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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 $V_{IN} = 12\text{ V}$ (Typ) and $R_{on} = 50\text{ m}\Omega$.

■ 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

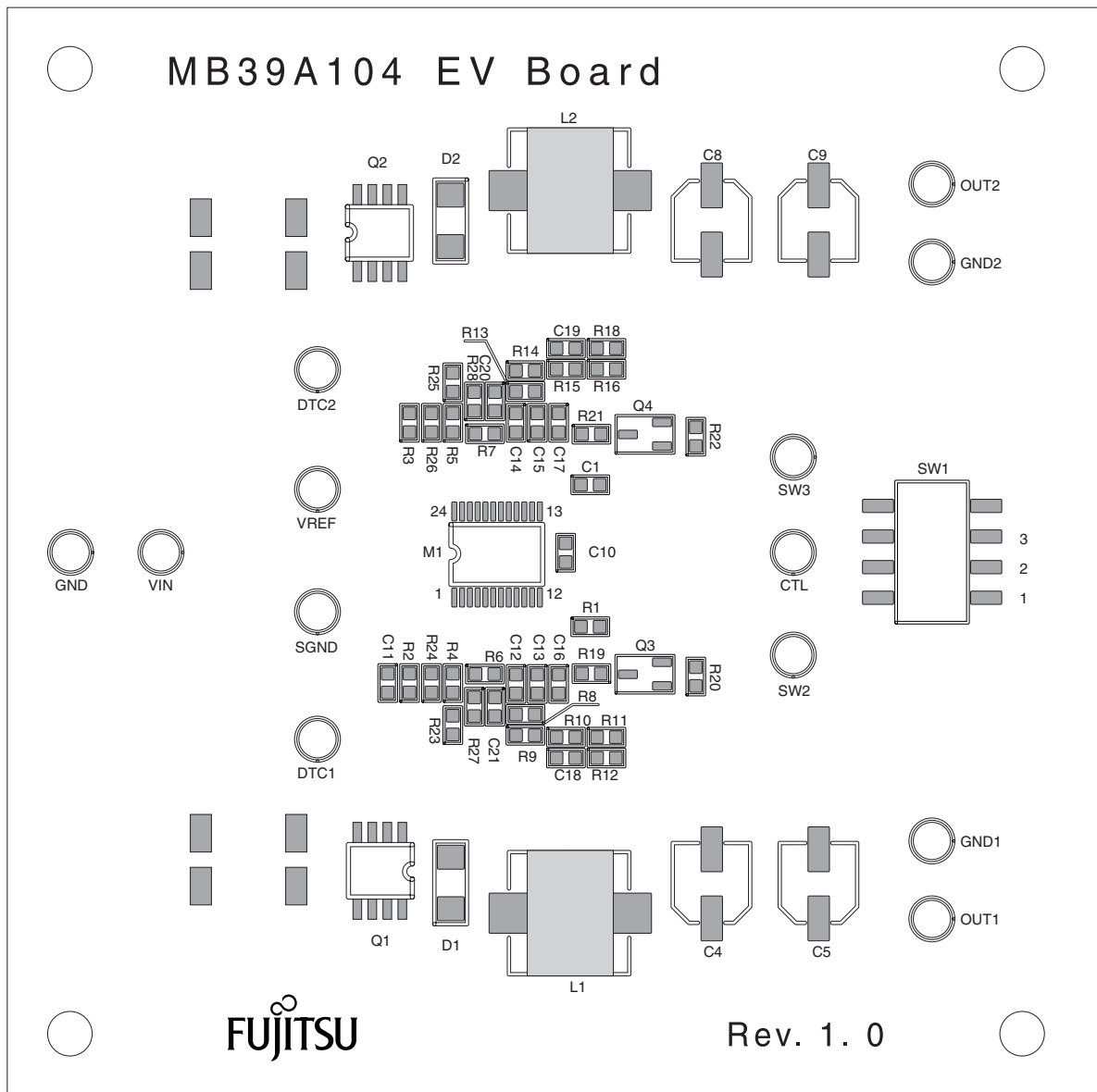
- Connect power supply terminal to VIN and GND. Connect OUT1 or OUT2 to the required loading device or measuring instrument.
- Set SW1, SW2, SW3 to OFF.

(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

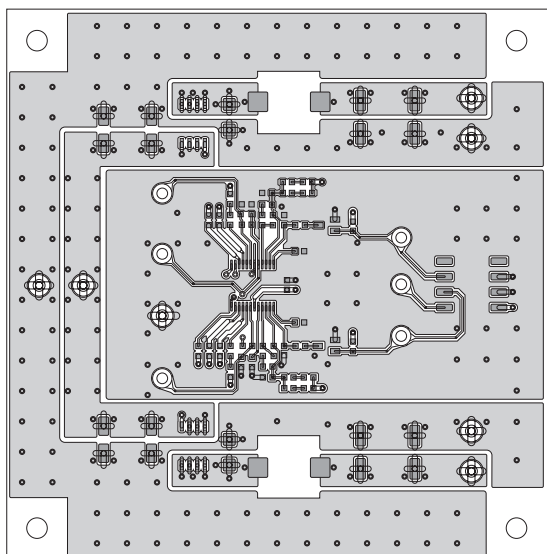
- On-board Component Layout



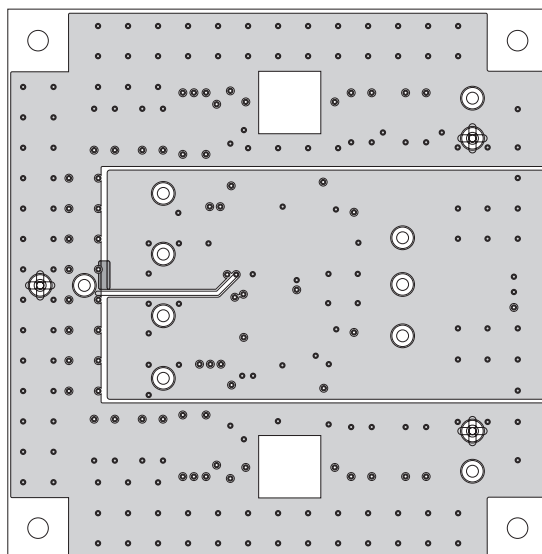
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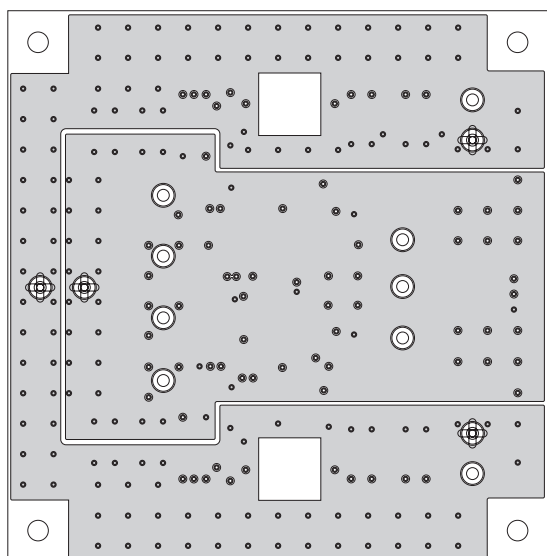
Board Layout



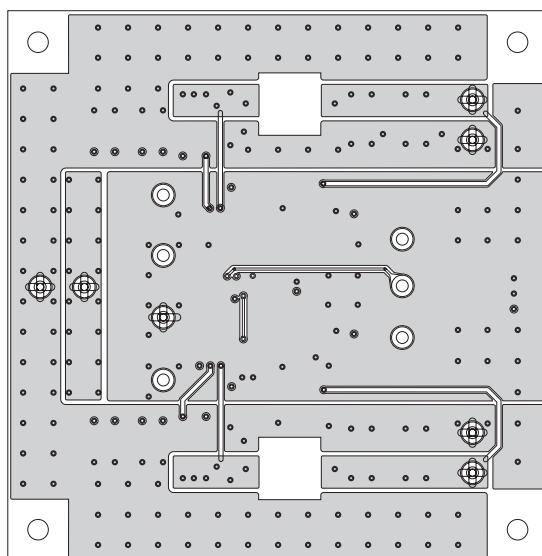
Top Side



Inside GND (LAYER2)

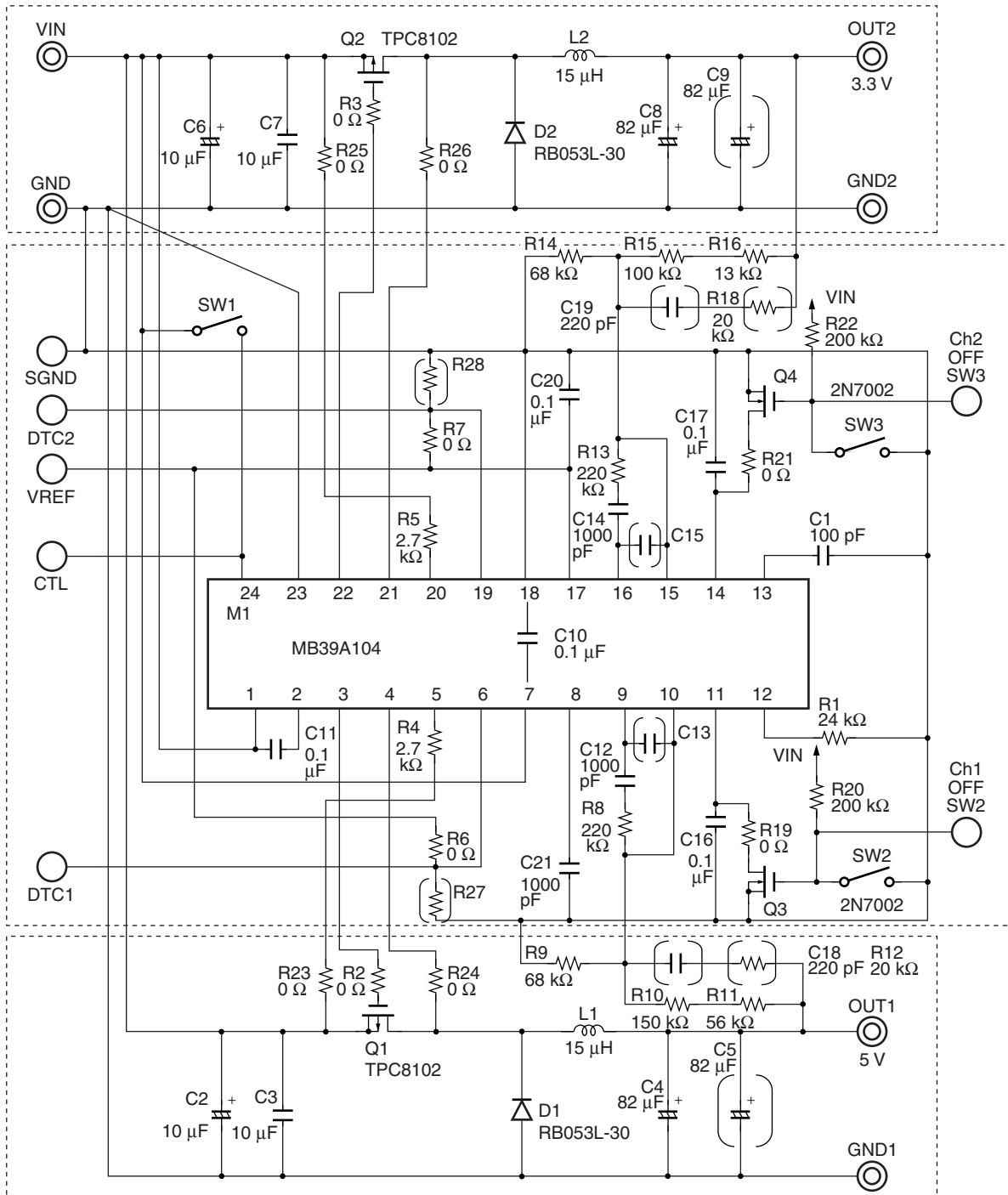


Inside VIN (LAYER3)



Bottom Side

CONNECTION DIAGRAM



MB39A104

■ 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 μ H | SUMIDA | SMD | CDRH104R-150 | |
| C1 | Ceramic condenser | 100 pF (50 V) | TDK | 1608 type | C1608CH1H101J | |
| C2, C6 | OS-CON™ | 10 μ F (20 V) | SANYO | SMD | 20SVP10M | |
| C3, C7 | Ceramic condenser | 10 μ F (25 V) | TDK | 3225 type | C3325JF1E106Z | |
| C4, C8 | OS-CON™ | 82 μ F (6.3 V) | SANYO | SMD | 6SVP82M | |
| C5, C9 | OS-CON™ | 82 μ F (6.3 V) | SANYO | SMD | 6SVP82M | Not mounted |
| C10, C11, C20 | Ceramic condenser | 0.1 μ F (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 μ F (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 k Ω (0.5%) | ssm | 1608 type | RR0816P243D | |
| R2, R3, R6, R7 | Jumper | 0 Ω | KOA | 1608 type | RK73Z1J-0D | |
| R4, R5 | Resistor | 2.7 k Ω (0.5%) | ssm | 1608 type | RR0816P272D | |
| R8 | Resistor | 220 k Ω (0.5%) | ssm | 1608 type | RR0816P224D | |

(Continued)

(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

$$V_{o1} \text{ (V)} = 1.24 / R9 \times (R9 + R10 + R11) \div 5.0 \text{ (V)}$$

CH2

$$V_{o2} \text{ (V)} = 1.24 / R14 \times (R14 + R15 + R16) \div 3.3 \text{ (V)}$$

(2) Oscillation frequency

$$f_{osc} \text{ (kHz)} = 1200000 / (C1 \text{ (pF)} \times R1 \text{ (k}\Omega\text{)}) \div 500 \text{ (kHz)}$$

(3) Soft-start time

CH1

$$t_s \text{ (s)} = 0.124 \times C16 \text{ (}\mu\text{F)} \div 12.4 \text{ (ms)}$$

CH2

$$t_s \text{ (s)} = 0.124 \times C17 \text{ (}\mu\text{F)} \div 12.4 \text{ (ms)}$$

(4) Short-circuit detection time

$$t_{scp} \text{ (s)} = 0.73 \times C21 \text{ (}\mu\text{F)} \div 0.73 \text{ (ms)}$$

(5) Detection current of overcurrent protection

CH1 ($I_{LIM} = 110 \mu\text{A}$, $R_{ON} = 50.0 \text{ m}\Omega$, $V_{IN} = 12 \text{ V}$, $V_{o1} = 5.0 \text{ V}$)

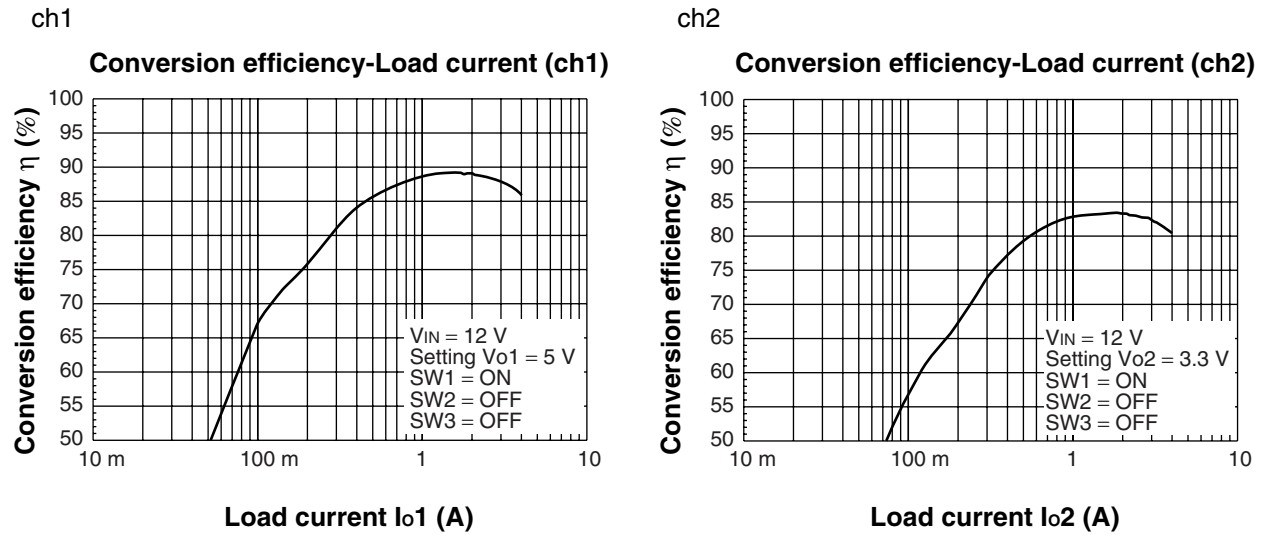
$$I_{ocp} \text{ (A)} = I_{LIM} \times R4 / R_{ON} - (V_{IN} - V_{o1}) \times V_{o1} / (2 \times V_{IN} \times f_{osc} \times L1) \div 5.75 \text{ (A)}$$

CH2 ($I_{LIM} = 110 \mu\text{A}$, $R_{ON} = 50.0 \text{ m}\Omega$, $V_{IN} = 12 \text{ V}$, $V_{o2} = 3.3 \text{ V}$)

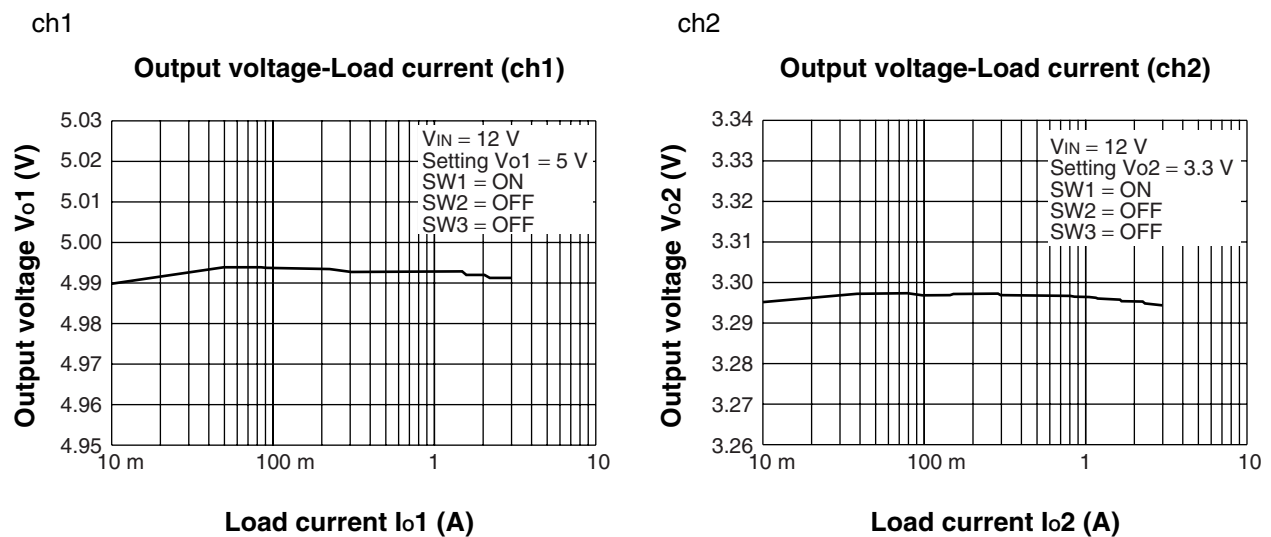
$$I_{ocp} \text{ (A)} = I_{LIM} \times R5 / R_{ON} - (V_{IN} - V_{o2}) \times V_{o2} / (2 \times V_{IN} \times f_{osc} \times L2) \div 5.78 \text{ (A)}$$

■ REFERENCE DATA

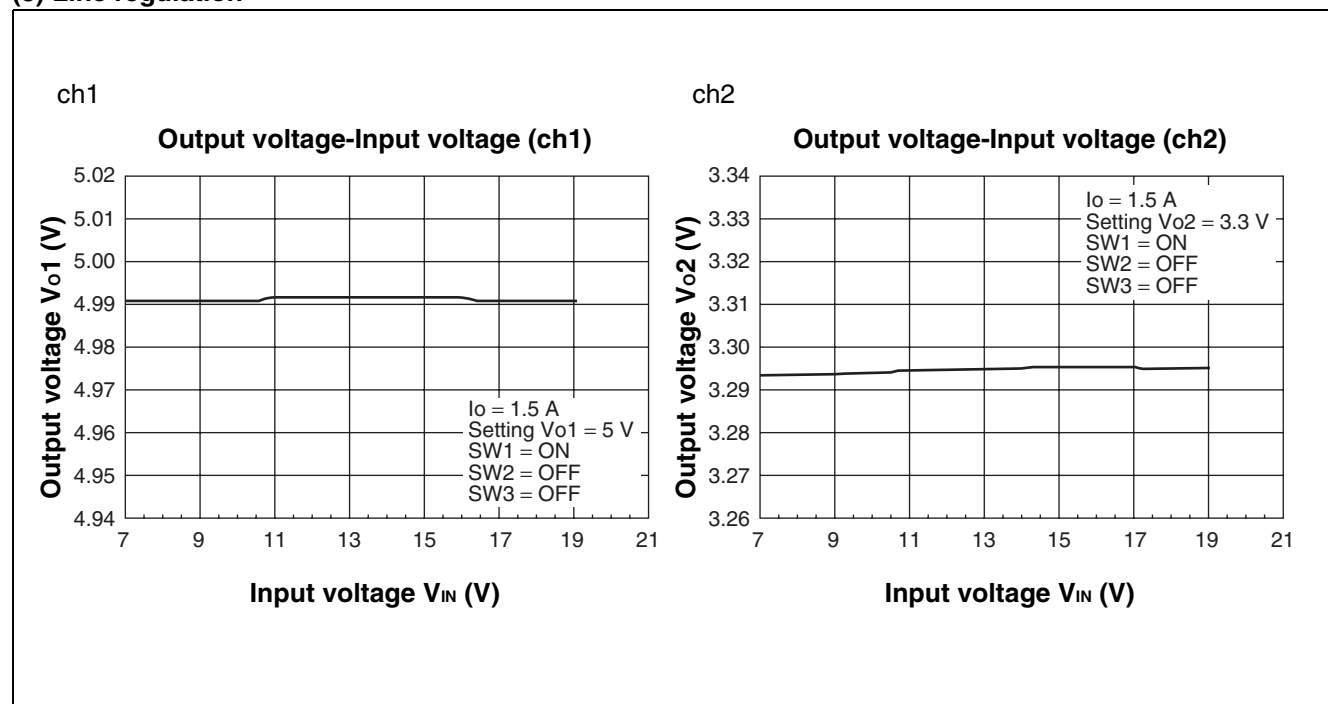
(1) Conversion efficiency vs. load current characteristics ($V_{IN} = 12\text{ V}$)



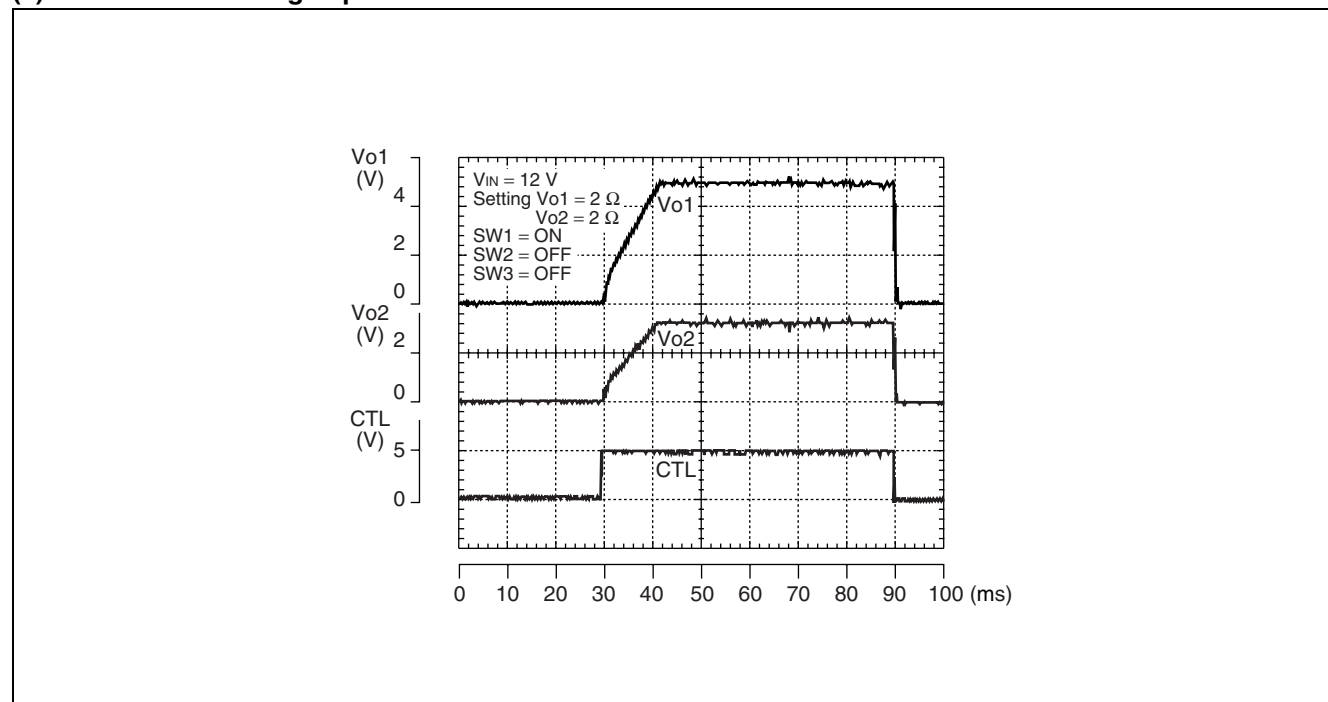
(2) Load Regulation ($V_{IN} = 12\text{ V}$)



(3) Line regulation

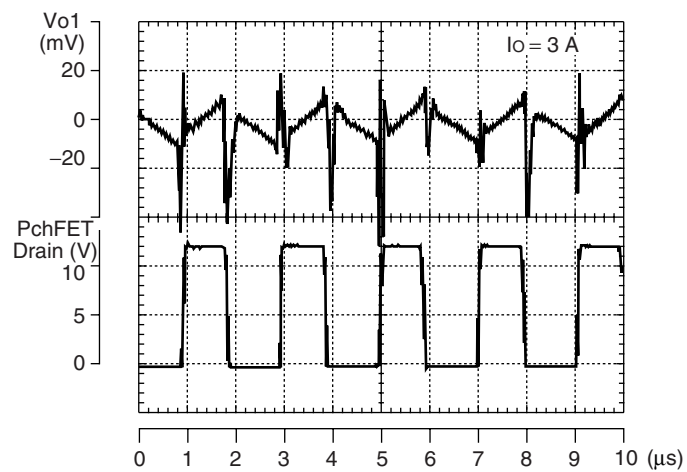
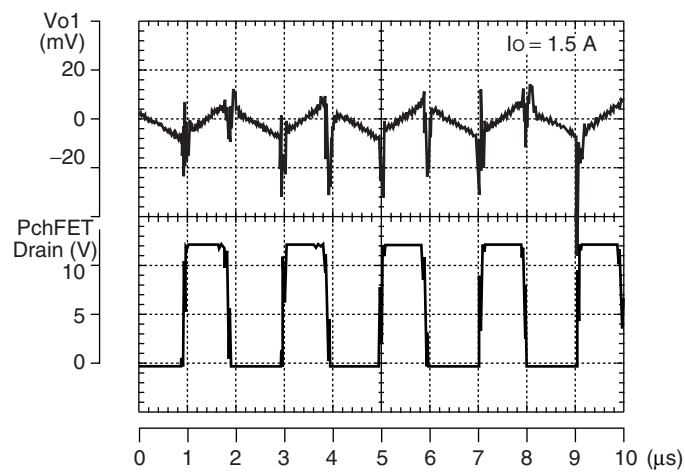
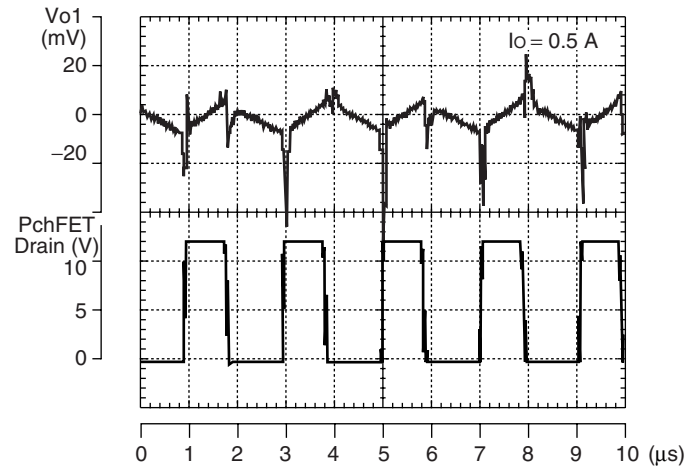


(4) Soft - start/discharge operation waveforms

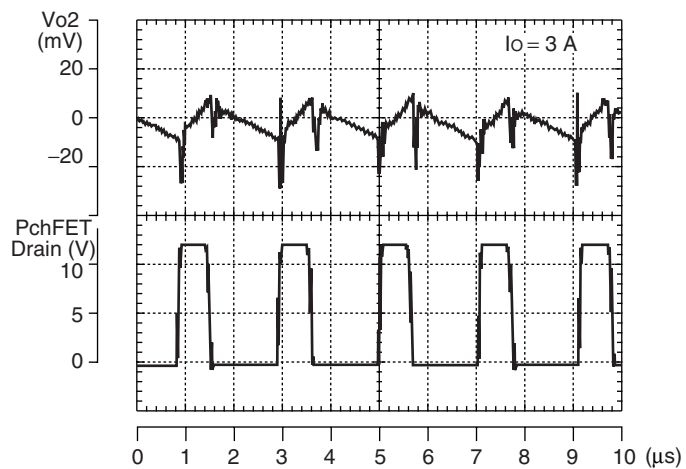
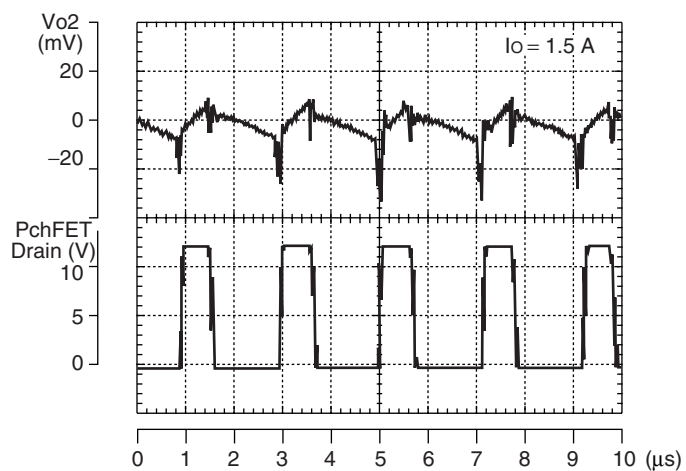
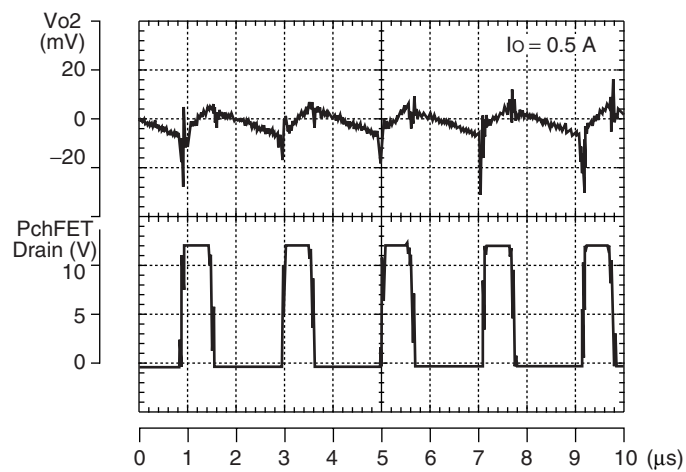


(5) Output ripple waveforms ($V_{IN} = 12\text{ V}$)

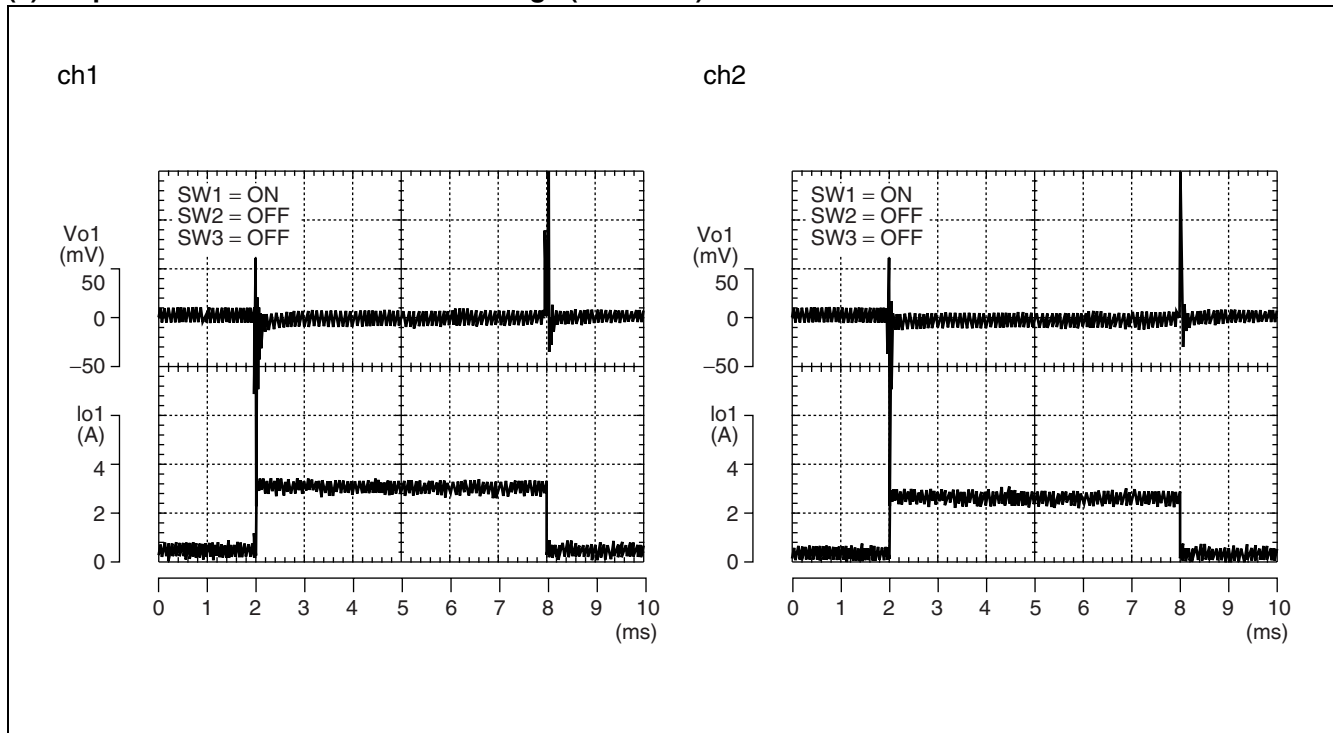
ch1



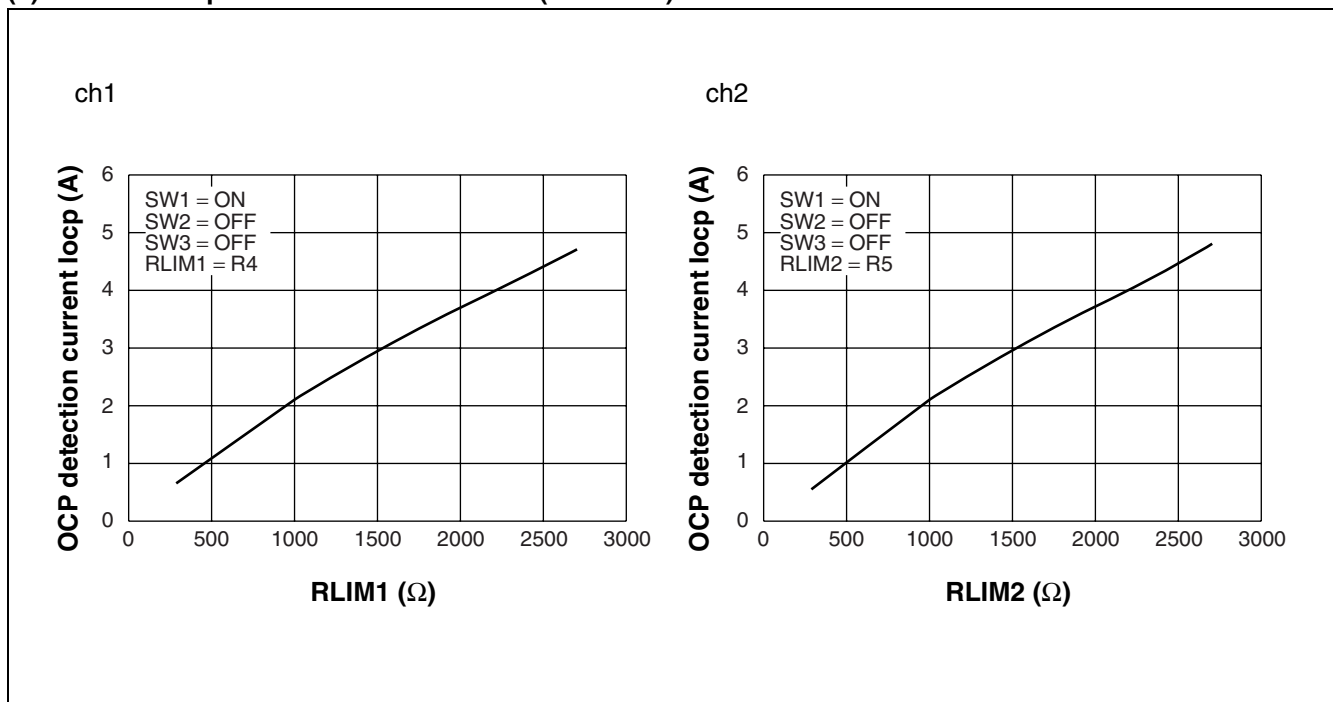
ch2



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

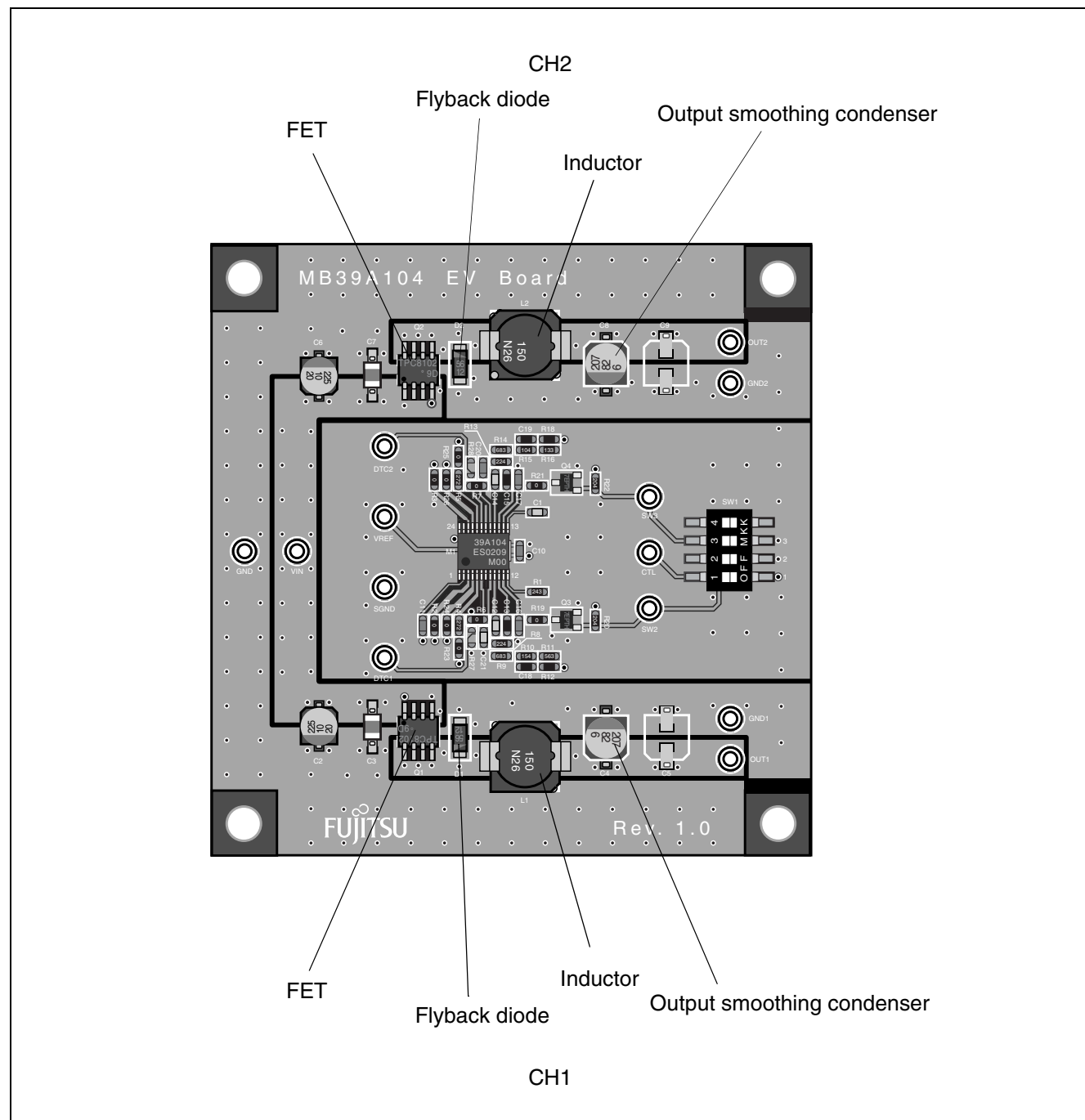


(7) Overcurrent protection characteristics ($V_{IN} = 12\text{ V}$)



■ COMPONENT SELECTION METHODS

1. Board view



Board Photograph

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

$V_{IN} = 19 \text{ V (Max)}$, $V_{o1} = 5.0 \text{ V}$, $V_{o2} = 3.3 \text{ V}$, $I_o = 3.0 \text{ A}$, $f_{osc} = 500 \text{ kHz}$

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

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

$$\begin{aligned} I_D &\geq I_o + \frac{V_{IN} - V_{o1}}{2L} t_{on} \\ &\geq 3 + \frac{19 - 5}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.263 \\ &\geq \underline{3.25 \text{ A}} \end{aligned}$$

ch2 side

$$\begin{aligned} I_D &\geq I_o + \frac{V_{IN} - V_{o2}}{2L} t_{on} \\ &\geq 3 + \frac{19 - 3.3}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.174 \\ &\geq \underline{3.18 \text{ A}} \end{aligned}$$

3. Inductor (CDRH104R - 150:SUMIDAproduct)

15 μ H (tolerance $\pm 30\%$), 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

$$\begin{aligned} L &\geq \frac{2(V_{IN} - V_{o1})}{I_o} \times t_{on} \\ &\geq \frac{2 \times (19 - 5)}{3} \times \frac{1}{500 \times 10^3} \times 0.263 \\ &\geq \underline{4.91 \mu H} \end{aligned}$$

ch2 side

$$\begin{aligned} L &\geq \frac{2(V_{IN} - V_{o2})}{I_o} \times t_{on} \\ &\geq \frac{2 \times (19 - 3.3)}{3} \times \frac{1}{500 \times 10^3} \times 0.174 \\ &\geq \underline{3.64 \mu H} \end{aligned}$$

The load current satisfying the continuous current condition

ch1 side

$$\begin{aligned} I_o &\geq \frac{V_{o1}}{2L} \times t_{off} \\ &\geq \frac{5}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times (1 - 0.263) \\ &\geq \underline{245.7 \text{ mA}} \end{aligned}$$

ch2 side

$$\begin{aligned} I_o &\geq \frac{V_{o2}}{2L} \times t_{off} \\ &\geq \frac{3.3}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times (1 - 0.174) \\ &\geq \underline{181.7 \text{ mA}} \end{aligned}$$

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.

ch1 side

$$\begin{aligned}
 I_L &\geq I_o + \frac{V_{IN} - V_{o1}}{2L} \text{ton} \\
 &\geq 3 + \frac{19 - 5}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.263 \\
 &\geq \underline{3.25 \text{ A}}
 \end{aligned}$$

ch2 side

$$\begin{aligned}
 I_L &\geq I_o + \frac{V_{IN} - V_{o2}}{2L} \text{ton} \\
 &\geq 3 + \frac{19 - 3.3}{2 \times 15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.174 \\
 &\geq \underline{3.18 \text{ A}}
 \end{aligned}$$

Ripple current: Peak - to - peak value

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

ch1 side

$$\begin{aligned}
 \Delta I_L &= \frac{V_{IN} - V_{o1}}{L} \text{ton} \\
 &= \frac{19 - 5}{15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.263 \\
 &\div \underline{0.491 \text{ A}}
 \end{aligned}$$

ch2 side

$$\begin{aligned}
 \Delta I_L &= \frac{V_{IN} - V_{o2}}{L} \text{ton} \\
 &= \frac{19 - 3.3}{15 \times 10^{-6}} \times \frac{1}{500 \times 10^3} \times 0.174 \\
 &\div \underline{0.364 \text{ A}}
 \end{aligned}$$

4. Output smoothing condenser

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

The output ripple voltage is ΔV_o , output smoothing condenser is C_L , ripple current is I_{CLrms} , and series resistance is ESR.

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

Series resistance

ch1 side

$$\begin{aligned} \text{ESR} &\leq \frac{\Delta V_o}{\Delta I_L} - \frac{1}{2\pi f C_L} \\ &\leq \frac{0.050}{0.491} - \frac{1}{2\pi \times 500 \times 10^3 \times 82 \times 10^{-6}} \\ &\leq \underline{98.0 \text{ m}\Omega} \end{aligned}$$

Resistance of the above condenser is 50 m Ω and acceptable.

ch2 side

$$\begin{aligned} \text{ESR} &\leq \frac{\Delta V_o}{\Delta I_L} - \frac{1}{2\pi f C_L} \\ &\leq \frac{0.033}{0.364} - \frac{1}{2\pi \times 500 \times 10^3 \times 82 \times 10^{-6}} \\ &\leq \underline{86.8 \text{ m}\Omega} \end{aligned}$$

Resistance of the above condenser is 50 m Ω and acceptable.

Condenser

ch1 side

$$\begin{aligned} C_L &\geq \frac{\Delta I_L}{2\pi f (\Delta V_o - \Delta I_L \times \text{ESR})} \\ &\geq \frac{0.491}{2\pi \times 500 \times 10^3 \times (0.050 - 0.491 \times 0.05)} \\ &\geq \underline{6.14 \mu\text{F}} \end{aligned}$$

Capacitance of the above condenser is 82 μF (Typ) and acceptable.

ch2 side

$$\begin{aligned} C_L &\geq \frac{\Delta I_L}{2\pi f (\Delta V_o - \Delta I_L \times \text{ESR})} \\ &\geq \frac{0.364}{2\pi \times 500 \times 10^3 \times (0.033 - 0.364 \times 0.05)} \\ &\geq \underline{7.83 \mu\text{F}} \end{aligned}$$

Capacitance of the above condenser is 82 μF (Typ) and acceptable.

Ripple current

ch1 side

$$\begin{aligned}
 I_{CLrms} &\geq \frac{(V_{IN} - V_{O1}) \text{ ton}}{2\sqrt{3}L} \\
 &\geq \frac{(19 - 5) \times 0.263}{2\sqrt{3} \times 15 \times 10^{-6} \times 500 \times 10^3} \\
 &\geq \underline{141.7 \text{ mArms}}
 \end{aligned}$$

Maximum allowable ripple current of the above condenser is 1570 mArms and acceptable.

ch2 side

$$\begin{aligned}
 I_{CLrms} &\geq \frac{(V_{IN} - V_{O2}) \text{ ton}}{2\sqrt{3}L} \\
 &\geq \frac{(19 - 3.3) \times 0.174}{2\sqrt{3} \times 15 \times 10^{-6} \times 500 \times 10^3} \\
 &\geq \underline{105.1 \text{ mArms}}
 \end{aligned}$$

Maximum allowable ripple current of the above condenser is 1570 mArms 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 $I_F = 3.0$ A

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

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

$$I_{Di} \geq I_o \times \left(1 - \frac{V_{o1}}{V_{IN}}\right) = 3 \times (1 - 0.263) \div \underline{2.21 \text{ A}}$$

ch2 side

$$I_{Di} \geq I_o \times \left(1 - \frac{V_{o2}}{V_{IN}}\right) = 3 \times (1 - 0.174) \div \underline{2.48 \text{ A}}$$

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

$$I_{Dip} \geq \left(I_o + \frac{V_{o1}}{2L} \text{ toff}\right) \div \underline{3.24 \text{ A}}$$

ch2 side

$$I_{Dip} \geq \left(I_o + \frac{V_{o2}}{2L} \text{ toff}\right) \div \underline{3.18 \text{ A}}$$

■ ORDERING INFORMATION

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

MEMO

MEMO

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