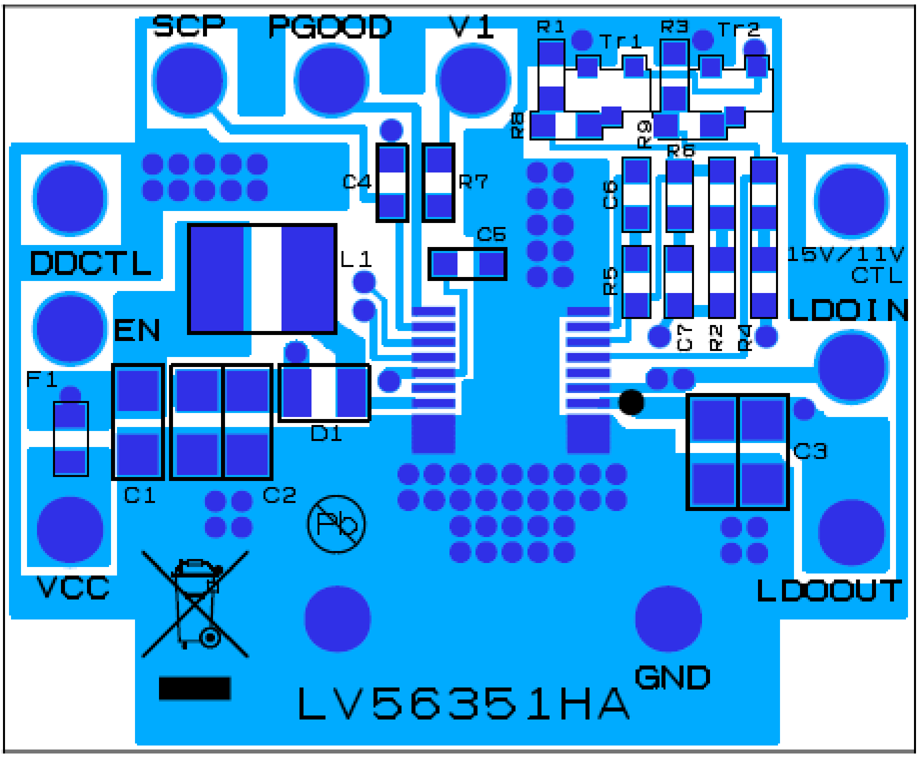


PGOOD→ Low (Output good)

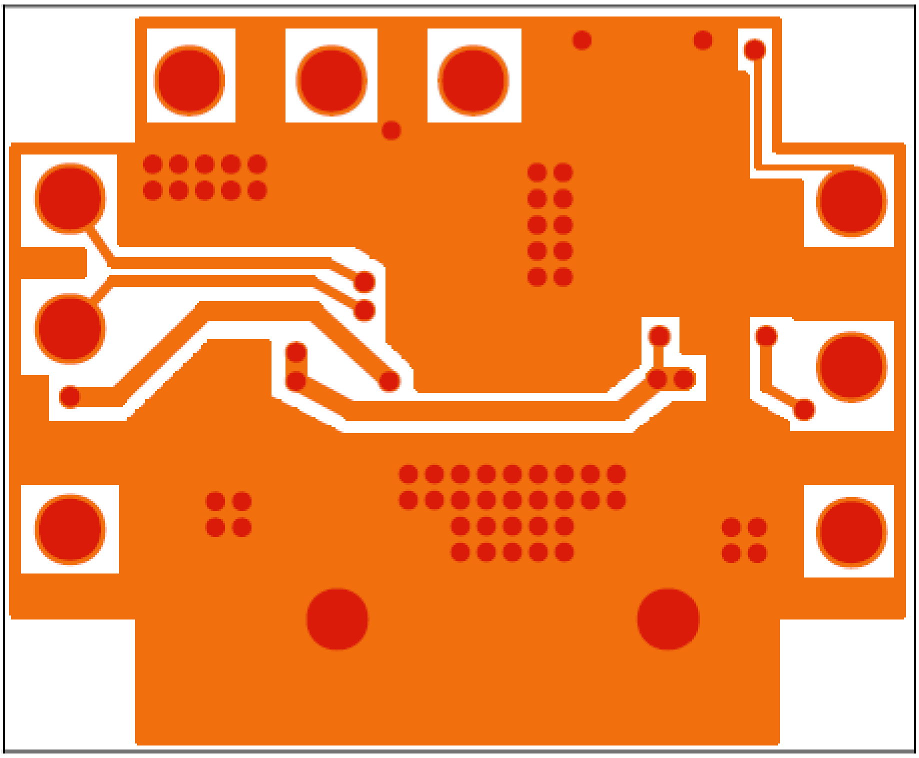


4.6 Board Layout

• Top-Side



• Bottom-Side



Board size: 63.0mm×38.5mm

5. Detailed description

5.1 Output voltage setting

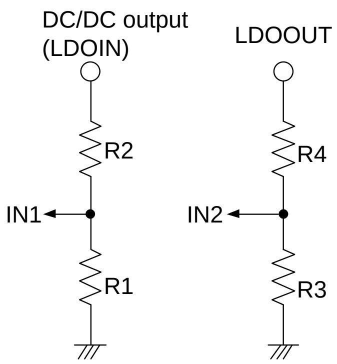
"DC/DC boost converter output (LDOIN)" and "LDOOUT" are given by the following expressions.

$$LDOIN = \left(\frac{R1+R2}{R1}\right) \times V_{REF}$$

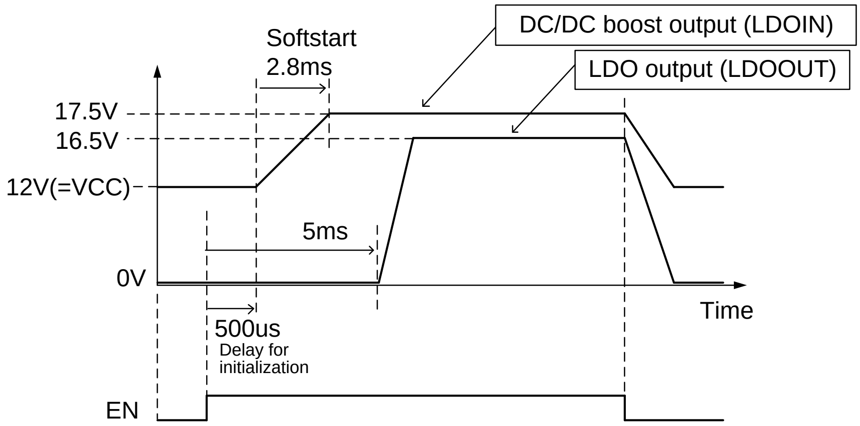
$$LDOOUT = \left(\frac{R3+R4}{R3}\right) \times V_{REF}$$

where,

$V_{REF} = 1.26\ V\ (typical)$



5.2 Start-up and Stop Diagram



5.2 Short Circuit Protection (SCP) time setting

When the output voltage of DC/DC boost converter decreases due to short circuit; for example, SCP function latches off the outputs of DC/DC and LDO by timer.

To define SCP time (T_{SCP}), you need to calculate a value of SCP capacitor (C4) using the following formula.

$$T_{SCP} = \frac{C4 \times V_{REF}}{I_{SCP}}$$

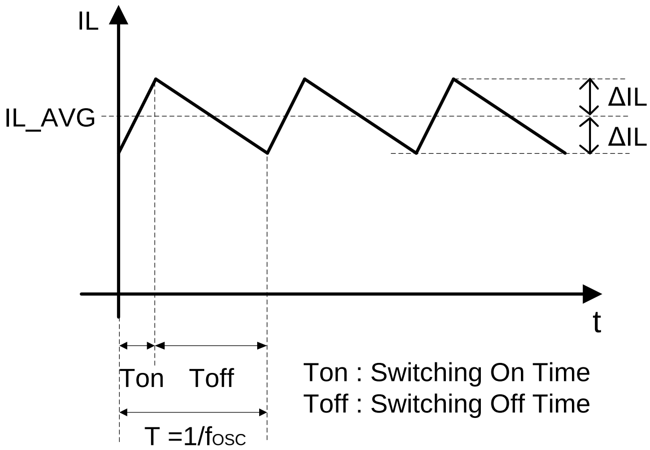
where,

$I_{SCP} = 4.8\ uA\ (typical)$

5.3 Inductor

In DCDC boost converter, the current as shown in the figure on the right-hand side flows through inductor.

DCDC boost converter output voltage (VOUT) is given by the following expression.



$$VOUT = \frac{VIN}{1 - D}$$

where,

VIN : Input voltage

D : Power MOSFET ON Duty, $D = \frac{Ton}{T}$

Ton : Power MOSFET ON Time

T : Switching period, $T = \frac{1}{f_{OSC}}$

f_{OSC} *: Switching frequency = 1 MHz (typical)*

Ripple current of the inductor (ΔIL) is given by the following expression.

$$\Delta IL = \frac{VIN \times D}{2 \times L \times f_{OSC}} = \frac{VIN \times Ton}{2 \times L}$$

where,

L : Inductance value of L1

At the maximum output load (IO_{max}), the peak of the inductor current (ILpeak) is given by

$$ILpeak = IL\_AVG_{[max]} + \Delta IL$$

where,

$IL\_AVG_{[max]}$ *: The average of inductor current at the maximum output load*

Select an inductor (L1) which can permit ILpeak.

If ΔIL is higher than the average inductor current, the mode is switched to Discontinuous Mode.

5.3 Input capacitor

RMS ripple current of the input capacitor (C1,C5) is given by

$$Irms(Cin) = \frac{1}{2\sqrt{3}} \times \frac{VIN \times D}{L \times f_{OSC}}$$

Select the input capacitor which can be low ESR and enough capacitance value to supply the stable voltage to VCC pin.

5.4 Output capacitor for DCDC boost converter

RMS ripple current of the output capacitor (C2) for DCDC boost converter is given by

$$Irms(Cout) \approx IO \times \sqrt{\frac{VOUT - VIN}{VIN}}$$

where,

IO : Output load

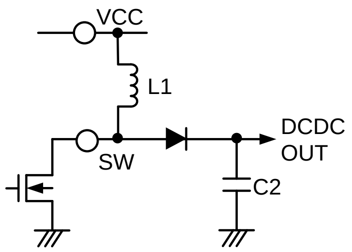
When VIN is minimum and IO is maximum, Irms(Cout) is maximum. Select the output capacitor which can permit the maximum Irms(Cout). Use the capacitor which has enough margin to the maximum rating.

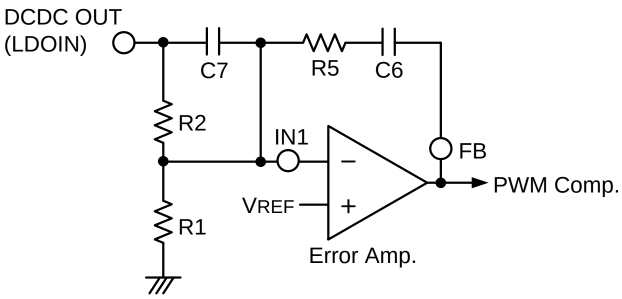
5.5 Rectifier diode for DCDC boost converter

Use the Schottky Diode as rectifier diode for DCDC boost converter. Make sure that the diode meets the following 3 conditions: 1) rated reverse voltage of the diode is higher than output voltage, 2) rated average current is higher than maximum load current and 3) rated surge forward current is higher than peak inductor current.

5.6 Phase compensation for DCDC boost converter

To stabilize DCDC boost converter by phase compensation, you need to cancel double pole (-180deg) caused by LC with 2 zeros (+90deg ×2). Set the frequency of 2 zeros near the LC resonance frequency.





【LC resonance frequency】

$$f_r = \frac{1}{2\pi \times \sqrt{L1 \times C2}} \ [Hz]$$

【Zero】

$$f_{z1} = \frac{1}{2\pi \times \sqrt{C5 \times RA}} \ [Hz]$$

$$f_{z2} = \frac{1}{2\pi \times \sqrt{C6 \times R2}} \ [Hz]$$