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DS04-71105-1Ea

ASSP for Power Supply Applications

Evaluation Board

MB39A104

■ DESCRIPTION

The MB39A104 evaluation board is a surface mount circuit board with 2 channels of down conversion circuit.Because output voltage set 5 V and 3.3 V, the current of Max 3 A is supplied from the power-supply voltage between 7 V to 19 V. MB39A104 has a circuit configuration with no sense resistor as it is provided with overcurrent protection, eliminating the need for an external sense resistor.The board incorporates the protective functions that upon detection of a short-circuit or activation of the under voltage lockout protection, the circuit protection feature shuts off transistors to stop the output.In addition, each channel can be controlled to be turned on and off and can be set for a soft-start.

■ EVALUATION BOARD SPECIFICATIONS

		Rating			Unit
		Min	Typ	Max	
Input voltage		7	12	19	V
Oscillation frequency		420	500	580	kHz
Output voltage	(CH1)	4.90	5.0	5.09	V
	(CH2)	3.24	3.3	3.36	
Output current	(CH1)	1.0	—	3.0	A
	(CH2)	1.0	—	3.0	
Output ripple voltage	(CH1)	—	—	50	mV
	(CH2)	—	—	33	
Soft-start time	(CH1)	7.8	12.4	23	ms
	(CH2)	7.8	12.4	23	
Short-circuit detection time		0.43	0.73	1.43	ms
Detection current of overcurrent protection*	(CH1)	5.54	5.75	5.88	A
	(CH2)	5.60	5.78	5.90	

* : These values are simulated at V_{IN} = 12 V (Typ) and Ron = 50 mΩ.

2003.7

■ TERMINAL DESCRIPTION

	Symbol	Function
1	VIN	Source and IC driving power - supply terminal
2	GND	Main GND terminal
3	CS1, CS2	Channel OFF terminal
4	GND	GND
5	OUT1, OUT2	Output terminal
6	GND1, GND2	DC/DC converter GND terminal
7	VREF	Reference voltage output terminal
8	SGND	IC control side GND terminal
9	DTC1, DTC2	External duty control terminal
10	CTL	Power - supply control terminal

■ SWITCH DESCRIPTION

SWITCH	FUNCTION	ON	OFF
SW1	power - supply control	H(operation)	L(Standby)
SW2	CH1 control	L(operation)	H(Standby)
SW3	CH2 control	L(operation)	H(Standby)

■ SETUP AND CHECKUP

(1) Setup

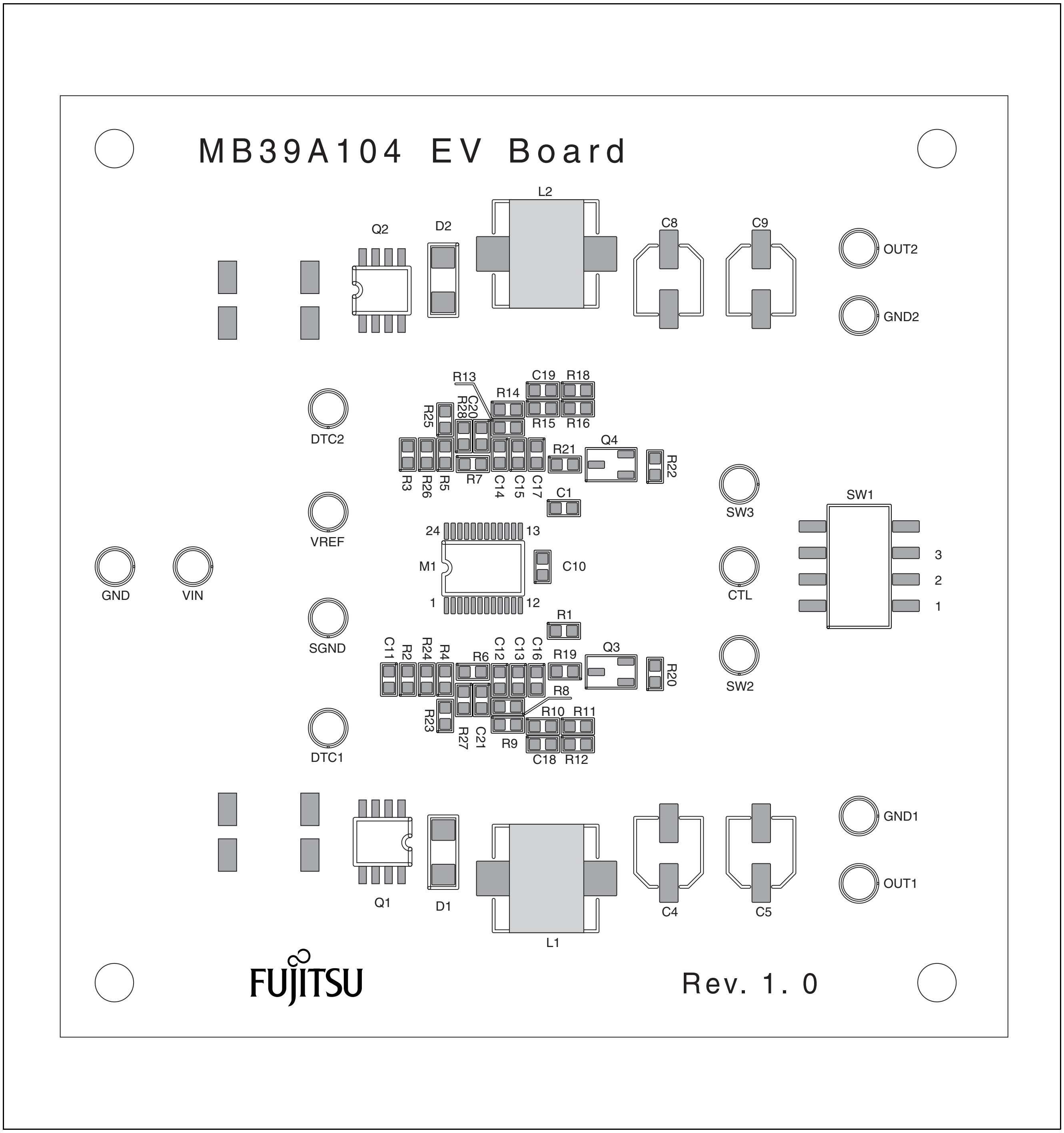
- Connect power supply terminal to VIN and GND.Connect OUT1 or OUT2 to the required loading device or measuring instrument.
- Set SW1, SW2, SW3 to OFF.

(2) Checkup

Set SW1, SW2, SW3 to ON, and turn on VIN. The IC works normally with the following outputs: OUT1 = 5 V (Typ), OUT2 = 3.3 V(Typ).

■ COMPONENT LAYOUT

• On-board Component Layout



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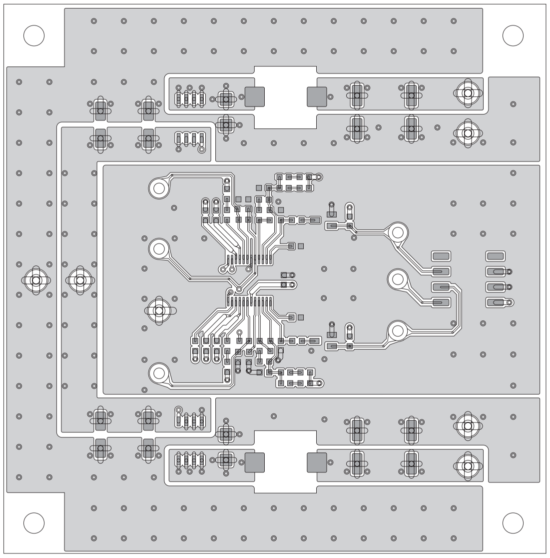
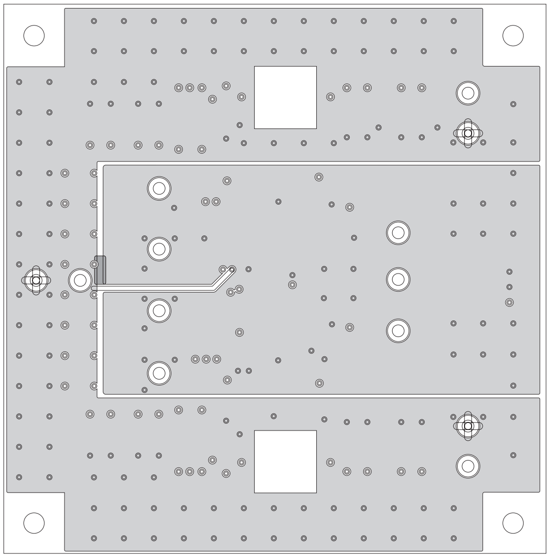
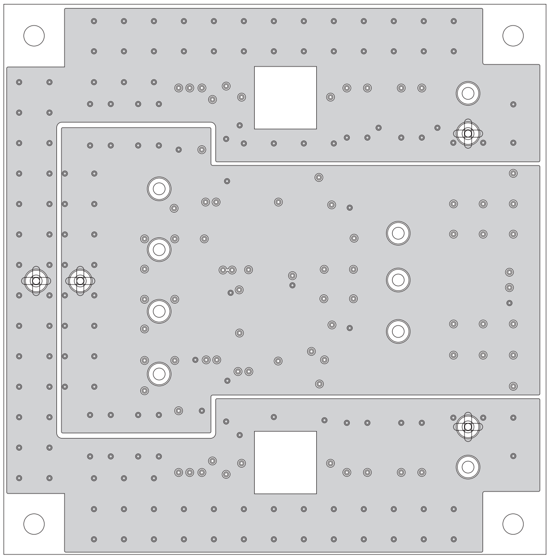
Board Layout



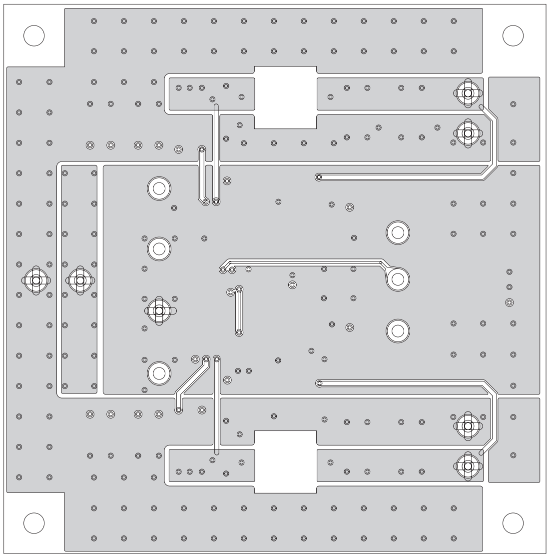
Top Side



Inside GND (LAYER2)

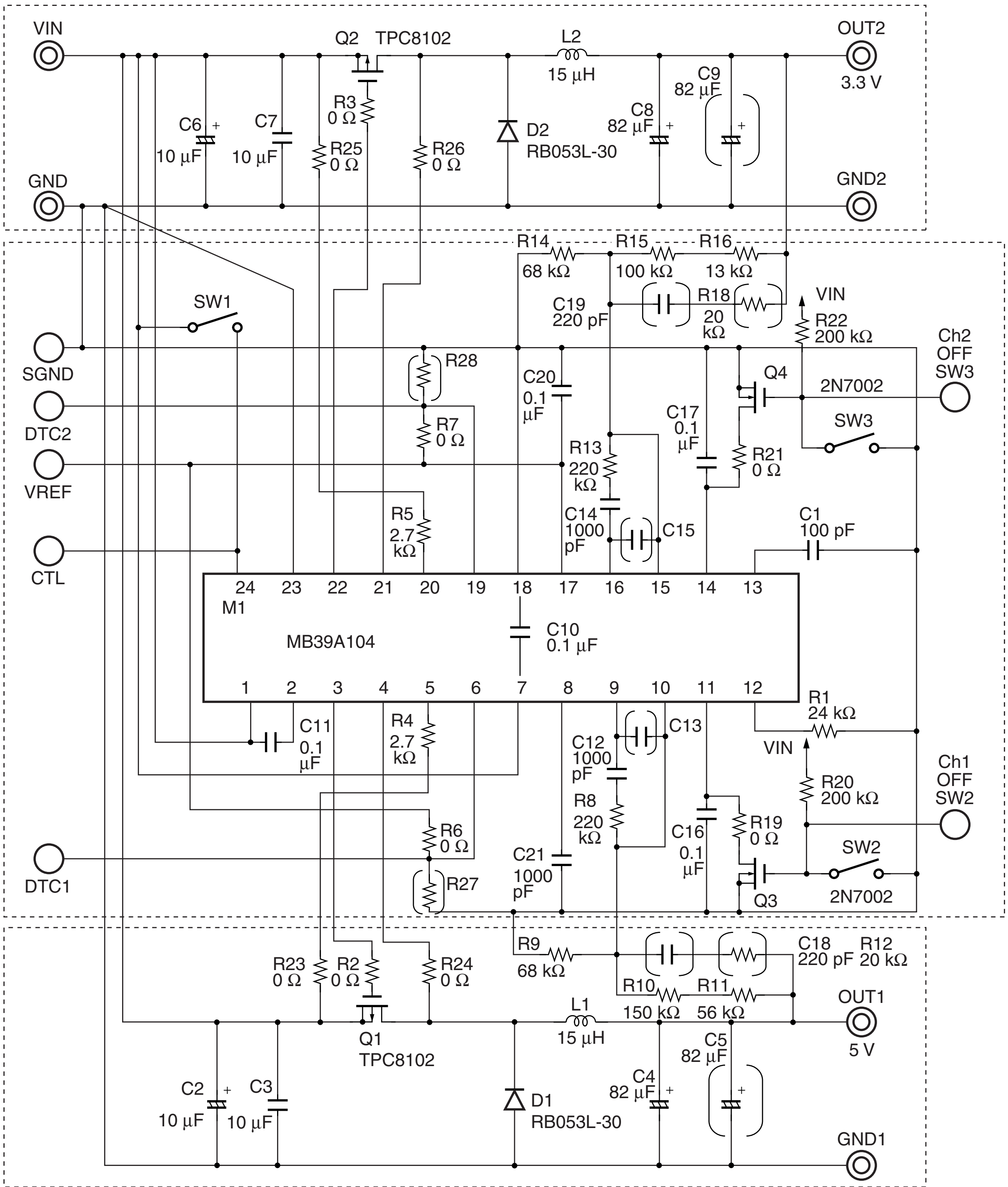


Inside VIN (LAYER3)



Bottom Side

■ CONNECTION DIAGRAM



■ PARTS LIST

Part No.	Part name	Specification	Manufacturer	Package	Part number	Note
M1	IC	MB39A104	FUJITSU MICROELEC-TRONICS	FPT-24P-M03	MB39A104PFV	
Q1, Q2	P-ch FET	VDS = − 30 V, Qg = 43 nC (Typ)	TOSHIBA	SO-8	TPC8102	
Q3, Q4	N-ch FET	VDS = 60 V, ID = 0.24 A (Max)	Siliconix	TO-236	2N7002E	
D1, D2	Diode	VF = 0.42 V (Max), at IF = 3 A	ROHM	PMDS	RB053L-30	
L1, L2	Inductor	15 µH	SUMIDA	SMD	CDRH104R-150	
C1	Ceramic condenser	100 pF (50 V)	TDK	1608 type	C1608CH1H101J	
C2, C6	OS-CON™	10 µF (20 V)	SANYO	SMD	20SVP10M	
C3, C7	Ceramic condenser	10 µF (25 V)	TDK	3225 type	C3325JF1E106Z	
C4, C8	OS-CON™	82 µF (6.3 V)	SANYO	SMD	6SVP82M	
C5, C9	OS-CON™	82 µF (6.3 V)	SANYO	SMD	6SVP82M	Not mounted
C10, C11, C20	Ceramic condenser	0.1 µF (50 V)	TDK	1608 type	C1608JB1H104K	
C12	Ceramic condenser	1000 pF (50 V)	TDK	1608 type	C1608JB1H102K	
C13, C15						Not mounted
C14	Ceramic condenser	1000 pF (50 V)	TDK	1608 type	C1608JB1H102K	
C16, C17	Ceramic condenser	0.1 µF (50 V)	TDK	1608 type	C1608JB1H104K	
C18	Ceramic condenser	220 pF (50 V)	TDK	1608 type	C1608JB1H221K	Not mounted
C19	Ceramic condenser	220 pF (50 V)	TDK	1608 type	C1608JB1H221K	Not mounted
C21	Ceramic condenser	1000 pF (50 V)	TDK	1608 type	C1608JB1H102K	
R1	Resistor	24 kΩ (0.5%)	ssm	1608 type	RR0816P243D	
R2, R3, R6, R7	Jumper	0 Ω	KOA	1608 type	RK73Z1J-0D	
R4, R5	Resistor	2.7 kΩ (0.5%)	ssm	1608 type	RR0816P272D	
R8	Resistor	220 kΩ (0.5%)	ssm	1608 type	RR0816P224D	

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(Continued)

Part No.	Part name	Specification	Manufacturer	Package	Part number	Note
R9	Resistor	68 kΩ (0.5%)	ssm	1608 type	RR0816P683D	
R10	Resistor	150 kΩ (0.5%)	ssm	1608 type	RR0816P154D	
R11	Resistor	56 kΩ (0.5%)	ssm	1608 type	RR0816P563D	
R12	Resistor	20 kΩ (0.5%)	ssm	1608 type	RR0816P203D	Not mounted
R13	Resistor	220 kΩ (0.5%)	ssm	1608 type	RR0816P224D	
R14	Resistor	68 kΩ (0.5%)	ssm	1608 type	RR0816P683D	
R15	Resistor	100 kΩ (0.5%)	ssm	1608 type	RR0816P104D	
R16	Resistor	13 kΩ (0.5%)	ssm	1608 type	RR0816P133D	
R18	Resistor	20 kΩ (0.5%)	ssm	1608 type	RR0816P203D	Not mounted
R19, R21	Jumper	0 Ω	KOA	1608 type	RK73Z1J-0D	
R20, R22	Resistor	200 kΩ (0.5%)	ssm	1608 type	RR0816P204D	
R23, R24, R25, R26	Jumper	0 Ω	KOA	1608 type	RK73Z1J-0D	
R27, R28						Not mounted
SW1, SW2, SW3	DIP switch	4 pole	MATSUKYU		DMS-4H	
Pin	Terminal pins	WT-2-1	MacEight		WT-2-1	

Note : OS-CON is a trademark of SANYO Electric Co., Ltd.

TOSHIBA	TOSHIBA CORPORATION Semiconductor Company
Siliconix	VISHAY Intertechnology, Inc
ROHM	ROHM Co., Ltd.
SUMIDA	Sumida Corporation
SANYO	SANYO Electric Co., Ltd.
TDK	TDK Corporation
ssm	SUSUMU CO., LTD.
KOA	KOA Corporation
MATSUKYU	Matsukyu Co., Ltd.
MacEight	MacEight Co., Ltd.

■ INITIAL SETTINGS

(1) Output voltage

CH1

$V_O1\ (V) = 1.24 / R9 \times (R9 + R10 + R11) \doteqdot 5.0\ (V)$

CH2

$V_O2\ (V) = 1.24 / R14 \times (R14 + R15 + R16) \doteqdot 3.3\ (V)$

(2) Oscillation frequency

$f_{OSC}\ (kHz) = 1200000 / (C1\ (pF) \times R1\ (k\Omega)) \doteqdot 500\ (kHz)$

(3) Soft-start time

CH1

$ts\ (s) = 0.124 \times C16\ (\mu F) \doteqdot 12.4\ (ms)$

CH2

$ts\ (s) = 0.124 \times C17\ (\mu F) \doteqdot 12.4\ (ms)$

(4) Short-circuit detection time

$tscp\ (s) = 0.73 \times C21\ (\mu F) \doteqdot 0.73\ (ms)$

(5) Detection current of overcurrent protection

CH1 ($I_{LIM} = 110\ \mu A$, $R_{ON} = 50.0\ m\Omega$, $V_{IN} = 12\ V$, $V_O1 = 5.0\ V$)

$I_{OCP}\ (A) = I_{LIM} \times R4 / R_{ON} - ((V_{IN} - V_O1) \times V_O1) / (2 \times V_{IN} \times f_{OSC} \times L1) \doteqdot 5.75\ (A)$

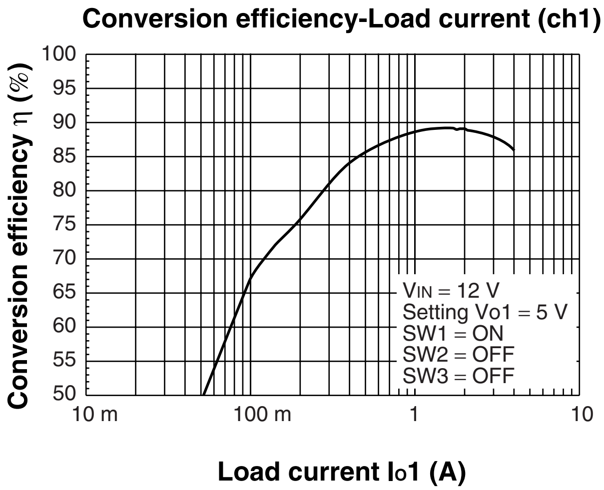
CH2 ($I_{LIM} = 110\ \mu A$, $R_{ON} = 50.0\ m\Omega$, $V_{IN} = 12\ V$, $V_O2 = 3.3\ V$)

$I_{OCP}\ (A) = I_{LIM} \times R5 / R_{ON} - ((V_{IN} - V_O2) \times V_O2) / (2 \times V_{IN} \times f_{OSC} \times L2) \doteqdot 5.78\ (A)$

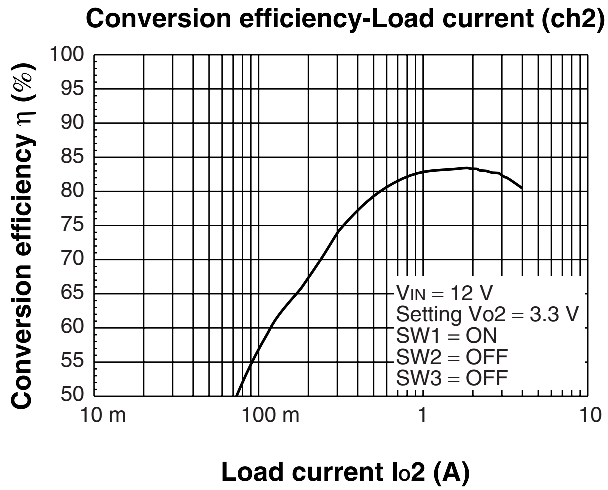
■ REFERENCE DATA

(1) Conversion efficiency vs. load current characteristics (V_{IN} = 12 V)

ch1

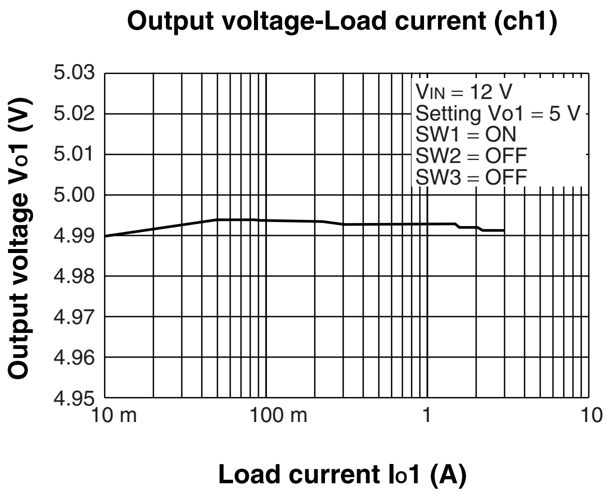


ch2

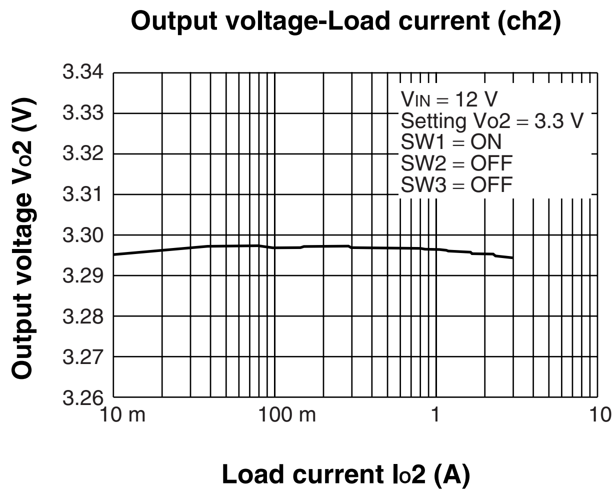


(2) Load Reguration (V_{IN} = 12 V)

ch1

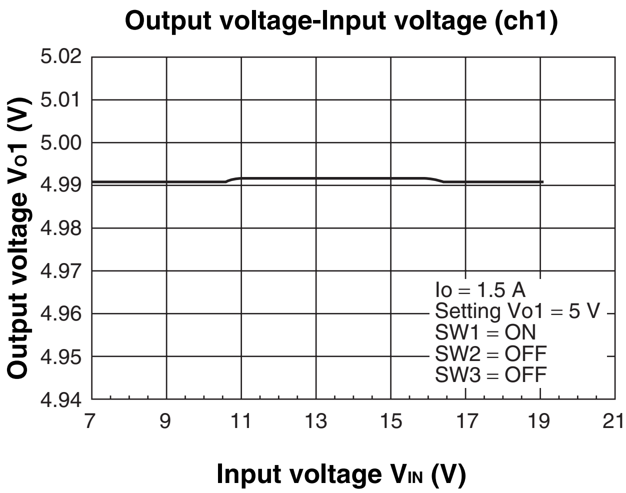


ch2

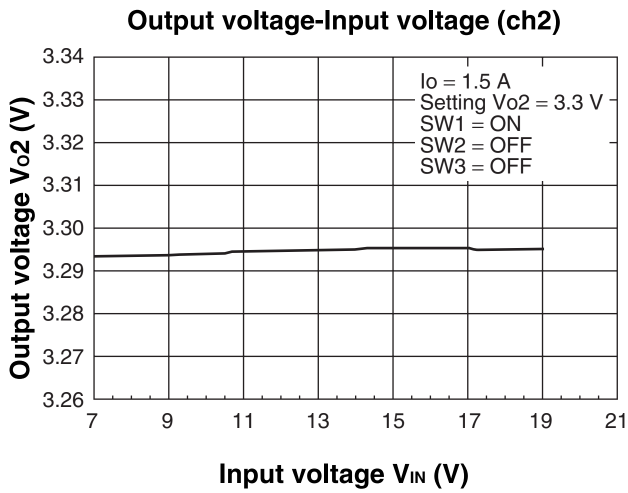


(3) Line regulation

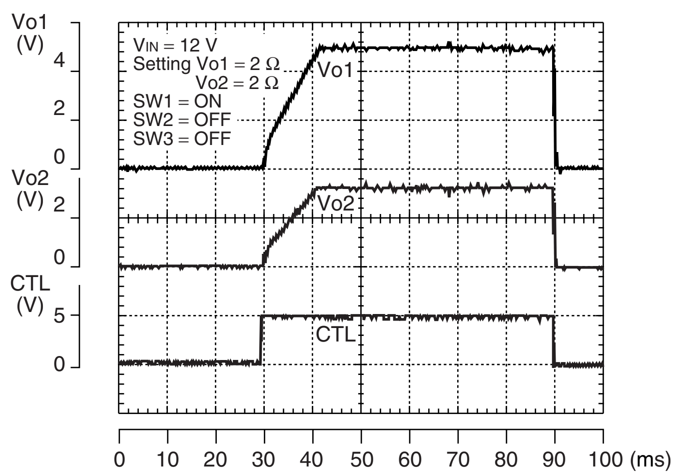
ch1



ch2

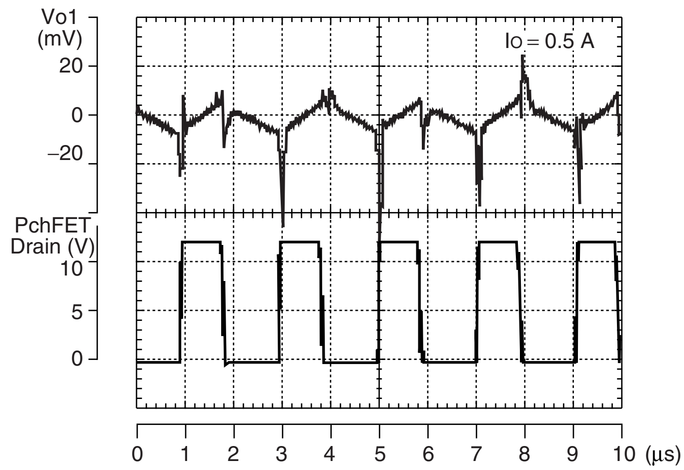


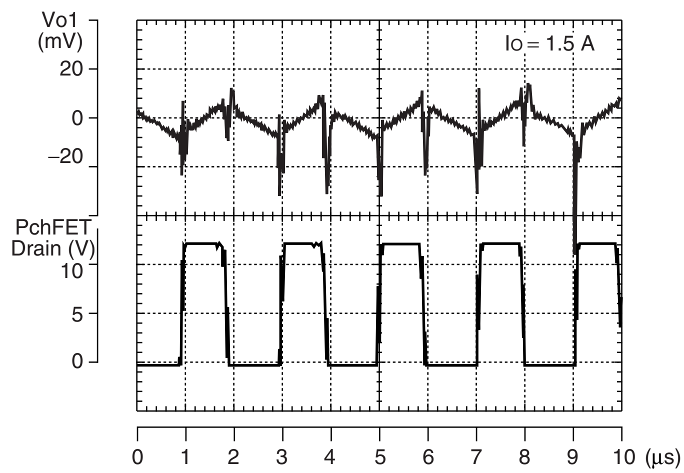
(4) Soft - start/discharge operation waveforms

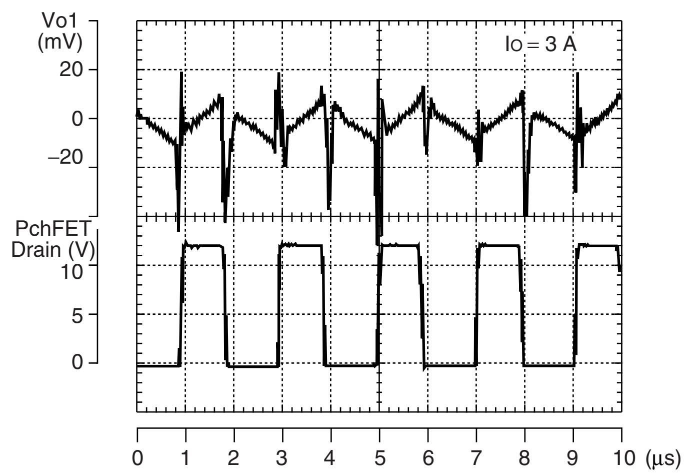


(5) Output ripple waveforms (V_{IN} = 12 V)

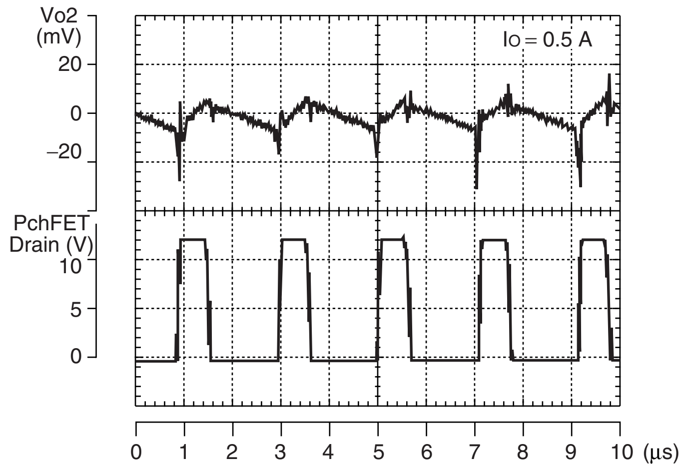
ch1

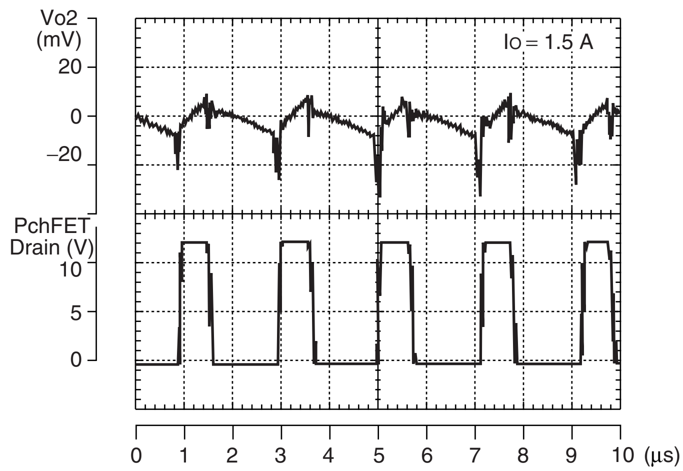


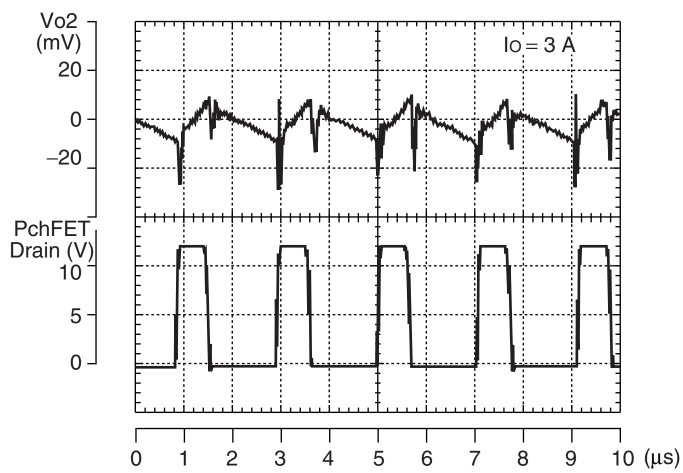




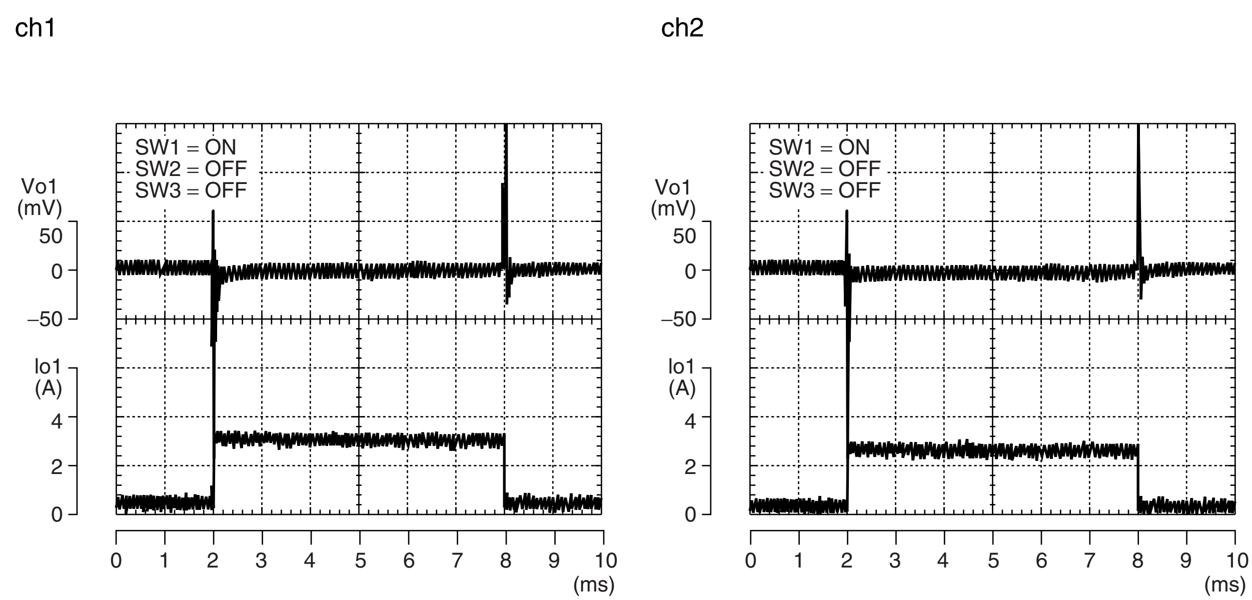
ch2


Vo2
(mV)
20
0
–20
PchFET
Drain (V)
10
5
0
IO = 0.5 A
0
1
2
3
4
5
6
7
8
9
10 (µs)

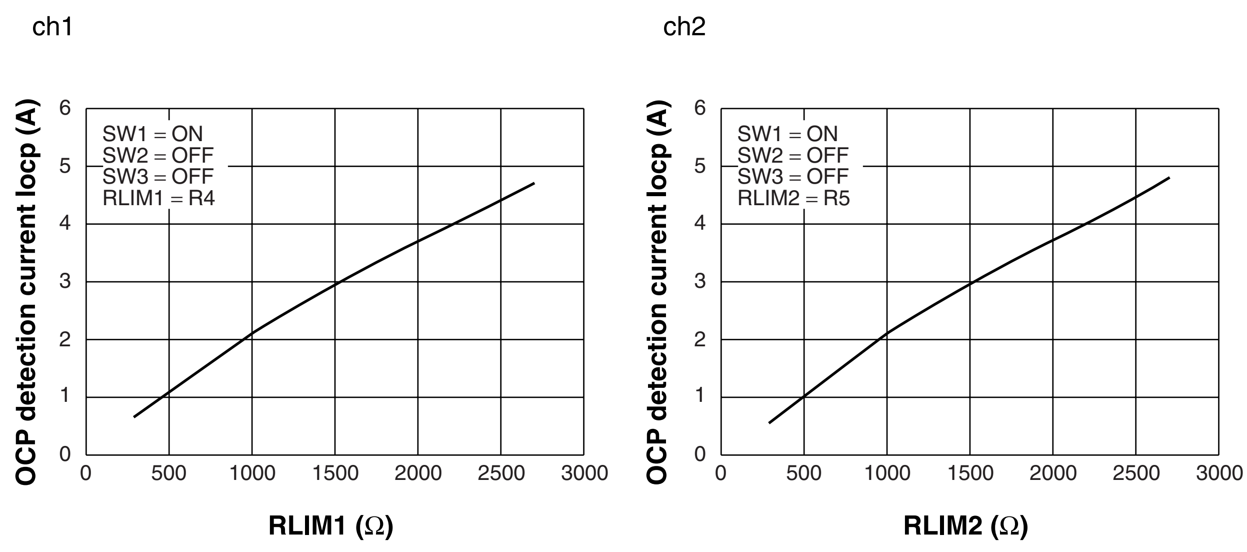

Vo2
(mV)
20
0
–20
PchFET
Drain (V)
10
5
0
IO = 1.5 A
0
1
2
3
4
5
6
7
8
9
10 (µs)


Vo2
(mV)
20
0
–20
PchFET
Drain (V)
10
5
0
IO = 3 A
0
1
2
3
4
5
6
7
8
9
10 (µs)

(6) Output waveform at load sudden change (V_{IN} = 12 V)

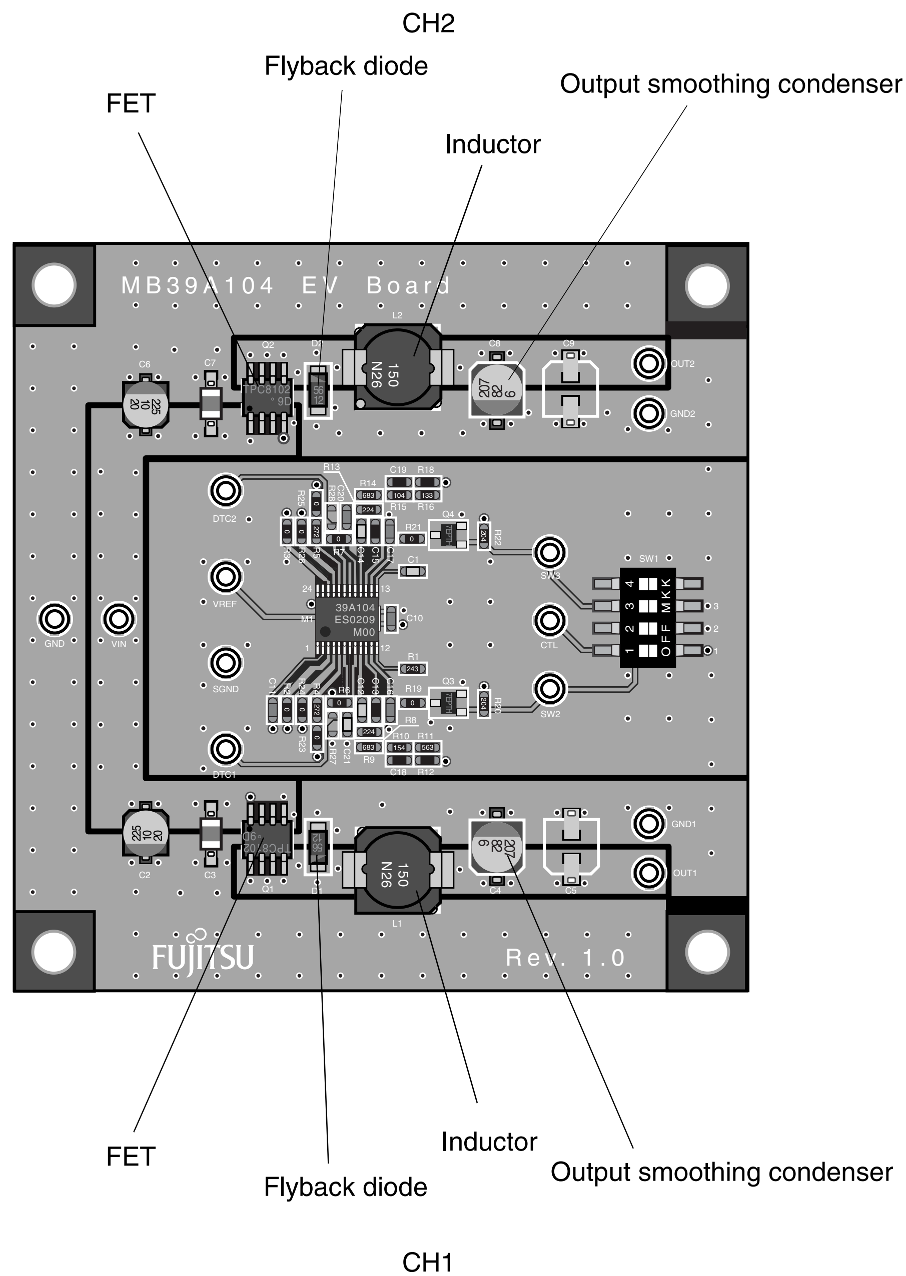


(7) Overcurrent protection characteristics (V_{IN} = 12 V)



■ COMPONENT SELECTION METHODS

1. Board view



Board Photograph

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

V_{IN} = 19 V (Max) , Vo1 = 5.0 V, Vo2 = 3.3 V, Io = 3.0 A, f_{OSC} = 500 kHz

2. P - ch MOSFET(TPC8102(TOSHIBA product))

$V_{DS} = -30$ V, $V_{GS} = \pm 20$ V, I_D = 6 A, R_{DS} (on) = 34 mΩ (Typ) , Qg = 43 nC (Typ)

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.

ch1 side

$$I_D \geq I_O + \frac{V_{IN} - Vo1}{2L} ton$$

$$\geq 3 + \frac{19 - 5}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.263$$

$$\geq \underline{3.25\ A}$$

ch2 side

$$I_D \geq I_O + \frac{V_{IN} - Vo2}{2L} ton$$

$$\geq 3 + \frac{19 - 3.3}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.174$$

$$\geq \underline{3.18\ A}$$

3. Inductor (CDRH104R - 150:SUMIDAproduct)

15 µH (tolerance ± 30%), rated current = 3.6 A

L value at entire road current condition: Set the peak-to-peak ripple current to less than half road current

ch1 side

$$L \geq \frac{2\,(V_{IN} - Vo1)}{I_O}\,ton$$

$$\geq \frac{2 \times (19 - 5)}{3} \times \frac{1}{500 \times 10^3} \times 0.263$$

$$\geq \underline{4.91\ \mu H}$$

ch2 side

$$L \geq \frac{2\,(V_{IN} - Vo2)}{I_O}\,ton$$

$$\geq \frac{2 \times (19 - 3.3)}{3} \times \frac{1}{500 \times 10^3} \times 0.174$$

$$\geq \underline{3.64\ \mu H}$$

The load current satisfying the continuous current condition

ch1 side

$$I_O \geq \frac{Vo1}{2L}\,toff$$

$$\geq \frac{5}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times (1 - 0.263)$$

$$\geq \underline{245.7\ mA}$$

ch2 side

$$I_O \geq \frac{Vo2}{2L}\,toff$$

$$\geq \frac{3.3}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times (1 - 0.174)$$

$$\geq \underline{181.7\ mA}$$

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.

ch1 side

$$I_L \geq I_O + \frac{V_{IN} - Vo1}{2L} ton$$

$$\geq 3 + \frac{19 - 5}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.263$$

$$\geq \underline{3.25\ A}$$

ch2 side

$$I_L \geq I_O + \frac{V_{IN} - Vo2}{2L} ton$$

$$\geq 3 + \frac{19 - 3.3}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.174$$

$$\geq \underline{3.18\ A}$$

Ripple current:Peak - to - peak value

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

ch1 side

$$\Delta I_L = \frac{V_{IN} - Vo1}{L} ton$$

$$= \frac{19 - 5}{15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.263$$

$$\doteqdot \underline{0.491\ A}$$

ch2 side

$$\Delta I_L = \frac{V_{IN} - Vo2}{L} ton$$

$$= \frac{19 - 3.3}{15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.174$$

$$\doteqdot \underline{0.364\ A}$$

4. Output smoothing condenser

82 µF, rated voltage = 6.3 V, ESR = 50 mΩ, maximum allowable ripple current = 1570 mArms

The output ripple voltage is ΔV_O, output smoothing condenser is C_L, ripple current is $I_{CL}rms$, and series resistance is ESR.

ESR, C_L, $I_{CL}rms$ values of single using are obtained by the following formula.

Series resistance

ch1 side

$$ESR \leq \frac{\Delta Vo}{\Delta I_L} - \frac{1}{2\pi f C_L}$$

$$\leq \frac{0.050}{0.491} - \frac{1}{2\pi \times 500 \times 10^3 \times 82 \times 10^{-6}}$$

$$\leq \underline{98.0\ m\Omega}$$

Resistance of the above condenser is <u>50 mΩ</u> and acceptable.

ch2 side

$$ESR \leq \frac{\Delta Vo}{\Delta I_L} - \frac{1}{2\pi f C_L}$$

$$\leq \frac{0.033}{0.364} - \frac{1}{2\pi \times 500 \times 10^3 \times 82 \times 10^{-6}}$$

$$\leq \underline{86.8\ m\Omega}$$

Resistance of the above condenser is <u>50 mΩ</u> and acceptable.

Condenser

ch1 side

$$C_L \geq \frac{\Delta I_L}{2\pi f\ (\Delta Vo - \Delta I_L \times ESR)}$$

$$\geq \frac{0.491}{2\pi \times 500 \times 10^3 \times (0.050 - 0.491 \times 0.05)}$$

$$\geq \underline{6.14\ \mu F}$$

Capacitance of the above condenser is <u>82 µF (Typ)</u> and acceptable.

ch2 side

$$C_L \geq \frac{\Delta I_L}{2\pi f\ (\Delta Vo - \Delta I_L \times ESR)}$$

$$\geq \frac{0.364}{2\pi \times 500 \times 10^3 \times (0.033 - 0.364 \times 0.05)}$$

$$\geq \underline{7.83\ \mu F}$$

Capacitance of the above condenser is <u>82 µF (Typ)</u> and acceptable.

Ripple current

ch1 side

$$I_{CL}rms \geq \frac{(V_{IN} - Vo1)\ ton}{2\sqrt{3}L}$$

$$\geq \frac{(19 - 5) \times 0.263}{2\sqrt{3} \times 15 \times 10^{-6} \times 500 \times 10^{3}}$$

$\geq$ <u>141.7 mArms</u>

Maximum allowable ripple current of the above condenser is <u>1570 mArms</u> and acceptable.

ch2 side

$$I_{CL}rms \geq \frac{(V_{IN} - Vo2)\ ton}{2\sqrt{3}L}$$

$$\geq \frac{(19 - 3.3) \times 0.174}{2\sqrt{3} \times 15 \times 10^{-6} \times 500 \times 10^{3}}$$

$\geq$ <u>105.1 mArms</u>

Maximum allowable ripple current of the above condenser is <u>1570 mArms</u> and acceptable.

5. Flyback diode(RB053L - 30:ROHM product)

V_R (reverse DC voltage) = 30 V, average output current = 3.0 A, peak current = 10 A

V_F (forward voltage) = 0.42V, at IF = 3.0 A

V_R : value enough to satisfy the input voltage→30 V

On time of the diode is assumed to be t_D(Max), the diode average current I_{Di} is obtained by the following formula.
ch1 side

$$I_{Di} \geq I_O \times (1 - \frac{Vo1}{V_{IN}}) = 3 \times (1 - 0.263) \doteqdot \underline{2.21\ A}$$

ch2 side

$$I_{Di} \geq I_O \times (1 - \frac{Vo2}{V_{IN}}) = 3 \times (1 - 0.174) \doteqdot \underline{2.48\ A}$$

On time of the diode is assumed to be t_D(Max), the diode peak current I_{Dip} is obtained by the following formula.
ch1 side

$$I_{Dip} \geq (I_O + \frac{Vo1}{2L} toff) \doteqdot \underline{3.24\ A}$$

ch2 side

$$I_{Dip} \geq (I_O + \frac{Vo2}{2L} toff) \doteqdot \underline{3.18\ A}$$

■ ORDERING INFORMATION

EV board part No.	EVboard version No.	Remarks
MB39A104EVB	MB39A104 EV Board Rev.1.0	

MEMO

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