

*ASSP for Power Supply Applications***Evaluation Board****MB39A102****DESCRIPTION**

The MB39A102 evaluation board is a surface mount circuit board with four channels of up conversion, down conversion and up/down conversion circuits. The internal structure consists of one channel of step-down type, two channels of transformer type, and one channel of Sepic type. A total of seven lines of output terminals are provided, supporting voltage settings from -7 V to +15 V and supplying a current Max 500 mA (Sepic type) at a power-supply voltage between +2.5 V and +6 V. The output circuit (ch1) can be changed to the Zata type by optional replacement of components. The board incorporates the protective functions that upon detection of a short circuit or activation of the under voltage lockout protection circuit, the short-circuit protection feature shuts off transistors to stop the output. Also, the short-circuit detection comparator can detect a short circuit through an external input (initial number P12). In addition, each channel can be controlled to be turned on and off and can be set for a soft-start.

EVALUATION BOARD SPECIFICATIONS

	Terminal	Min	Typ	Max	Unit
Input voltage	VIN	2.5	3.6	6	V
Oscillation frequency	—	400	500	600	kHz
Output voltage	Vo-1	2.2	2.5	2.8	V
	Vo-2-1	13	15	17	
	Vo-2-2	4.5	5	5.5	
	Vo-2-3	-8.3	-7.5	-6.7	
	Vo-3-1	13	15	17	
	Vo-3-2	4.5	5	5.5	
	Vo-4	2.9	3.3	3.7	

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	Terminal	Min	Typ	Max	Unit
Output current	Vo-1	—	—	250	mA
	Vo-2-1	—	—	10	
	Vo-2-2	—	—	50	
	Vo-2-3	—	—	-5	
	Vo-3-1	—	—	10	
	Vo-3-2	—	—	50	
	Vo-4	—	—	500	
Short-circuit detection time	—	4.6	7	12.5	ms
Soft-start time	—	7.6	10.3	15.8	ms

■ TERMINAL DESCRIPTION

Symbol	Function
VIN	Power-supply terminal $V_{IN} = 2.5 \text{ V to } 6.0 \text{ V (Typ: } 3.6 \text{ V)}$
VoX	DC/DC converter output terminal
CTL	Power-supply control terminal $V_{CTL} = 0 \text{ V to } 0.8 \text{ V}$: Standby mode $V_{CTL} = 2.0 \text{ V to } V_{IN}$: Operation mode
GNDX	DC/DC converter GND terminal
ICGND	MB39A102 GND terminal

■ SWITCH DESCRIPTION

SW	NAME	FUNCTION	ON	OFF
1	CS1	CH1 control	Output ON	Output OFF
2	CS2	CH2 control	Output ON	Output OFF
3	CS3	CH3 control	Output ON	Output OFF
4	CS4	CH4 control	Output ON	Output OFF
5	CTL	Power supply control	Operation mode	Standby mode

■ SETUP AND CHECKUP

(1) Setup

- Connect the power-supply terminal side to VIN and GND. Connect the Vo side to the required loading device or measuring instrument.
- Connect a startup power supply from 2.0 V to VIN to the CTL terminal. (This can be done by connection from VIN.)
- Set SW5 (CTL) to OFF (Standby mode) and SW1 through SW4 (CS1 through CS4) to OFF (output off).

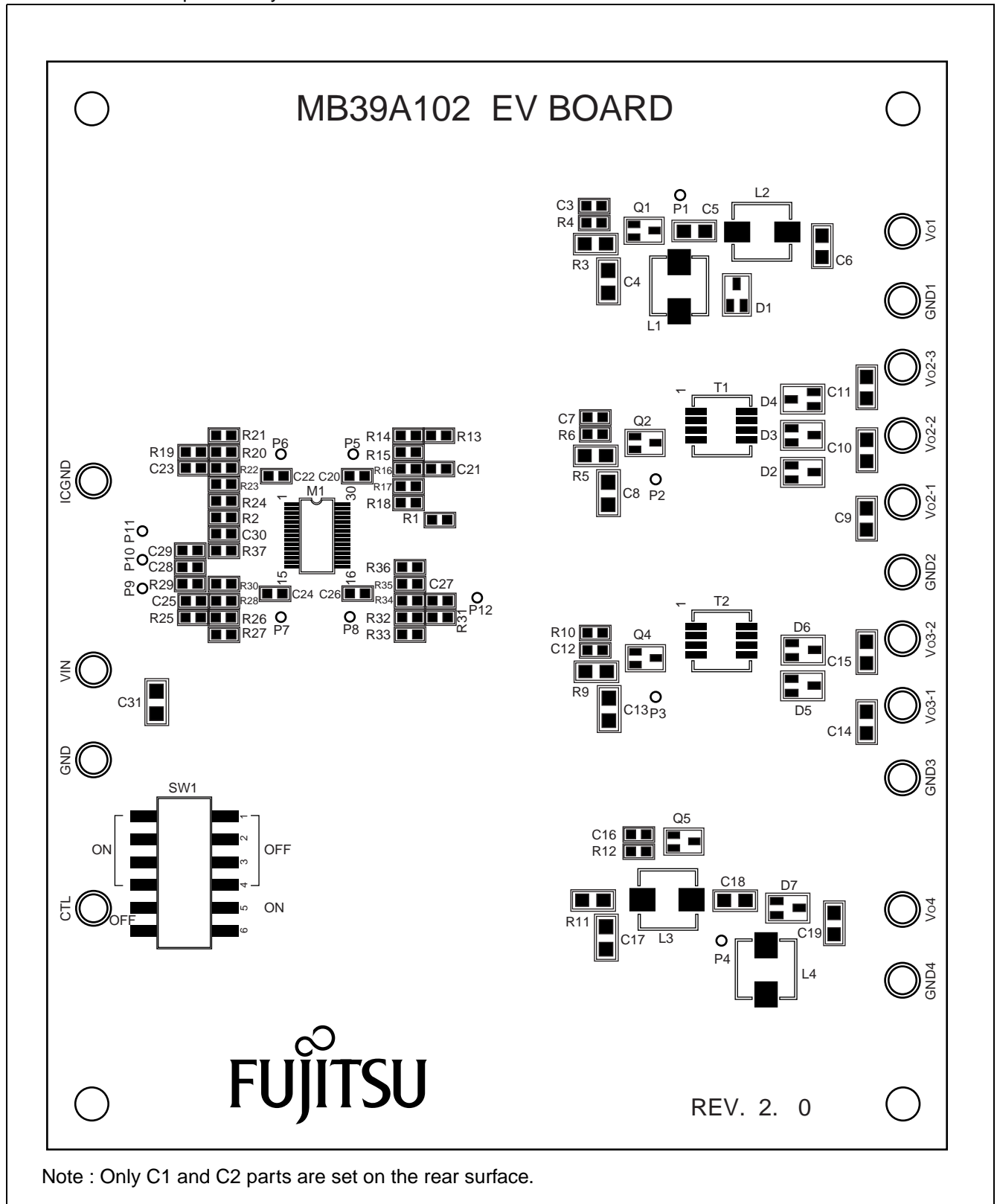
(2) Checkup

- Turn on VIN (power supply), set SW5 to ON (Operation mode) and SW1 through SW4 to ON (output on).
The IC works normally with the following outputs:
Vo1 = 2.5 V (Typ) , Vo2-1 = 15 V (Typ) , Vo2-2 = 5 V (Typ) , Vo2-3 = -7.5 V (Typ) , Vo3-1 = 15 V (Typ) ,
Vo3-2 = 5 V (Typ) , Vo4 = 3.3 V (Typ)

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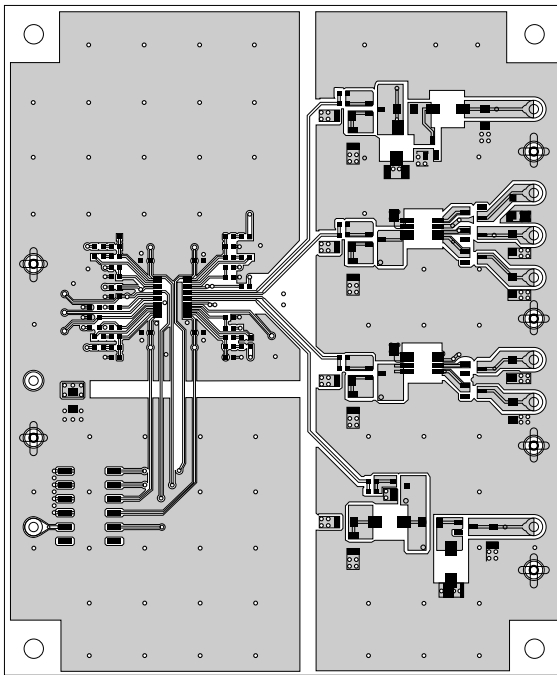
■ COMPONENT LAYOUT

- On-board Component Layout

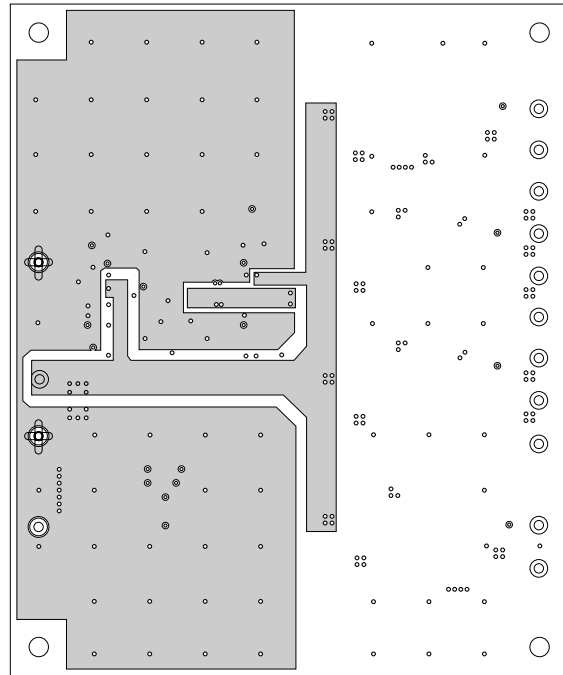


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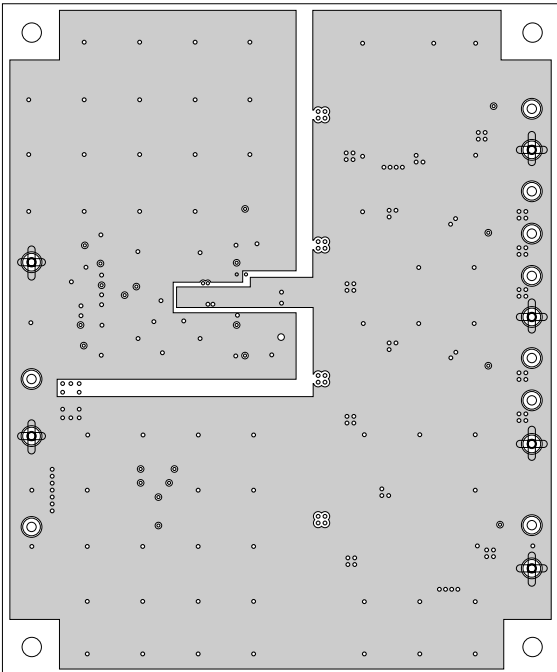
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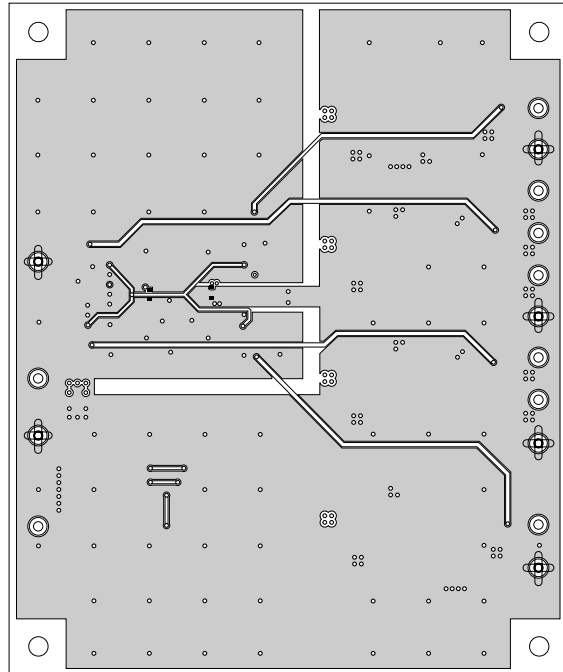
Top side



Inside VIN & GND (Layer2)



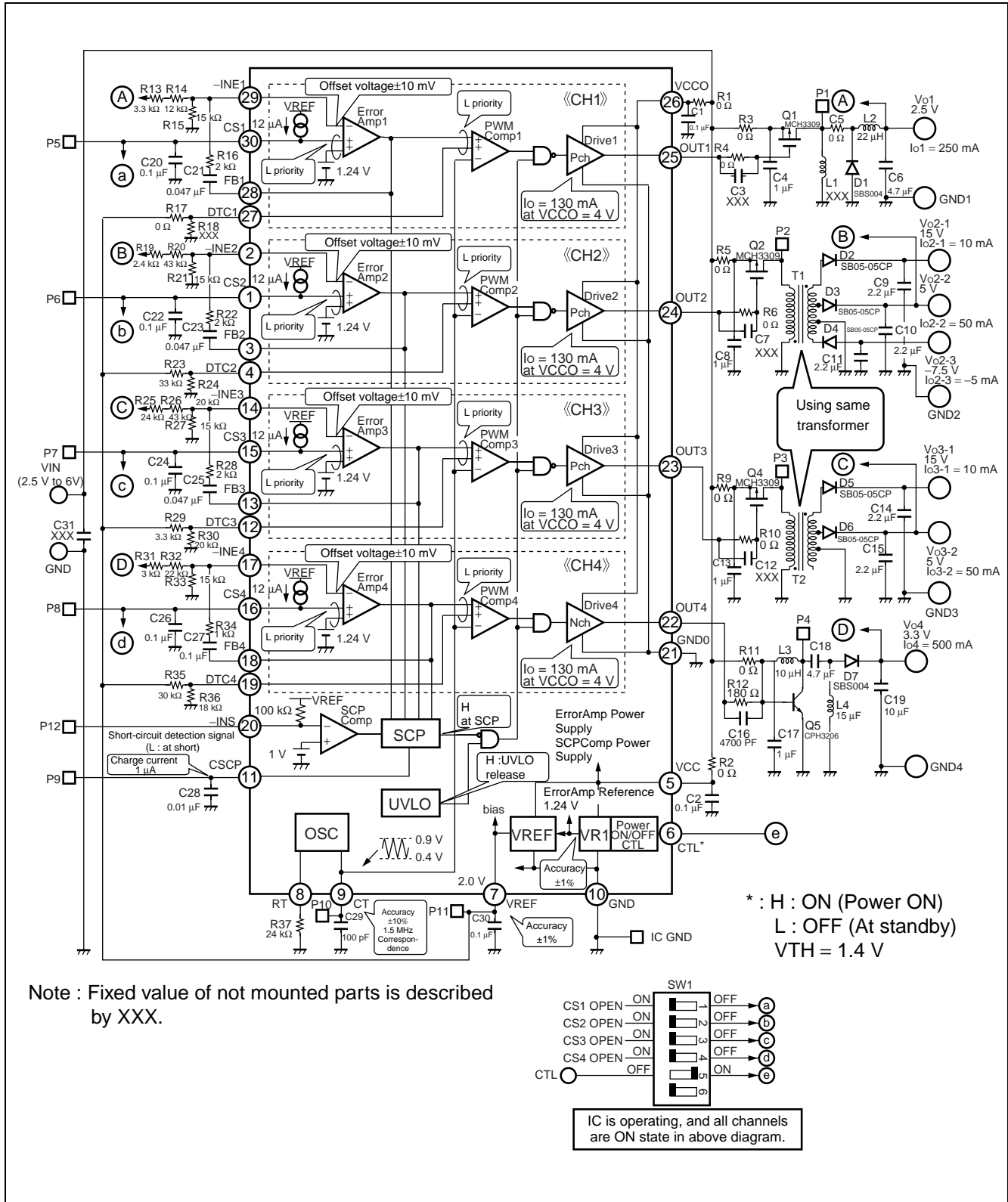
Inside GND (Layer3)



Bottom Side

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CONNECTION DIAGRAM



■ PARTS LIST

No	Symbol	Part name	Model name	Specification						Package	Manufacturer	Note
				Rating 1	Rating 2	Rating 3	Value	Deviation	Features			
1	M1	IC	MB39A102 PFT	—	—	—	—	—	—	FPT-30P-M04	FUJITSU	
2	Q1	Pch FET	MCH3309	PD = 0.9 W	VGSS = 10 V	ID = 1.5 A	—	—	—	—	SANYO	
3	Q2	Pch FET	MCH3309	PD = 0.9 W	VGSS = 10 V	ID = 1.5 A	—	—	—	—	SANYO	
4	Q4	Pch FET	MCH3309	PD = 0.9 W	VGSS = 10 V	ID = 1.5 A	—	—	—	—	SANYO	
5	Q5	NPN	CPH3206	PC = 0.9 W	VCEO = 15 V	IC = 3.0 A	—	—	—	SC-62	SANYO	
6	D1	SBD	SBS004	IF(AV) = 1.0 A	VRRM = 15 V	—	—	—	—	SOT-23	SANYO	
7	D2	SBD	SB05-05CP	IF(AV) = 0.5 A	VRRM = 50 V	—	—	—	—	SOT-23	SANYO	
8	D3	SBD	SB05-05CP	IF(AV) = 0.5 A	VRRM = 50 V	—	—	—	—	SOT-23	SANYO	
9	D4	SBD	SB05-05CP	IF(AV) = 0.5 A	VRRM = 50 V	—	—	—	—	SOT-23	SANYO	
10	D5	SBD	SB05-05CP	IF(AV) = 0.5 A	VRRM = 50 V	—	—	—	—	SOT-23	SANYO	
11	D6	SBD	SB05-05CP	IF(AV) = 0.5 A	VRRM = 50 V	—	—	—	—	SOT-23	SANYO	
12	D7	SBD	SBS004	IF(AV) = 1.0 A	VRRM = 15 V	—	—	—	—	SOT-23	SANYO	
13	L1	Coil	—	—	—	—	—	—	—	—	—	Not mounted
14	L2	Coil	RLF5018T-220MR63	IDC1 = 0.63 A	IDC2 = 0.86 A	—	22 μ	$\pm 20\%$	RDC = 0.13 Ω	—	TDK	
15	L3	Coil	RLF5018T-100MR94	IDC1 = 0.94 A	IDC2 = 1.3 A	—	10 μ	$\pm 20\%$	RDC = 0.067 Ω	—	TDK	
16	L4	Coil	RLF5018T-150MR76	IDC1 = 0.76 A	IDC2 = 1.0 A	—	15 μ	$\pm 20\%$	RDC = 0.097 Ω	—	TDK	
17	T1	Transformer	CLQ52 5388-T095	—	—	—	—	—	—	—	SUMIDA	
18	T2	Transformer	CLQ52 5388-T095	—	—	—	—	—	—	—	SUMIDA	
19	C1	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
20	C2	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
21	C3	Ceramic condenser	—	—	—	—	—	—	—	—	—	Not mounted
22	C4	Ceramic condenser	C3216JB1 E105K	25 V	—	—	1 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
23	C5	Jumper	—	1/4 W	—	—	0 Ω	Max 50 m Ω	—	3216	—	

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No	Symbol	Part name	Model name	Specification						Package	Manufacturer	Note
				Rating 1	Rating 2	Rating 3	Value	Deviation	Features			
24	C6	Ceramic condenser	C3216JB1 A475M	10 V	—	—	4.7 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
25	C7	Ceramic condenser	—	—	—	—	—	—	—	—	—	Not mounted
26	C8	Ceramic condenser	C3216JB1 E105K	25 V	—	—	1 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
27	C9	Ceramic condenser	C3216JB1 C225K	16 V	—	—	2.2 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
28	C10	Ceramic condenser	C3216JB1 C225K	16 V	—	—	2.2 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
29	C11	Ceramic condenser	C3216JB1 C225K	16 V	—	—	2.2 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
30	C12	Ceramic condenser	—	—	—	—	—	—	—	—	—	Not mounted
31	C13	Ceramic condenser	C3216JB1 E105K	25 V	—	—	1 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
32	C14	Ceramic condenser	C3216JB1 C225K	16 V	—	—	2.2 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
33	C15	Ceramic condenser	C3216JB1 C225K	16 V	—	—	2.2 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
34	C16	Ceramic condenser	C1608JB1 H472K	50 V	—	—	4700 P	$\pm 10\%$	Temperature characteristics B	1608	TDK	
35	C17	Ceramic condenser	C3216JB1 E105K	25 V	—	—	1.0 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
36	C18	Ceramic condenser	C3216JB1 A475M	10 V	—	—	4.7 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
37	C19	Ceramic condenser	C3216JB1 A106M	6.3 V	—	—	10 μ	$\pm 10\%$	Temperature characteristics B	3216	TDK	
38	C20	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
39	C21	Ceramic condenser	C1608JB1 H473K	50 V	—	—	0.047 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
40	C22	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
41	C23	Ceramic condenser	C1608JB1 H473K	50 V	—	—	0.047 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
42	C24	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
43	C25	Ceramic condenser	C1608JB1 H473K	50 V	—	—	0.047 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
44	C26	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
45	C27	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	

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No	Sym bol	Part name	Model name	Specification						Package	Manu- facturer	Note
				Rating 1	Rating 2	Rating 3	Value	Devia- tion	Features			
46	C28	Ceramic condenser	C1608JB1 H103K	50 V	—	—	0.01 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
47	C29	Ceramic condenser	C1608CH1 H101J	50 V	—	—	100 p	$\pm 5\%$	Temperature characteristics B	1608	TDK	
48	C30	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μ	$\pm 10\%$	Temperature characteristics B	1608	TDK	
49	C31	Ceramic condenser	—	—	—	—	—	—	—	—	—	Not mounted
50	R1	Jumper	—	1/16 W	—	—	0 Ω	Max 50 m Ω	—	1608	—	
51	R2	Jumper	—	1/16 W	—	—	0 Ω	Max 50 m Ω	—	1608	—	
52	R3	Jumper	—	1/4 W	—	—	0 Ω	Max 50 m Ω	—	3216	—	
53	R4	Jumper	—	1/16 W	—	—	0 Ω	Max 50 m Ω	—	1608	—	
54	R5	Jumper	—	1/4 W	—	—	0 Ω	Max 50 m Ω	—	3216	—	
55	R6	Jumper	—	1/16 W	—	—	0 Ω	Max 50 m Ω	—	1608	—	
56	R9	Jumper	—	1/4 W	—	—	0 Ω	Max 50 m Ω	—	3216	—	
57	R10	Jumper	—	1/16 W	—	—	0 Ω	Max 50 m Ω	—	1608	—	
58	R11	Jumper	—	1/4 W	—	—	0 Ω	Max 50 m Ω	—	3216	—	
59	R12	Resistor	RR0816P-181-D	1/16 W	—	—	180 Ω	$\pm 0.5\%$	± 25 ppm/ $^{\circ}\text{C}$	1608	ssm	
60	R13	Resistor	RR0816P-332-D	1/16 W	—	—	3.3 k Ω	$\pm 0.5\%$	± 25 ppm/ $^{\circ}\text{C}$	1608	ssm	
61	R14	Resistor	RR0816P-123-D	1/16 W	—	—	12 k Ω	$\pm 0.5\%$	± 25 ppm/ $^{\circ}\text{C}$	1608	ssm	
62	R15	Resistor	RR0816P-153-D	1/16 W	—	—	15 k Ω	$\pm 0.5\%$	± 25 ppm/ $^{\circ}\text{C}$	1608	ssm	
63	R16	Resistor	RR0816P-202-D	1/16 W	—	—	2.0 k Ω	$\pm 0.5\%$	± 25 ppm/ $^{\circ}\text{C}$	1608	ssm	
64	R17	Jumper	—	1/16 W	—	—	0 Ω	Max 50 m Ω	—	1608	—	
65	R18	Resistor	—	—	—	—	—	—	—	—	—	Not mounted
66	R19	Resistor	RR0816P-242-D	1/16 W	—	—	2.4 k Ω	$\pm 0.5\%$	± 25 ppm/ $^{\circ}\text{C}$	1608	ssm	

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No	Sym bol	Part name	Model name	Specification						Package	Manu- facturer	Note
				Rating 1	Rating 2	Rating 3	Value	Devi- ation	Features			
67	R20	Resistor	RR0816P-433-D	1/16 W	—	—	43 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
68	R21	Resistor	RR0816P-153-D	1/16 W	—	—	15 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
69	R22	Resistor	RR0816P-202-D	1/16 W	—	—	2.0 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
70	R23	Resistor	RR0816P-333-D	1/16 W	—	—	33 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
71	R24	Resistor	RR0816P-203-D	1/16 W	—	—	20 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
72	R25	Resistor	RR0816P-242-D	1/16 W	—	—	2.4 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
73	R26	Resistor	RR0816P-433-D	1/16 W	—	—	43 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
74	R27	Resistor	RR0816P-153-D	1/16 W	—	—	15 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
75	R28	Resistor	RR0816P-202-D	1/16 W	—	—	2.0 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
76	R29	Resistor	RR0816P-333-D	1/16 W	—	—	33 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
77	R30	Resistor	RR0816P-203-D	1/16 W	—	—	20 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
78	R31	Resistor	RR0816P-302-D	1/16 W	—	—	3.0 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
79	R32	Resistor	RR0816P-223-D	1/16 W	—	—	22 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
80	R33	Resistor	RR0816P-153-D	1/16 W	—	—	15 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
81	R34	Resistor	RR0816P-102-D	1/16 W	—	—	1.0 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
82	R35	Resistor	RR0816P-303-D	1/16 W	—	—	30 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
83	R36	Resistor	RR0816P-183-D	1/16 W	—	—	18 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
84	R37	Resistor	RR0816P-243-D	1/16 W	—	—	24 kΩ	±0.5%	±25 ppm/ °C	1608	ssm	
85	SW1	Switch	DMS-6H	—	—	—	—	—	—	—	MAT-SUKYU	
86	PIN	Terminal pins	WT-2-1	—	—	—	—	—	—	—	MacEight	

SANYO : SANYO Electric Co., Ltd.
 TDK : TDK Corporation
 SUMIDA : Sumida Corporation
 ssm : SUSUMU CO., LTD.
 MATSUKYU : Matsukyu Co., Ltd.
 MacEight : MacEight Co., Ltd.

■ INITIAL SETTINGS

(1) Output voltage

$$\text{CH1 : } V_{o1} \text{ (V)} = 1.24/R_{15} \times (R_{13}+R_{14}+R_{15}) \cong 2.5 \text{ (V)}$$

$$\text{CH2 : } V_{o2-2} \text{ (V)} = 1.24/R_{21} \times (R_{19}+R_{20}+R_{21}) \cong 5.0 \text{ (V)}$$

$$\text{CH3 : } V_{o3-2} \text{ (V)} = 1.24/R_{27} \times (R_{25}+R_{26}+R_{27}) \cong 5.0 \text{ (V)}$$

$$\text{CH4 : } V_{o4} \text{ (V)} = 1.24/R_{33} \times (R_{31}+R_{32}+R_{33}) \cong 3.3 \text{ (V)}$$

(2) Oscillation frequency

$$f_{osc} \text{ (kHz)} = 1200000 / (C_{29} \text{ (pF)} \times R_{37} \text{ (k}\Omega\text{)}) \cong 500 \text{ (kHz)}$$

(3) Soft-start time

$$\text{CH1 : } t_s \text{ (s)} = 0.103 \times C_{20} \text{ (\mu F)} \cong 10.3 \text{ (ms)}$$

$$\text{CH2 : } t_s \text{ (s)} = 0.103 \times C_{22} \text{ (\mu F)} \cong 10.3 \text{ (ms)}$$

$$\text{CH3 : } t_s \text{ (s)} = 0.103 \times C_{24} \text{ (\mu F)} \cong 10.3 \text{ (ms)}$$

$$\text{CH4 : } t_s \text{ (s)} = 0.103 \times C_{26} \text{ (\mu F)} \cong 10.3 \text{ (ms)}$$

(4) Short-circuit detection time

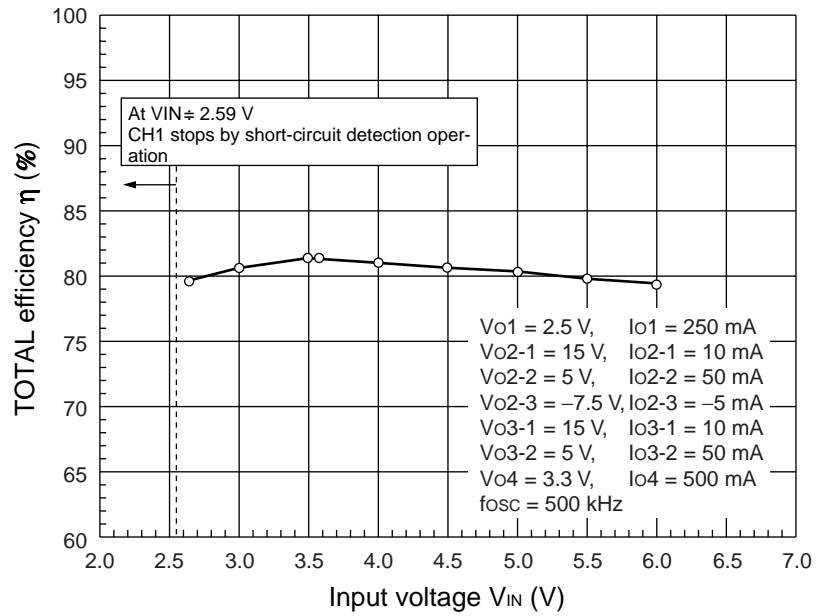
$$t_{scp} \text{ (s)} = 0.70 \times C_{28} \text{ (\mu F)} \cong 7.0 \text{ (ms)}$$

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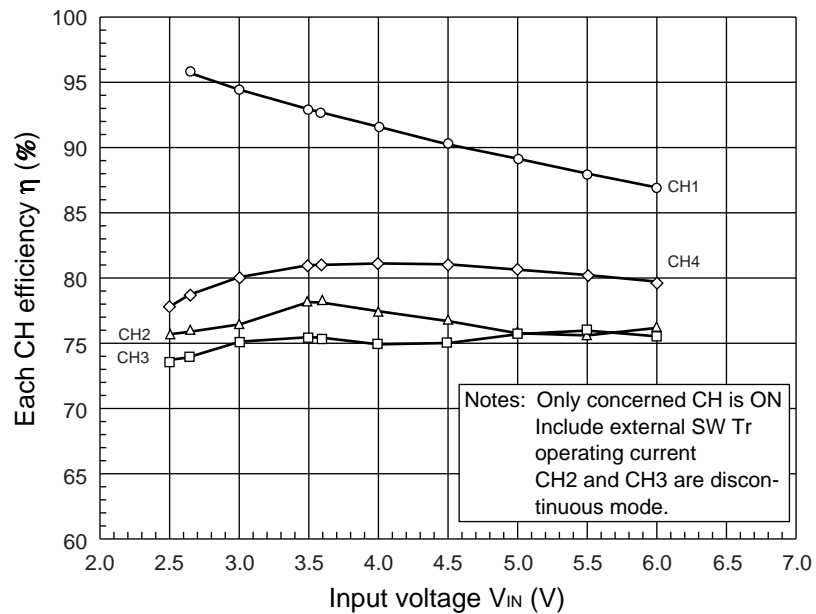
REFERENCE DATA

- Conversion efficiency — Input voltage

- TOTAL efficiency

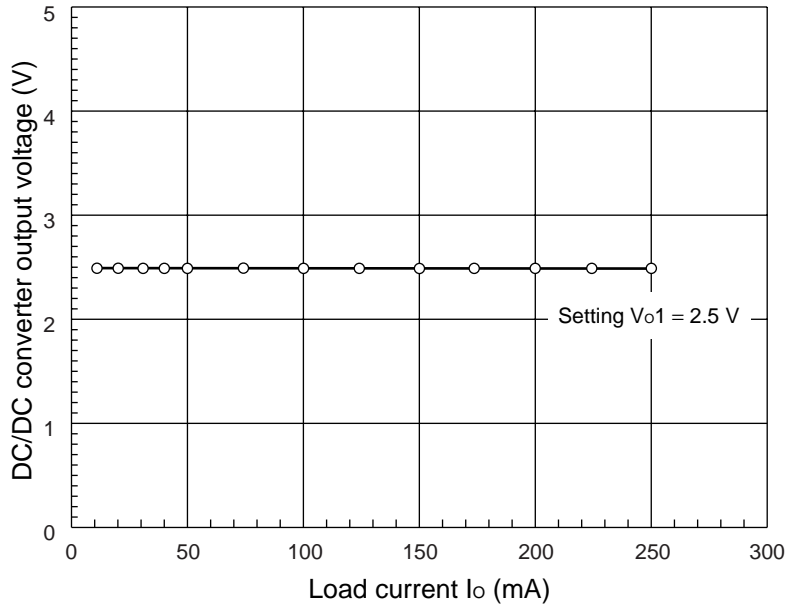


- Each CH Efficiency

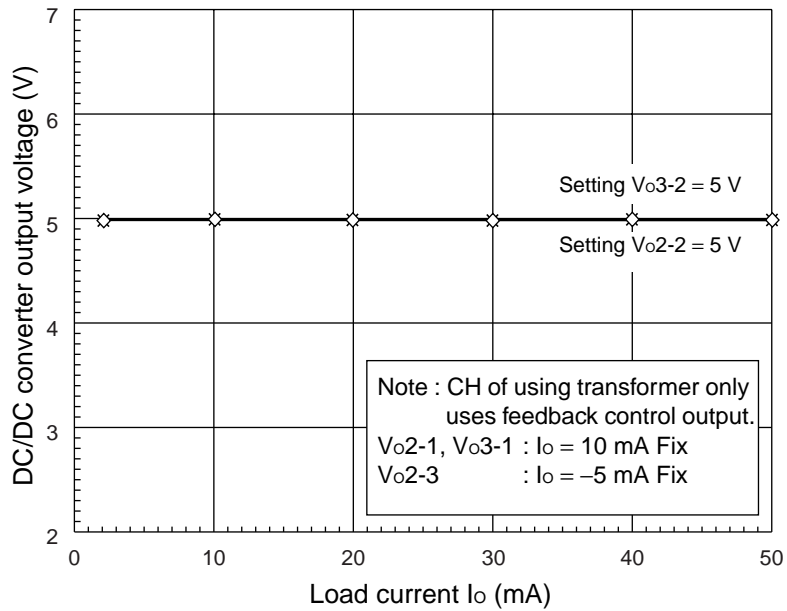


• Load Regulation ($V_{IN} = 3.6\text{ V}$)

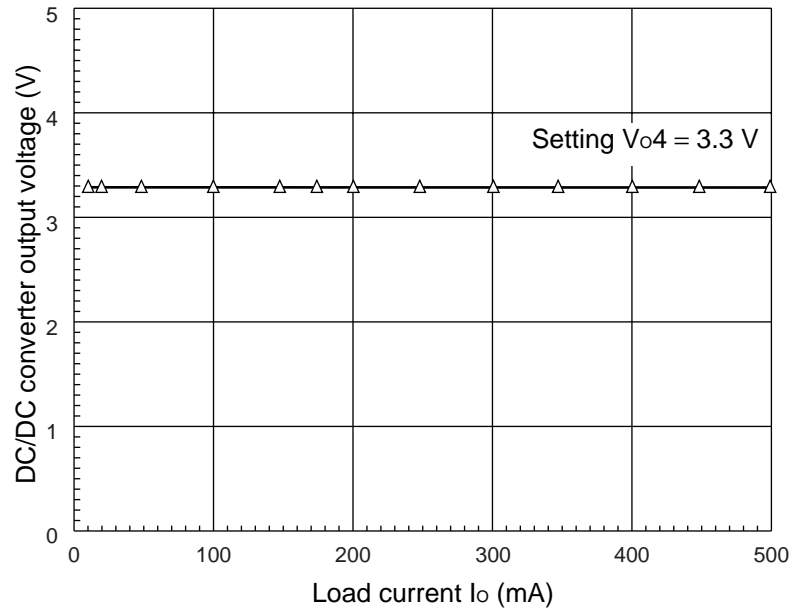
• CH1



• CH2, CH3

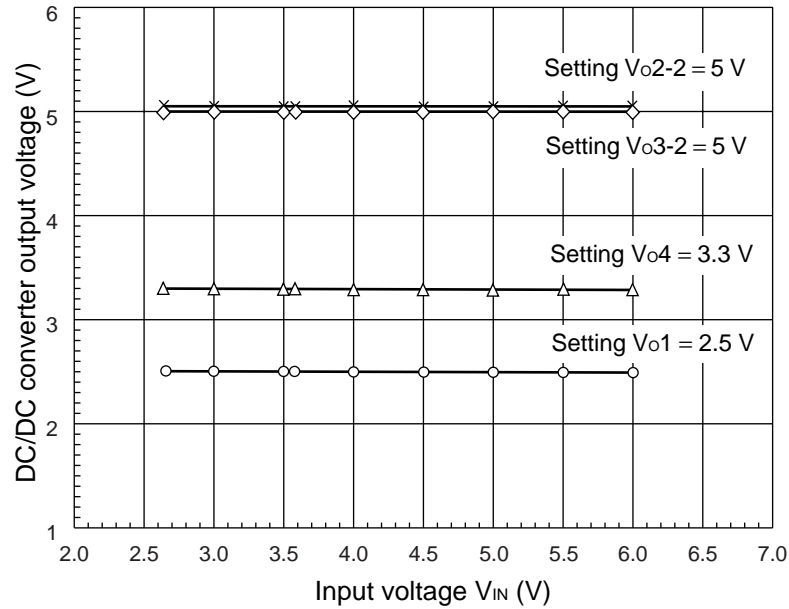


• CH4

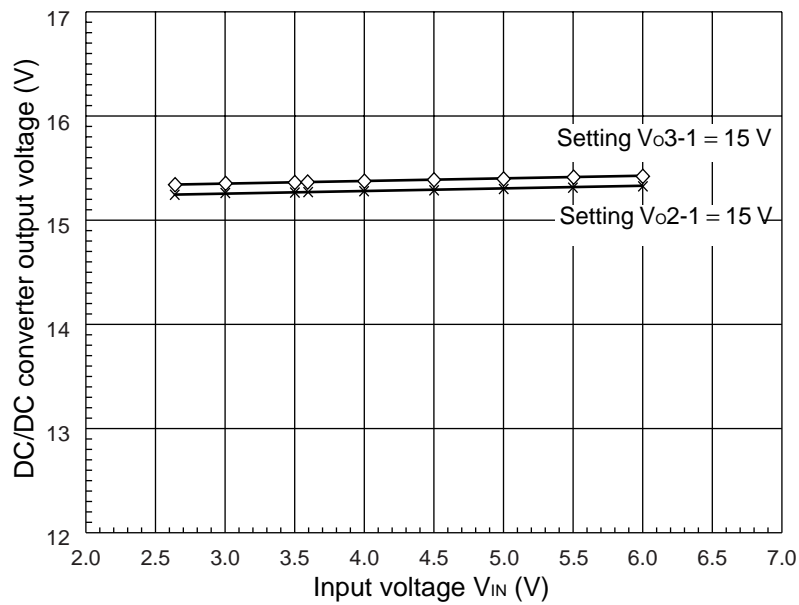


- Line Regulation

- Output is a feedback control.



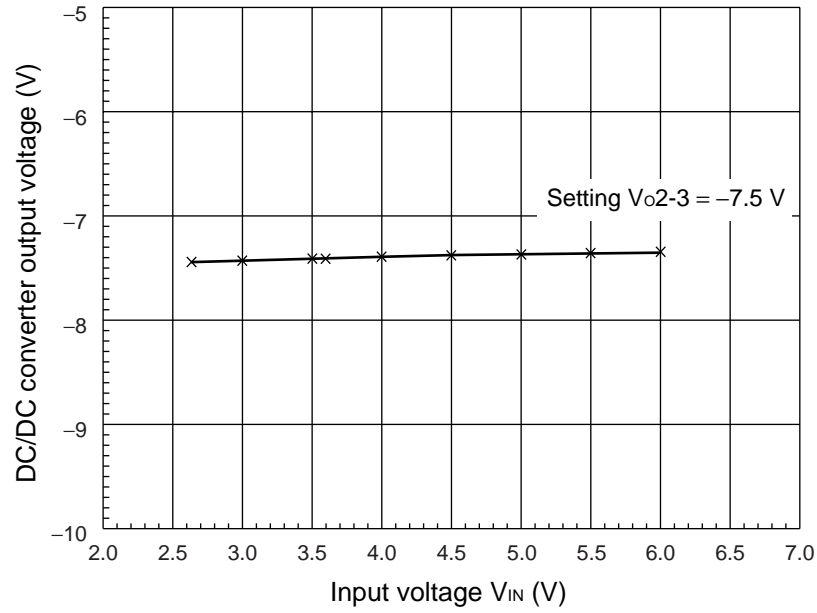
- Output is a feedback control none.



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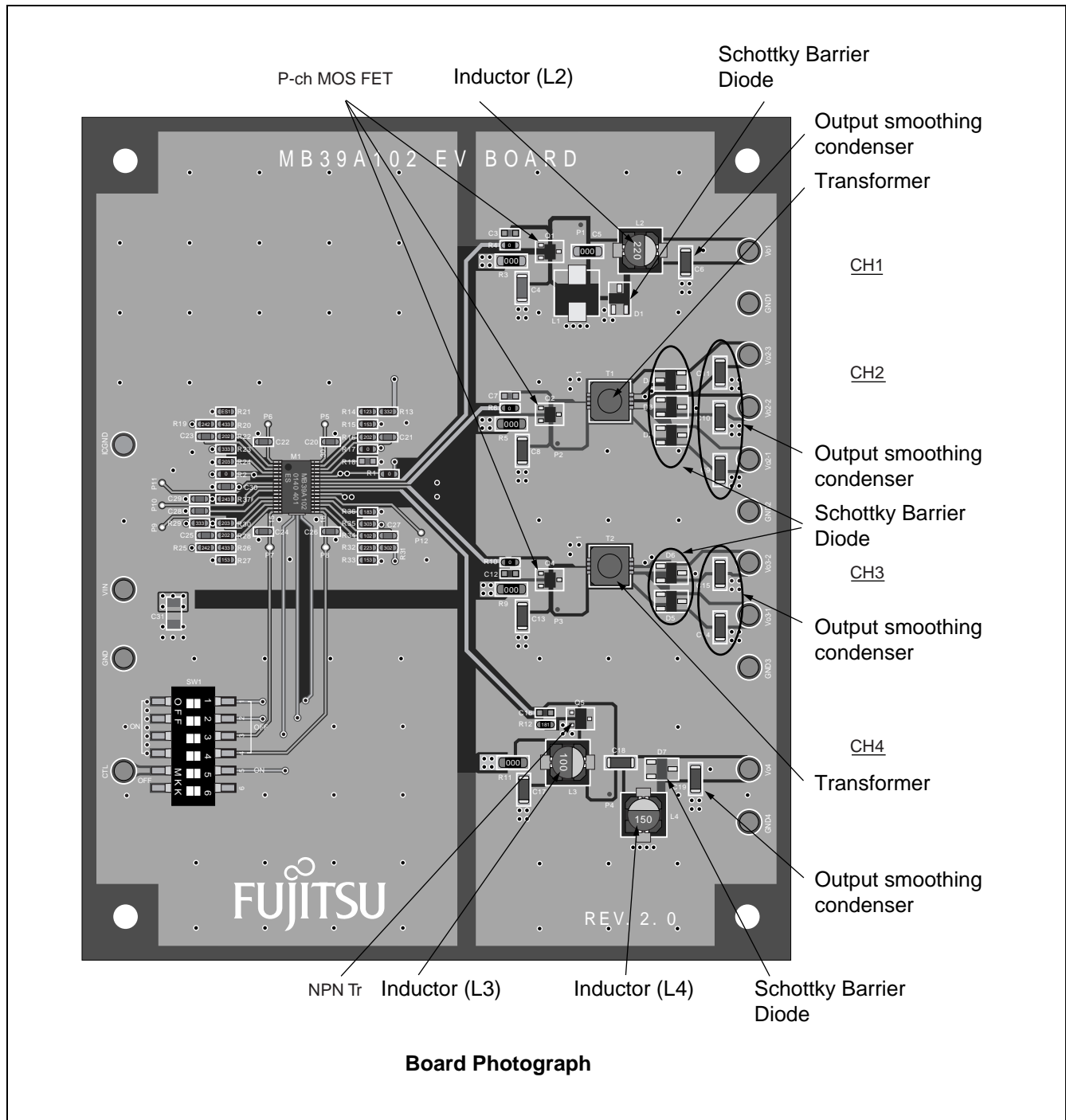
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- Output is a feedback control none.



■ COMPONENT SELECTION METHODS

1. Board view



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The following subsections show the component selection methods with the following common parametric values.

2. CH1 : Output 2.5 V (Downconversion Type)

$$V_{IN(\text{Max})} = 6.0 \text{ V}, I_o = 250 \text{ mA}, f_{\text{osc}} = 500 \text{ kHz}$$

(1) P-ch MOS FET (MCH3309 (SANYO product))

$$V_{DS} = -20 \text{ V}, V_{GS} = \pm 10 \text{ V}, I_D = -1.5 \text{ A}, R_{DS(\text{ON})} = 340 \text{ m}\Omega (\text{Max}), Q_g = 3.2 \text{ nC}$$

- Drain current: Peak value

The peak drain current of this FET must be within its rated current.

If the FET's peak drain current is I_D , it is obtained by the following formula.

$$V_o = V_{IN} \times \frac{t_{\text{ON}}}{t}$$

$$t_{\text{ON}} = t \times \frac{V_o}{V_{IN}} = \frac{1}{f_{\text{OSC}}} \times \frac{V_o}{V_{IN}}$$

$$I_D \geq I_o + \frac{V_{IN(\text{Max})} - V_o}{2L} \times t_{\text{ON}}$$

$$\geq 0.25 + \frac{6 - 2.5}{2 \times 22 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.417$$

$$\geq \underline{0.316 \text{ A}}$$

- Drain-source voltage / Gate-source voltage

The source-drain and gate-source voltages of the FET should be in the rated voltage value of FET.

The FET source-drain voltage (V_{DS}) and gate-source voltage (V_{GS}) are obtained by the following formula.

$$\begin{aligned} V_{DS} &\leq -V_{IN(\text{Max})} \\ &\leq \underline{-6 \text{ V}} \end{aligned}$$

$$\begin{aligned} V_{GS} &\geq V_{IN(\text{Max})} \\ &\geq \underline{6 \text{ V}} \end{aligned}$$

(2) Schottky Barrier Diode (SBS004 (SANYO product))

$$V_F (\text{forward voltage}) = 0.35 \text{ V (Max)} : \text{ at } I_F = 1 \text{ A}, V_{RRM} (\text{repeated peak reverse voltage}) = 15 \text{ V}$$

$$I_F (\text{mean output current}) = 1 \text{ A}, I_{FSM} (\text{surge forward current}) = 10 \text{ A}$$

- Diode current: Peak value

The peak diode current must be within its rated current.

If the peak diode current is I_{FSM} , it is obtained by the following formula.

$$I_{FSM} \geq I_o + \frac{V_o}{2L} \times t_{\text{OFF}}$$

$$\geq 0.25 + \frac{2.5}{2 \times 22 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times (1 - 0.417)$$

$$\geq \underline{0.316 \text{ A}}$$

- Diode current: Average value

The mean value of diode current must be within its rated current.

If the mean value of diode current is I_F , it is obtained by the following formula.

$$\begin{aligned} I_F &\geq I_o \times \frac{t_{OFF}}{t} \\ &\geq 0.25 \times 0.583 \\ &\geq \underline{0.146A} \end{aligned}$$

- Repeated peak reverse voltage

The repeated peak reverse voltage must be within its rated voltage.

If the repeated peak reverse voltage is V_{RRM} , it is obtained by the following formula.

$$\begin{aligned} V_{RRM} &\geq V_{IN (Max)} \\ &\geq \underline{6V} \end{aligned}$$

(3) Inductor (SLF12565T-220M3R5 : TDK product)

22 μ H (tolerance $\pm 20\%$) , rated current = 0.63 A

The condition for L to be a continuous current within the operating voltage range is obtained by the following formula.

$$\begin{aligned} L &\geq \frac{V_{IN (Max)} - V_o}{2I_o} \times t_{ON} \\ &\geq \frac{6-2.5}{2 \times 0.25} \times \frac{1}{500 \times 10^3} \times 0.42 \\ &\geq \underline{5.88 \mu H} \end{aligned}$$

The load current satisfying the continuous current condition is obtained by the following formula.

$$\begin{aligned} I_o &\geq \frac{V_o}{2L} \times t_{OFF} \\ &\geq \frac{2.5}{2 \times 22 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times (1-0.42) \\ &\geq \underline{66 mA} \end{aligned}$$

- Ripple current: Peak value

The peak ripple current must be within the rated current of the inductor.

If the peak ripple current is I_L , it is obtained by the following formula.

$$\begin{aligned} I_L &\geq I_o + \frac{V_{IN (Max)} - V_o}{2L} \times t_{ON} \\ &\geq 0.25 + \frac{6-2.5}{2 \times 22 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.417 \\ &\geq \underline{0.316 A} \end{aligned}$$

- Ripple current: Peak-to-peak value

If the peak-to-peak ripple current is ΔI_L , it is obtained by the following formula.

$$\begin{aligned} \Delta I_L &= \frac{V_{IN (Max)} - V_o}{L} \times t_{ON} \\ &= \frac{6-2.5}{22 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.42 \\ &\doteq \underline{0.134 A} \end{aligned}$$

3. CH2, CH3 : (Transformer Conversion Type)

$$\begin{array}{lll} V_{IN (Max)} = 6 \text{ V} & V_{O2-1}, V_{O3-1} = 15 \text{ V} & I_{O2-1}, I_{O3-1} = 10 \text{ mA} \\ V_{IN (Min)} = 2.5 \text{ V} & V_{O2-2}, V_{O3-2} = 5 \text{ V} & I_{O2-2}, I_{O3-2} = 50 \text{ mA} \\ & V_{O2-3} = -7.5 \text{ V} & I_{O2-3} = -5 \text{ mA} \end{array}$$

(1) P-ch MOS FET (MCH3309 (SANYO product))

$$V_{DS} = -20 \text{ V}, V_{GS} = \pm 10 \text{ V}, I_D = -1.5 \text{ A}, R_{DS(ON)} = 340 \text{ m}\Omega \text{ (Max)}, Q_g = 3.2 \text{ nC}$$

The FET's rated drain current must be at least 0.7 A.

The FET's rated drain-source and gate-source voltages must be at least 9 V.

(2) Schottky Barrier Diode (SB05-05CP (SANYO product))

$$V_{RRM} \text{ (repeated peak reverse voltage)} = 50 \text{ V},$$

$$I_F \text{ (average output current)} = 500 \text{ mA}, I_{FSM} \text{ (surge forward current)} = 5 \text{ A}$$

The each diode rated parameter must be at least V_{RRM} (repeated peak reverse voltage) = 49 V,

I_F (mean output current) = 50 mA, I_{FSM} (surge forward current) = 0.3 A.

4. CH4 : 3.3 V output (Sepic Type)

$$V_{IN (Min)} = 2.5 \text{ V}, I_o = 500 \text{ mA}, f_{OSC} = 500 \text{ kHz}$$

(1) NPN Tr (CPH3206 (SANYO product))

$$V_{CEO} = 15 \text{ V}, V_{CBO} = 15 \text{ V}, I_c = 3 \text{ A}, h_{FE} = 200 \text{ (Min)}$$

- Collector current: Peak value

The peak collector current of this Tr must be within its rated current.

If the Tr's peak collector current is I_c , it is obtained by the following formula.

$$V_o = V_{IN} \times \frac{t_{ON}}{t_{OFF}}$$

$$t_{ON} = t \times \frac{V_o}{V_{IN} + V_o}$$

$$= \frac{1}{f_{OSC}} \times \frac{V_o}{V_{IN} + V_o}$$

$$I_c \geq \frac{V_o + V_{IN (Min)}}{V_{IN (Min)}} \times I_o + \frac{1}{2} \left(\frac{1}{L_3} + \frac{1}{L_4} \right) \times V_{IN (Min)} \times t_{ON}$$

$$\geq \frac{3.3+2.5}{2.5} \times 0.5 + \frac{1}{2} \left(\frac{1}{10 \times 10^{-6}} + \frac{1}{15 \times 10^{-6}} \right) \times 2.5 \times \frac{1}{500 \times 10^3} \times 0.69$$

$$\geq \underline{1.397 \text{ A}}$$

Collector-emitter voltage / Collector-base voltage

The collector-emitter and collector-base voltages of the Tr should be in the rated voltage value of Tr.

The Tr's collector-emitter voltage (V_{CEO}) and collector-base voltage (V_{CBO}) are obtained by the following formula.

$$\begin{aligned} V_{CEO} = V_{CBO} &\geq V_{IN (Max)} + V_o \\ &\geq 6+3.3 \\ &\geq \underline{9.3 \text{ V}} \end{aligned}$$

(2) Schottky Barrier Diode (SBS004 (SANYO product))

V_F (forward voltage) = 0.35 V (Max) : at $I_F = 1$ A, V_{RRM} (repeated peak reverse voltage) = 15 V

I_{FSM} (surge forward current) = 10 A, I_F (mean output current) = 1 A

- Diode current: Peak value

The peak current of this diode must be within its rated current.

If the diode's peak current is I_{FSM} , it is obtained by the following formula.

$$\begin{aligned} I_{FSM} &\geq \frac{V_O + V_{IN(Min)}}{V_{IN(Min)}} \times I_o + \frac{1}{2} \left(\frac{1}{L_3} + \frac{1}{L_4} \right) \times V_o \times t_{OFF} \\ &\geq \frac{3.3+2.5}{2.5} \times 0.5 + \frac{1}{2} \left(\frac{1}{10 \times 10^{-6}} + \frac{1}{15 \times 10^{-6}} \right) \times 3.3 \times \frac{1}{500 \times 10^3} \times (1-0.569) \\ &\geq \underline{1.397 A} \end{aligned}$$

- Diode current: Average value

The mean value of diode current must be within its rated current.

If the mean value of diode current is I_F , it is obtained by the following formula.

$$\begin{aligned} I_F &\geq I_o \\ &\geq \underline{0.5 A} \end{aligned}$$

- Repeated peak reverse voltage

The repeated peak reverse voltage of this diode must be within its rated voltage.

If the diode's repeated peak reverse voltage is V_{RRM} , it is obtained by the following formula.

$$\begin{aligned} V_{RRM} &\geq V_{IN(Max)} + V_o \\ &\geq 6 + 3.3 \\ &\geq \underline{9.3 V} \end{aligned}$$

(3) Inductor (L3 : RLF5018T-100MR94, TDK product)

10 μ H (tolerance $\pm 20\%$) , rated current = 0.94 A

The condition for L to be a continuous current within the operating voltage range is obtained by the following formula.

$$\begin{aligned} L &\geq \frac{V_{IN(Max)}^2}{2I_oV_o} \times t_{ON} \\ &\geq \frac{6^2}{2 \times 0.5 \times 3.3} \times \frac{1}{500 \times 10^3} \times 0.355 \\ &\geq \underline{7.7 \mu H} \end{aligned}$$

The load current satisfying the continuous current condition is obtained by the following formula.

$$\begin{aligned} I_o &\geq \frac{V_{IN(Max)}^2}{2LV_o} \times t_{ON} \\ &\geq \frac{6^2}{2 \times 10 \times 10^{-6} \times 3.3} \times \frac{1}{500 \times 10^3} \times 0.355 \\ &\geq \underline{0.387 A} \end{aligned}$$

Note : The continuous current condition becomes a large current value compared with the current value obtained by L4.

- IL current: Peak value

The peak IL current of this inductor must be within its rated current.

IL current is obtained by the following formula.

$$\begin{aligned} I_L &\geq \frac{V_o}{V_{IN(\text{Min})}} \times I_o + \frac{V_{IN(\text{Min})}}{2L} \times t_{ON} \\ &\geq \frac{3.3}{2.5} \times 0.5 + \frac{2.5}{2 \times 10 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.57 \\ &\geq \underline{0.802 \text{ A}} \end{aligned}$$

(4) Inductor (L4 : RLF5018T-150MR76, TDK product)

15 μH (tolerance $\pm 20\%$) , rated current = 0.76 A

The condition for L to be a continuous current within the operating voltage range is obtained by the following formula.

$$\begin{aligned} L &\geq \frac{V_{IN(\text{Max})}}{2I_o} \times t_{ON} \\ &\geq \frac{6}{2 \times 0.5} \times \frac{1}{500 \times 10^3} \times 0.355 \\ &\geq \underline{4.3 \mu\text{H}} \end{aligned}$$

The load current satisfying the continuous current condition is obtained by the following formula.

$$\begin{aligned} I_o &\geq \frac{V_{IN(\text{Max})}}{2L} \times t_{ON} \\ &\geq \frac{6}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.355 \\ &\geq \underline{0.142 \text{ A}} \end{aligned}$$

Note : The continuous current condition becomes a large current value compared with the current value obtained by L3.

- IL current: Peak value

The peak IL current of this inductor must be within its rated current.

IL current is obtained by the following formula.

$$\begin{aligned} I_L &\geq I_o + \frac{V_{IN(\text{Max})}}{2L} \times t_{ON} \\ &\geq 0.5 + \frac{6}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.355 \\ &\geq \underline{0.642 \text{ A}} \end{aligned}$$

■ ORDERING INFORMATION

EV board part No.	EVboard version No.	Note
MB39A102EVB	MB39A102EV Board Rev. 2.0	IC Package TSSOP

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