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 V to 6.0 V (Typ: 3.6 V)
VoX	DC/DC converter output terminal
CTL	Power-supply control terminal V_{CTL} = 0 V to 0.8 V : Standby mode V_{CTL} = 2.0 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

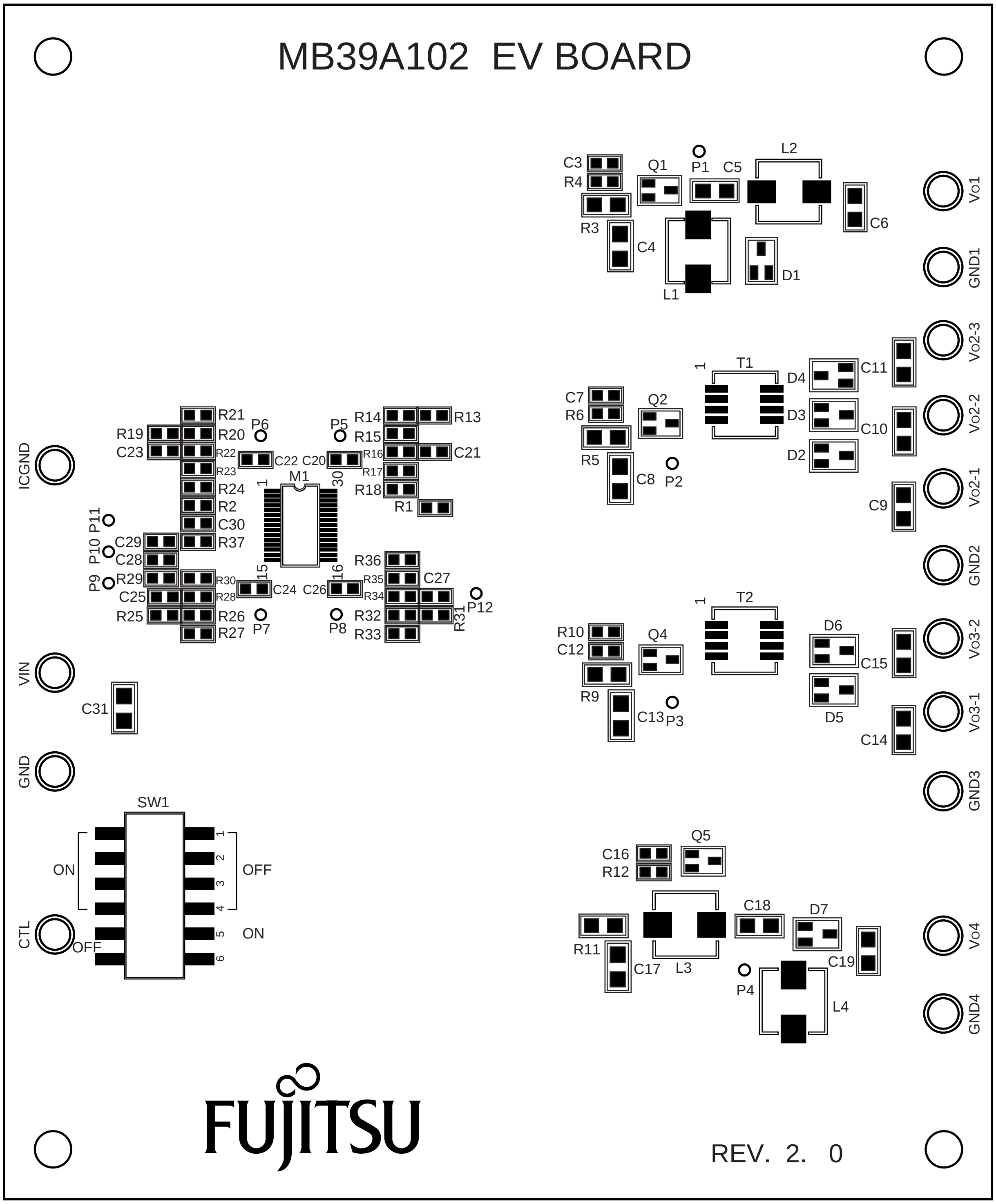
- Connect the power-supply terminal side to VIN and GND. Connect the Vo side to the required loading device or measuring instrument.
- Connect a startup power supply from 2.0 V to VIN to the CTL terminal. (This can be done by connection from VIN.)
- Set SW5 (CTL) to OFF (Standby mode) and SW1 through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

■ COMPONENT LAYOUT

• On-board Component Layout



Note : Only C1 and C2 parts are set on the rear surface.

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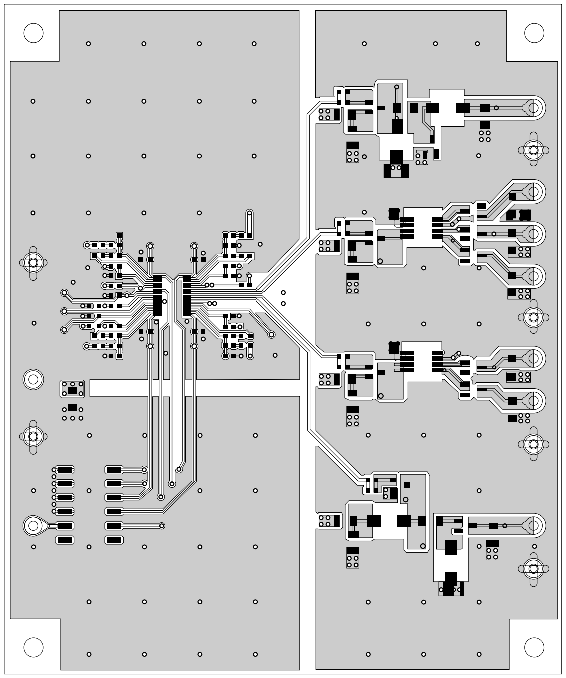
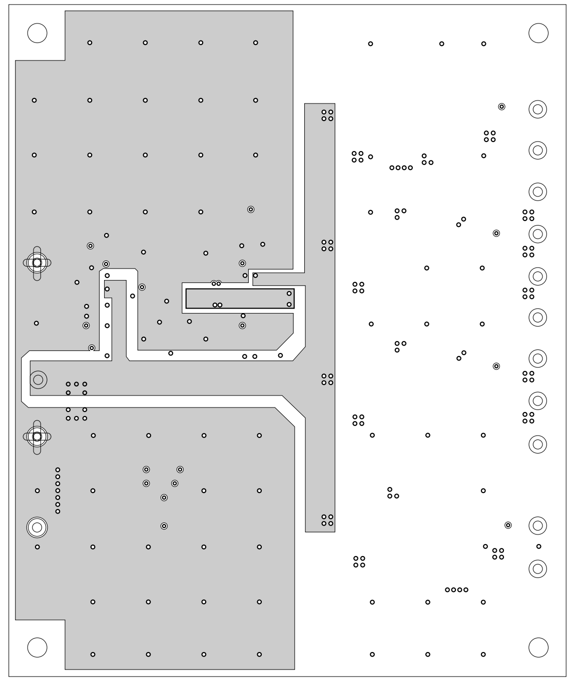
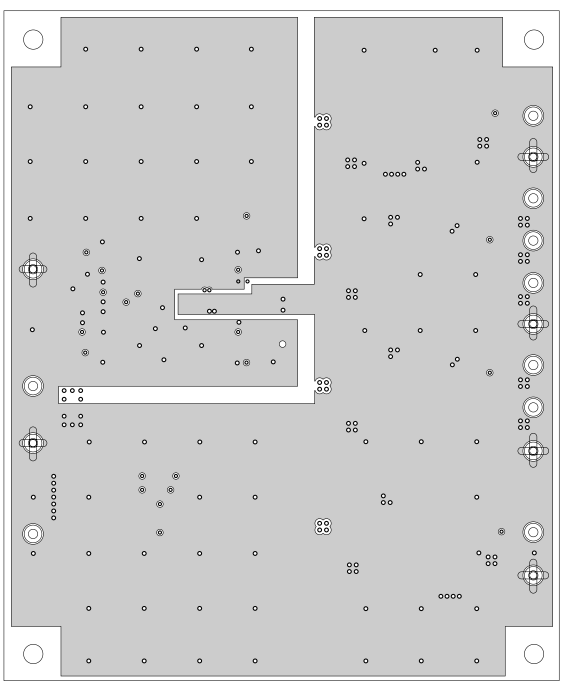


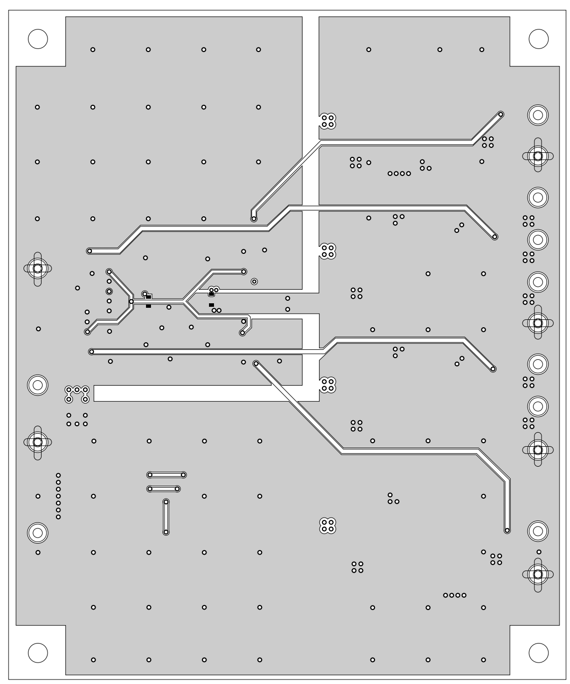
Top side



Inside VIN & GND (Layer2)

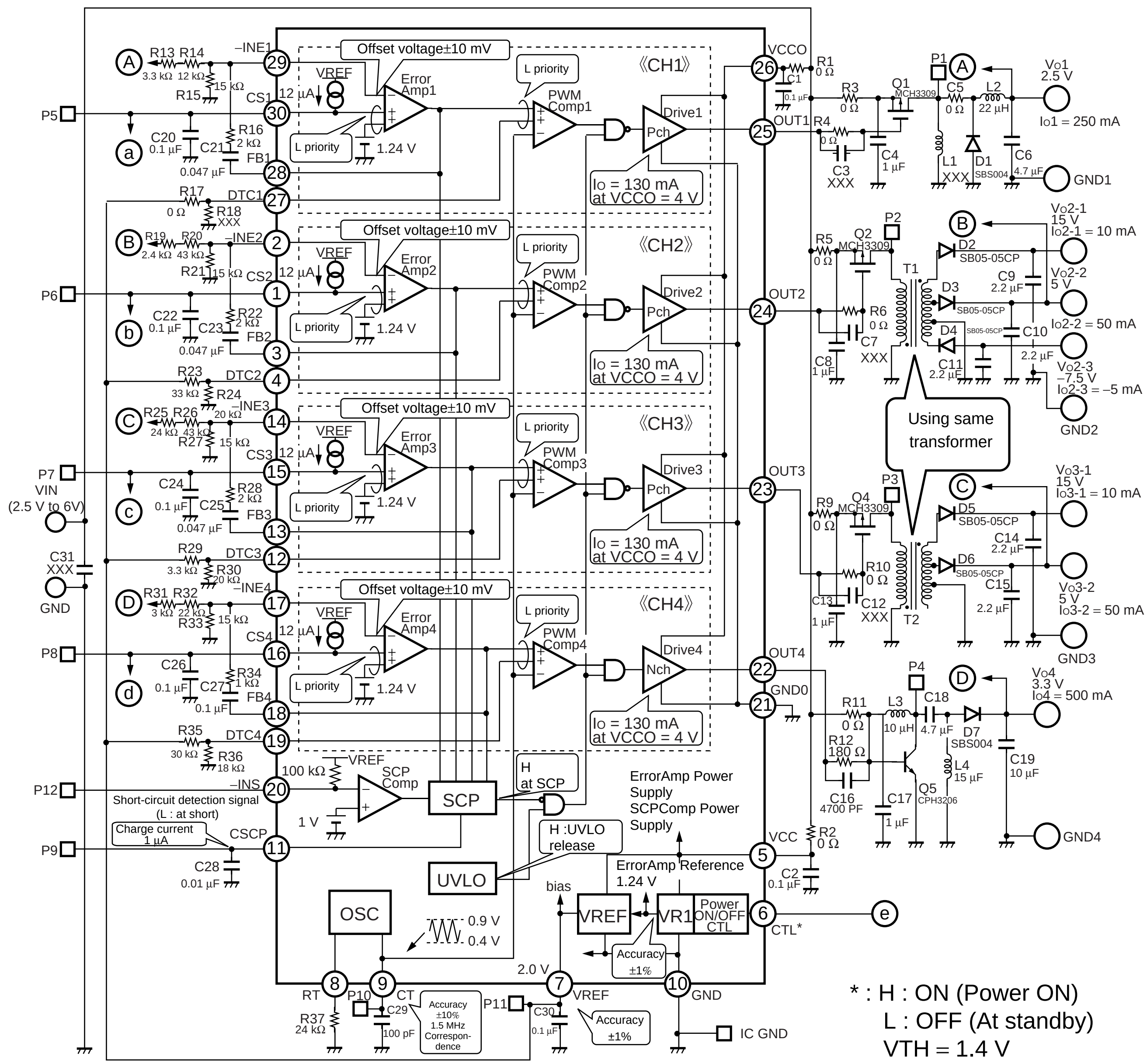


Inside GND (Layer3)

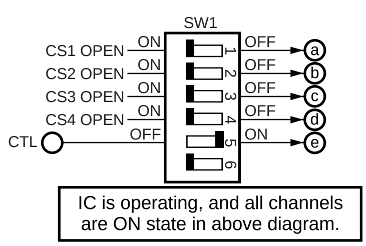


Bottom Side

■ CONNECTION DIAGRAM



Note : Fixed value of not mounted parts is described by XXX.



■ PARTS LIST

No	Sym bol	Part name	Model name	Specification: Rating 1	Rating 2	Rating 3	Val-ue	Devia-tion	Features	Pack-age	Manu-facturer	Note
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	±20%	RDC = 0.13 Ω	—	TDK	
15	L3	Coil	RLF5018T-100MR94	IDC1 = 0.94 A	IDC2 = 1.3 A	—	10 µ	±20%	RDC = 0.067 Ω	—	TDK	
16	L4	Coil	RLF5018T-150MR76	IDC1 = 0.76 A	IDC2 = 1.0 A	—	15 µ	±20%	RDC = 0.097 Ω	—	TDK	
17	T1	Trans-former	CLQ52 5388-T095	—	—	—	—	—	—	—	SUMIDA	
18	T2	Trans-former	CLQ52 5388-T095	—	—	—	—	—	—	—	SUMIDA	
19	C1	Ceramic condens-er	C1608JB1 H104K	50 V	—	—	0.1 µ	±10%	Temperature characteristics B	1608	TDK	
20	C2	Ceramic condens-er	C1608JB1 H104K	50 V	—	—	0.1 µ	±10%	Temperature characteristics B	1608	TDK	
21	C3	Ceramic condens-er	—	—	—	—	—	—	—	—	—	Not mounted
22	C4	Ceramic condens-er	C3216JB1 E105K	25 V	—	—	1 µ	±10%	Temperature characteristics B	3216	TDK	
23	C5	Jumper	—	1/4 W	—	—	0 Ω	Max 50 mΩ	—	3216	—	

(Continued)

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

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

CH1 : Vol (V) $= 1.24/R15 \times (R13+R14+R15) \fallingdotseq 2.5$ (V)

CH2 : Vo2-2 (V) $= 1.24/R21 \times (R19+R20+R21) \fallingdotseq 5.0$ (V)

CH3 : Vo3-2 (V) $= 1.24/R27 \times (R25+R26+R27) \fallingdotseq 5.0$ (V)

CH4 : Vo4 (V) $= 1.24/R33 \times (R31+R32+R33) \fallingdotseq 3.3$ (V)

(2) Oscillation frequency

fosc (kHz) $= 1200000/(C29\ (pF) \times R37\ (k\Omega)) \fallingdotseq 500$ (kHz)

(3) Soft-start time

CH1 : ts (s) $= 0.103 \times C20\ (\mu F) \fallingdotseq 10.3$ (ms)

CH2 : ts (s) $= 0.103 \times C22\ (\mu F) \fallingdotseq 10.3$ (ms)

CH3 : ts (s) $= 0.103 \times C24\ (\mu F) \fallingdotseq 10.3$ (ms)

CH4 : ts (s) $= 0.103 \times C26\ (\mu F) \fallingdotseq 10.3$ (ms)

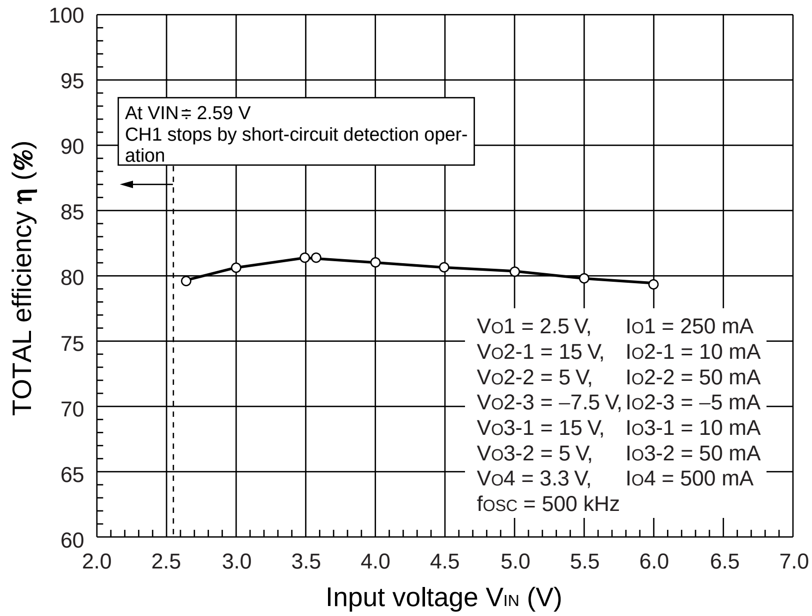
(4) Short-circuit detection time

tscp (s) $= 0.70 \times C28\ (\mu F) \fallingdotseq 7.0$ (ms)

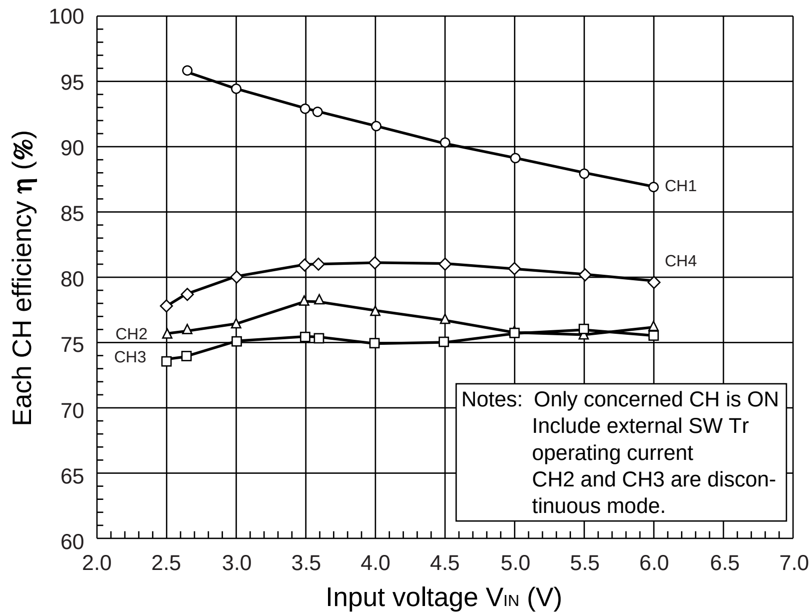
■ REFERENCE DATA

• Conversion efficiency — Input voltage

• TOTAL efficiency



• Each CH Efficiency



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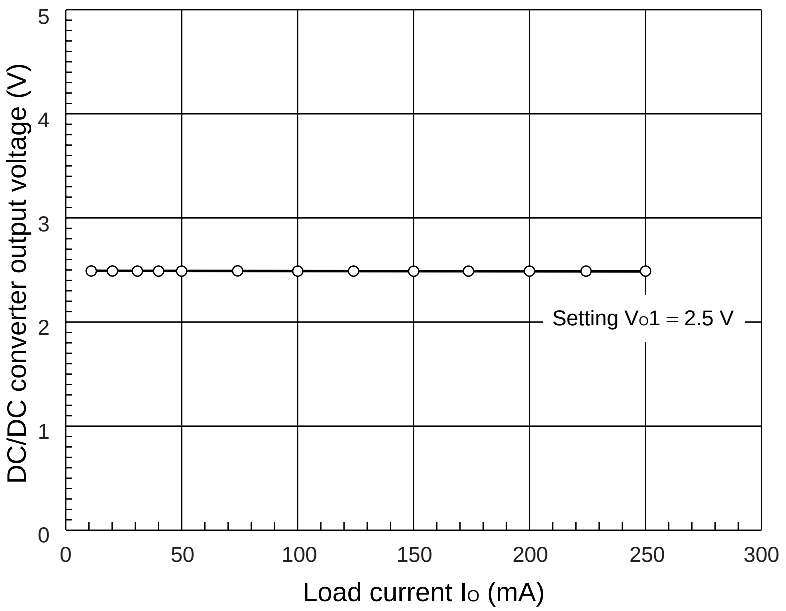
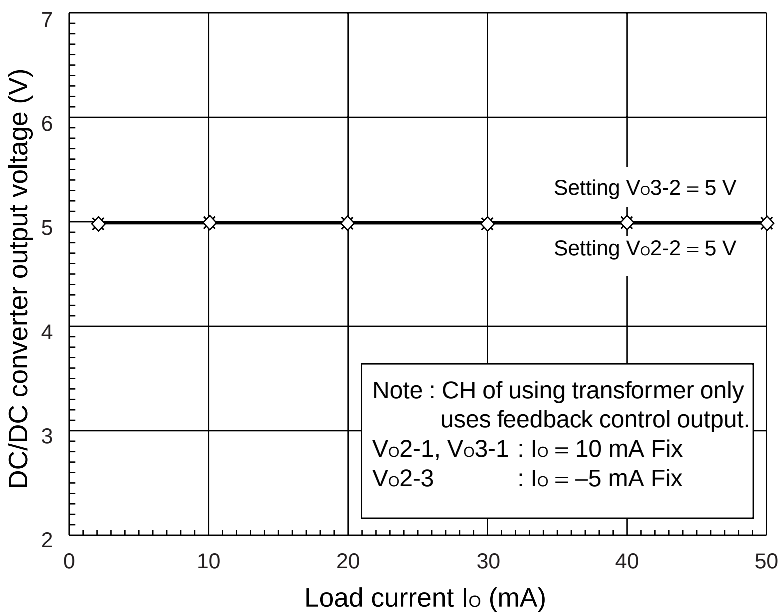
• Load Reguration (V_{IN} = 3.6 V)

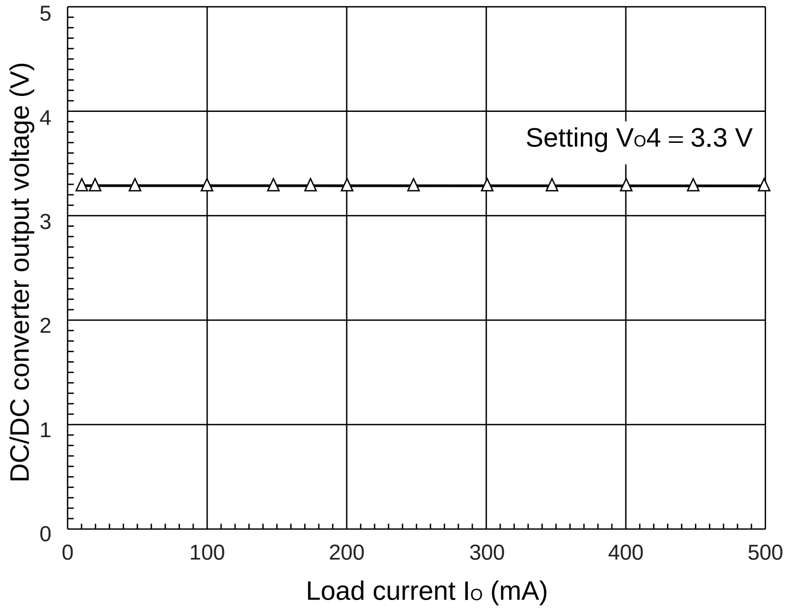
• CH1



• CH2, CH3

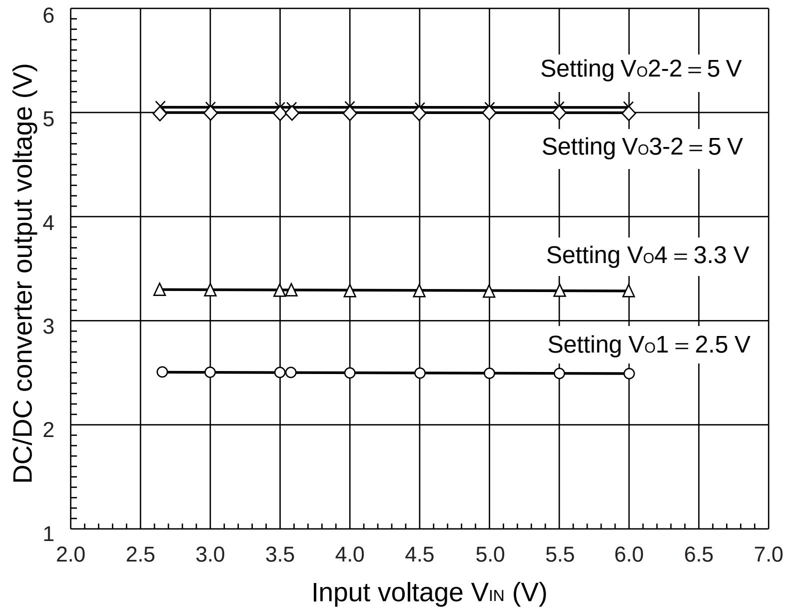


• CH4

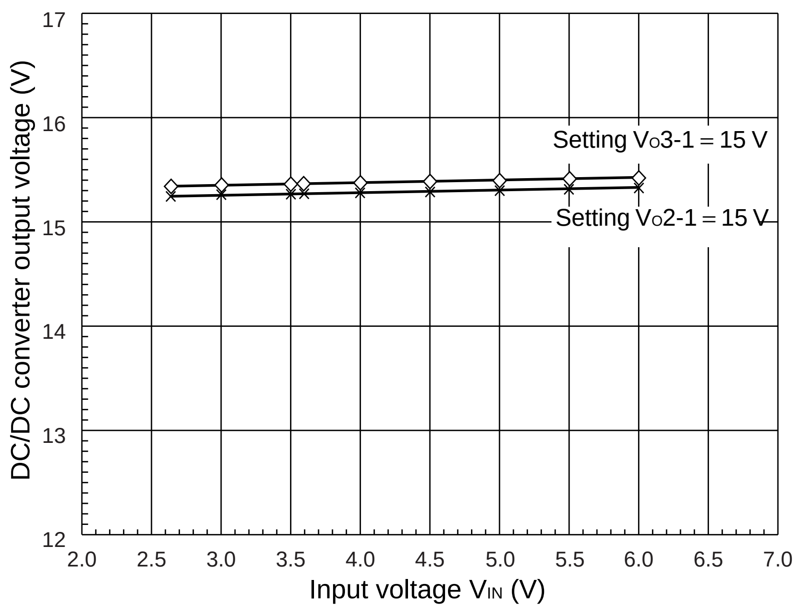

Setting Vo4 = 3.3 V
DC/DC converter output voltage (V)
Load current Io (mA)
0
1
2
3
4
5
0
100
200
300
400
500

• Line Regulation

• Output is a feedback control.



• Output is a feedback control none.



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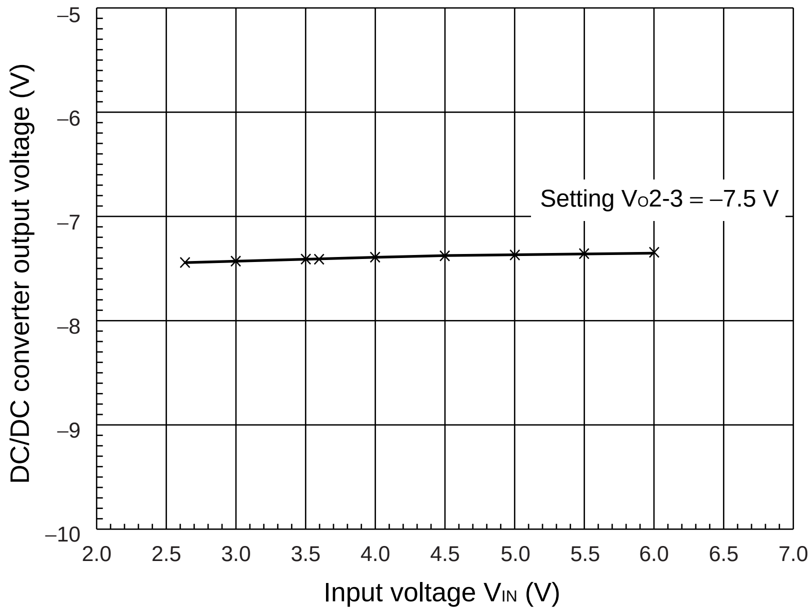
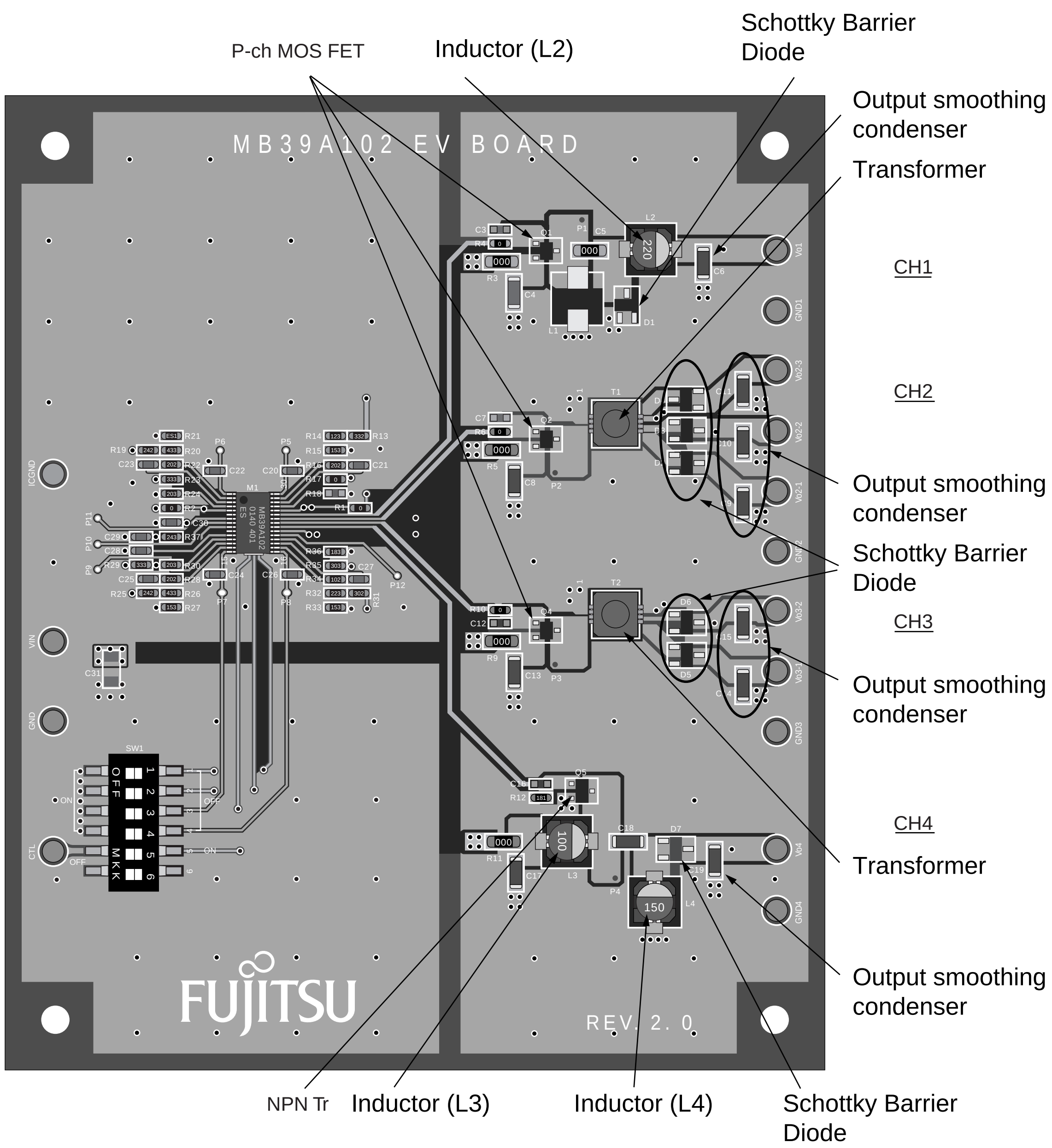
• Output is a feedback control none.



■ COMPONENT SELECTION METHODS

1. Board view



Board Photograph

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

2. CH1 : Output 2.5 V (Downconversion Type)

$V_{IN\,(Max)} = 6.0$ V, Io = 250 mA, fosc = 500 kHz

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

$V_{DS} = -20$ V, $V_{GS} = \pm 10$ V, $I_D = -1.5$ A, $R_{DS\,(ON)} = 340$ mΩ (Max) , Qg = 3.2 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.

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

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

$$I_D \geq I_O + \frac{V_{IN\,(Max)} - V_O}{2L} \times t_{ON}$$

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

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

- 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.

$$V_{DS} \leq -V_{IN\,(Max)}$$

$$\leq \underline{-6\text{ V}}$$

$$V_{GS} \geq V_{IN\,(Max)}$$

$$\geq \underline{6\text{ V}}$$

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

$$I_{FSM} \geq I_O + \frac{V_O}{2L} \times t_{OFF}$$

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

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

- 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.

$$I_F \geq I_O \times \frac{t_{OFF}}{t}$$

$$\geq 0.25 \times 0.583$$

$$\geq \underline{0.146A}$$

- 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.

$$V_{RRM} \geq V_{IN\ (Max)}$$

$$\geq \underline{6\ V}$$

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

22 µH (tolerance ± 20%) , rated current = 0.63 A
The condition for L to be a continuous current within the operating voltge range is obtained by the following formula.

$$L \geq \frac{V_{IN\ (Max)} - V_O}{2I_O} \times t_{ON}$$

$$\geq \frac{6-2.5}{2 \times 0.25} \times \frac{1}{500 \times 10^3} \times 0.42$$

$$\geq \underline{5.88\ \mu H}$$

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

$$I_O \geq \frac{V_O}{2L} \times t_{OFF}$$

$$\geq \frac{2.5}{2 \times 22 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times (1-0.42)$$

$$\geq \underline{66\ mA}$$

- 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.

$$I_L \geq I_O + \frac{V_{IN\ (Max)} - V_O}{2L} \times t_{ON}$$

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

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

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

$$\Delta I_L = \frac{V_{IN\ (Max)} - V_O}{L} \times t_{ON}$$

$$= \frac{6-2.5}{22 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.42$$

$$\fallingdotseq \underline{0.134\ A}$$

3. CH2, CH3 : (Transformer Conversion Type)

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

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

$V_{DS} = -20$ V, $V_{GS} = \pm 10$ V, $I_D = -1.5$ A, $R_{DS\,(ON)} = 340\text{ m}\Omega$ (Max) , Qg = 3.2 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} (repeated peak reverse voltage) = 50 V,
I_F (average output current) = 500 mA, I_{FSM} (surge forward current) = 5 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)

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

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

$V_{CEO} = 15$ V, $V_{CBO} = 15$ V, $I_C = 3$ A, $h_{FE} = 200$ (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.

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

$$t_{ON} = t \times \frac{V_O}{V_{IN}+V_O} = \frac{1}{f_{OSC}} \times \frac{V_O}{V_{IN}+V_O}$$

$$I_C \geq \frac{V_O+V_{IN\,(Min)}}{V_{IN\,(Min)}} \times I_O + \frac{1}{2}\left(\frac{1}{L_3}+\frac{1}{L_4}\right) \times V_{IN\,(Min)} \times t_{ON}$$

$$\geq \frac{3.3+2.5}{2.5} \times 0.5 + \frac{1}{2}\left(\frac{1}{10\times10^{-6}}+\frac{1}{15\times10^{-6}}\right) \times 2.5 \times \frac{1}{500\times10^{3}} \times 0.69$$

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

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.

$$V_{CEO} = V_{CBO} \geq V_{IN\,(Max)} + V_O$$

$$\geq 6+3.3$$

$$\geq \underline{9.3\text{ V}}$$

(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.

$$I_{FSM} \geq \frac{V_O+V_{IN\ (Min)}}{V_{IN\ (Min)}} \times I_O + \frac{1}{2}\left(\frac{1}{L_3}+\frac{1}{L_4}\right) \times V_O \times t_{OFF}$$

$$\geq \frac{3.3+2.5}{2.5} \times 0.5 + \frac{1}{2}\left(\frac{1}{10\times10^{-6}}+\frac{1}{15\times10^{-6}}\right) \times 3.3 \times \frac{1}{500\times10^{3}} \times (1-0.569)$$

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

- 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.

$$I_F \geq I_O$$

$$\geq \underline{0.5\ \text{A}}$$

- 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.

$$V_{RRM} \geq V_{IN\ (Max)}+V_O$$

$$\geq 6+3.3$$

$$\geq \underline{9.3\ \text{V}}$$

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

10 µH (tolerance ± 20%) , rated current = 0.94 A

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

$$L \geq \frac{V_{IN\ (Max)}{}^{2}}{2I_OV_O} \times t_{ON}$$

$$\geq \frac{6^2}{2\times0.5\times3.3} \times \frac{1}{500\times10^{3}} \times 0.355$$

$$\geq \underline{7.7\mu\text{H}}$$

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

$$I_O \geq \frac{V_{IN\ (Max)}{}^{2}}{2LV_O} \times t_{ON}$$

$$\geq \frac{6^2}{2\times10\times10^{-6}\times3.3} \times \frac{1}{500\times10^{3}} \times 0.355$$

$$\geq \underline{0.387\ \text{A}}$$

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.

$$I_L \geq \frac{V_O}{V_{IN\,(Min)}} \times I_O + \frac{V_{IN\,(Min)}}{2L} \times t_{ON}$$

$$\geq \frac{3.3}{2.5} \times 0.5 + \frac{2.5}{2 \times 10 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.57$$

$$\geq \underline{0.802\ A}$$

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

15 µH (tolerance ± 20%) , rated current = 0.76 A

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

$$L \geq \frac{V_{IN\,(Max)}}{2I_O} \times t_{ON}$$

$$\geq \frac{6}{2 \times 0.5} \times \frac{1}{500 \times 10^3} \times 0.355$$

$$\geq \underline{4.3 \mu H}$$

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

$$I_O \geq \frac{V_{IN\,(Max)}}{2L} \times t_{ON}$$

$$\geq \frac{6}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.355$$

$$\geq \underline{0.142\ A}$$

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.

$$I_L \geq I_O + \frac{V_{IN\,(Max)}}{2L} \times t_{ON}$$

$$\geq 0.5 + \frac{6}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.355$$

$$\geq \underline{0.642\ A}$$

■ ORDERING INFORMATION

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

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