# ASSP for Power Management Applications of Ultra Mobile PC 6ch DC/DC Converter IC for LPIA Platform VR 

## MB39C308

## DESCRIPTION

The MB39C308 is a 6 ch DC/DC buck converter LSI, which integrates all of necessary power supplies for UltraMobile PC powered by 2-cell Li-ion battery. And the MB39C308 uses current mode topology with N-channel synchronous rectification to realize high conversion efficiency.
The MB39C308 is the Power Management IC supporting the LPIA(Low Power Intel Architecture) which Intel Corporation proposes as the low power consumption platform for UMPC.
The CH 1 and CH 2 are flexible to adopt the output current capability by selection of external FETs and easy to optimize efficiency. The $\mathrm{CH} 3, \mathrm{CH} 4, \mathrm{CH} 5$ and CH 6 integrate the switching FETs capable of high current for downsizing the power supply solution.
The MB39C308 uses Fujitsu's LDMOS process technology and supplies all power without dispersing power from a lithium-ion battery.

## FEATURES

- Input voltage range
- Topology
- Integrated FET Driver for external MOSFETs : CH1, CH2
- Integrated Switching MOSFETs
- Fixed Preset Output Voltage
- Selectable Preset Output Voltage
: 5.5 V to 12.6 V
: Current Mode
: CH3, CH4, CH5, CH6
: $\mathrm{CH} 1, \mathrm{CH} 2, \mathrm{CH} 5$
: CH3, CH4, CH6

| Channel | Output <br> voltage | Output <br> current | Remarks |
| :--- | :---: | :---: | :---: |
| CH 1 | 5 V | $2 \mathrm{~A}^{*}$ | - |
| CH 2 | 3.3 V | $4.5 \mathrm{~A}^{*}$ | - |
| CH 3 | $1.8 \mathrm{~V} / 1.5 \mathrm{~V}$ | $\operatorname{Max}: 2.7 \mathrm{~A}$ | DDR2/DDR3 are selectable. |
| CH 4 | $0.9 \mathrm{~V} / 0.75 \mathrm{~V}$ | $\operatorname{Max}: 1.5 \mathrm{~A}$ | - |
| CH 5 | 1.5 V | $\operatorname{Max}: 2.5 \mathrm{~A}$ | - |
| CH 6 | $1.1 \mathrm{~V} / 1.05 \mathrm{~V}$ | $\operatorname{Max}: 3.5 \mathrm{~A}$ | Two values are selectable. |

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- PWM switching frequency


## : 0.7 MHz

(CH4 : 0.7 MHz/0.35 MHz)

- Various protection
- Over current protection (OCP) - Input over voltage protection (IVP)
- Output short circuit protection (SCP) - Under voltage lock out protection (UVLO)
- Output over voltage protection (OVP) - Over temperature protection (OTP)
- POWERGOOD function
- Soft start function independent from output loads.
- Soft stop function independent from output loads.
- High conversion efficiency in wide range of load current.
- Packaged in a compact package
: PFBGA-208 ( $9.00 \mathrm{~mm} \times 9.00 \mathrm{~mm} \times 1.30 \mathrm{~mm}$ )


## APPLICATIONS

- UMPC (Ultra Mobile PC)
- MID (Mobile Internet Device)
- Mobile equipment etc.


## PIN ASSIGNMENT

(BOTTOM VIEW)


## PIN DESCRIPTIONS

| Block | Pin Name | I/O | Description |
| :---: | :---: | :---: | :---: |
| CH1 | FB1 | 1 | CH1 Error amplifier input pin, being connected to output of CH 1. |
|  | PVDD1 | - | Power supply pin of the CH1 output block. |
|  | CB1 | O | Internal power supply pin of the CH 1 gate driver block. |
|  | LX1 | - | CH 1 inductor connection pin. |
|  | OUT1H | O | CH1 High-side N-ch FET drive output pin. |
|  | OUT1L | 0 | CH1 Low-side N-ch FET drive output pin. |
|  | PGND1 | - | Ground pin of the CH 1 output block. |
| CH2 | FB2 | 1 | CH 2 Error amplifier input pin, being connected to output of CH 2. |
|  | PVDD2 | - | Power supply pin of the CH2 output block. |
|  | CB2 | 0 | Internal power supply pin of the CH 2 gate driver block. |
|  | LX2 | - | CH 2 inductor connection pin. |
|  | OUT2H | 0 | CH2 High-side N-ch FET drive output pin. |
|  | OUT2L | O | CH2 Low-side N-ch FET drive output pin. |
|  | PGND2 | - | Ground pin of the CH 2 output block. |
| CH3 | FB3 | 1 | CH3 Error amplifier input pin, being connected to output of CH3. |
|  | $\begin{gathered} \hline \text { PVDD3A } \\ \text { to } \\ \text { PVDD3I } \end{gathered}$ | - | Power supply pins of the CH 3 output block. |
|  | CB3 | 0 | Internal power supply pin of the CH 3 gate driver block. |
|  | $\begin{gathered} \text { LX3A } \\ \text { to } \\ \text { LX31 } \end{gathered}$ | - | CH 3 inductor connection pins. |
|  | $\begin{gathered} \text { PGND3A } \\ \text { to } \\ \text { PGND3I } \end{gathered}$ | - | Ground pins of the CH 3 output block. |
| CH4 | FB4 | 1 | CH4 Error amplifier input pin, being connected to output of CH 4. |
|  | $\begin{gathered} \hline \text { PVDD4A } \\ \text { to } \\ \text { PVDD4G } \end{gathered}$ | - | Power supply pins of the CH 4 output block. |
|  | CB4 | 0 | Internal power supply pin of the CH 4 gate driver block. |
|  | $\begin{gathered} \text { LX4A } \\ \text { to } \\ \text { LX4H } \end{gathered}$ | - | CH 4 inductor connection pins. |
|  | $\begin{aligned} & \hline \text { PGND4A } \\ & \text { to } \\ & \text { PGND4H } \end{aligned}$ | - | Ground pins of the CH 4 output block. |

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| Block | Pin Name | I/O | Description |
| :---: | :---: | :---: | :---: |
| CH5 | FB5 | 1 | CH5 Error amplifier input pin, being connected to output of CH5. |
|  | $\begin{aligned} & \hline \text { PVDD5A } \\ & \text { to } \\ & \text { PVDD5H } \end{aligned}$ | - | Power supply pins of the CH5 output block. |
|  | CB5 | O | Internal power supply pin of the CH5 gate driver block. |
|  | $\begin{gathered} \text { LX5A } \\ \text { to } \\ \text { LX5I } \end{gathered}$ | - | CH 5 inductor connection pins. |
|  | $\begin{gathered} \hline \text { PGND5A } \\ \text { to } \\ \text { PGND5I } \end{gathered}$ | - | Ground pins of the CH5 output block. |
| CH6 | FB6 | I | CH6 Error amplifier input pin, being connected to output of CH6. |
|  | $\begin{gathered} \hline \text { PVDD6A } \\ \text { to } \\ \text { PVDD6J } \end{gathered}$ | - | Power supply pins of the CH6 output block. |
|  | CB6 | O | Internal power supply pin of the CH6 gate driver block. |
|  | $\begin{gathered} \text { LX6A } \\ \text { to } \\ \text { LX6J } \end{gathered}$ | - | CH6 inductor connection pins. |
|  | $\begin{gathered} \hline \text { PGND6A } \\ \text { to } \\ \text { PGND6J } \end{gathered}$ | - | Ground pins of the CH6 output block. |
| Common | CTL1 | 1 | CH1 Control input pin. (L: Standby / H : Normal operation) |
|  | CTL2 | 1 | CH2 Control input pin. (L: Standby / H : Normal operation) |
|  | CTL34 | 1 | CH3 and CH4 control input pin. (L: Standby / H: Normal operation) |
|  | CTL5 | 1 | CH5 Control input pin. (L: Standby / H : Normal operation) |
|  | CTL6 | 1 | CH6 Control input pin. (L : Standby / H : Normal operation) |
|  | PG1 | O | CH1 POWERGOOD output pin. (N-ch MOS open drain output) |
|  | PG2 | O | CH2 POWERGOOD output pin. (N-ch MOS open drain output) |
|  | PG3 | O | CH3 POWERGOOD output pin. (N-ch MOS open drain output) |
|  | PG4 | 0 | CH4 POWERGOOD output pin. (N-ch MOS open drain output) |
|  | PG5 | 0 | CH5 POWERGOOD output pin. (N-ch MOS open drain output) |
|  | PG6 | O | CH6 POWERGOOD output pin. (N-ch MOS open drain output) |
|  | ALLPG | O | POWERGOOD output pin (The ALLPG pin outputs " H ", When channels CH3, $\mathrm{CH} 4, \mathrm{CH} 5$ and CH 6 are the power good). |
|  | FSEL4 | 1 | CH4 switching frequency setting pin. <br> FSEL4 = "H" : 700 kHz <br> FSEL4 = "L": 0.35 MHz (Shown in the " ELECTRICAL CHARACTERISTICS") |

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| Block | Pin Name | 1/0 | Description |
| :---: | :---: | :---: | :---: |
| Common | VSEL34 | 1 | Preset output voltage setting pin for $\mathrm{CH} 3 / \mathrm{CH} 4$. <br> VSEL34 = "H" : Vout CH3 $=1.8 \mathrm{~V}$, Vout $\mathrm{CH} 4=0.9 \mathrm{~V}$ <br> VSEL34 = "L" : Vout_CH3 $=1.5 \mathrm{~V}$, Vout_CH4 $=0.75 \mathrm{~V}$ |
|  | DVSEL6 | 1 | Preset output voltage setting pin for CH 6 dynamically. <br> DVSEL6 = "H" : Vout_CH6 = 1.1 V <br> DVSEL6 = "L" : Vout_CH6 = 1.05 V |
|  | SS1 | 1 | Soft-Start and Soft-Stop time setting pin (Shown in the " DESCRIPTION OF SOFT-START AND SOFT-STOP OPERATION • Soft-Start/Soft-Stop time (tson/tsoff) Setting Conditions"). |
|  | SS2 |  |  |
|  | VB | O | Bias voltage output pin for bootstrap and low-side N-ch gate driver of all channels. |
|  | DIN | 1 | Bias voltage input pin for bootstrap. DIN pin should be connected with VB pin. (Shown in the " BLOCK DIAGRAM") |
|  | PVDD7 | - | Power supply pin of VB block. |
|  | PGND7 | - | Ground pin of VB block. |
|  | AVDD | - | Power supply pin for common block. |
|  | VREF | O | Reference voltage output pin. |
|  | AGND | - | Ground pin of common block. |

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Condition | Rating |  | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Min | Max |  |
| Power supply voltage | Vdo | AVDD, PVDD1 to PVDD7 pin | -0.3 | + 13.5 | V |
| CB voltage | $\mathrm{V}_{\text {с }}$ | CB1 to CB6 pin | -0.3 | + 18.5 | V |
| LX voltage | Vıx | LX1 to LX6 pin | -0.3 | Vdo | V |
| CB to LX voltage | V cblx | CB pin to LX pin | -0.3 | + 7 | V |
| OUTH voltage | Vouth | OUT1H, OUT2H pin | VLx-0.3 | V св | V |
| OUTL voltage | Voutı | OUT1L, OUT2L pin | -0.3 | + 7 | V |
| DIN voltage | Voin | DIN pin | -0.3 | + 7 | V |
| VB voltage | Vvв | VB pin | -0.3 | + 7 | V |
| VREF voltage | V VREF | VREF pin | -0.3 | + 7 | V |
| CTL voltage | Vctı | CTL1 to CTL6 pin | -0.3 | + 13.5 | V |
| VSEL voltage | $V_{\text {sel }}$ | VSEL34, DVSEL6 pin | -0.3 | + 7 | V |
| FSEL voltage | Vfsel | FSEL4 pin | -0.3 | + 7 | V |
| FB voltage | $V_{\text {fb }}$ | FB1 to FB6 pin | -0.3 | + 7 | V |
| PG voltage | VPG | PG1 to PG6, ALLPG pin | -0.3 | + 7 | V |
| SS voltage | Vss | - | -0.3 | + 7 | V |
| Package power dissipation | PD | $\mathrm{Ta} \leq+25^{\circ} \mathrm{C}$ | - | 2940* | mW |
|  |  | $\mathrm{Ta}=+85^{\circ} \mathrm{C}$ | - | 1180* | mW |
| Operating ambient temperature | Ta | - | -40 | +85 | ${ }^{\circ} \mathrm{C}$ |
| Storage temperature | Tsta | - | -55 | + 125 | ${ }^{\circ} \mathrm{C}$ |

*: See the diagram of " TYPICAL CHARACTERISTICS • Maximum Power Dissipation vs. Operating Ambient Temperature", for the package power dissipation of Ta from $+25^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$.
WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

WARNING: The use of negative voltage below -0.3 Volts on the GND pins (AGND, PGND1 to PGND7) may activate parasitic transistors on the silicon, which can introduce abnormal operation.
Connecting the LX pin to either VDD pins (AVDD, PVDD1 to PVDD7) or GND pins (AGND, PGND1 to PGND7) directly may cause permanently damage to the device.
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| Parameter | Symbol | Condition | Value |  |  | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Min | Typ | Max |  |
| VB output capacitor | Cve | VB pin | - | 1 | - | $\mu \mathrm{F}$ |
| VREF output capacitor | Crref | VREF pin | - | 4.7 | - | $\mu \mathrm{F}$ |
| VREF output current | Ivref | VREF pin | -1 | - | 0 | mA |
| PG input voltage | VPG | PG1 to PG6, ALLPG pin | - | - | 6 | V |
| PG sink current | IPG | PG1 to PG6, ALLPG pin | - | - | 2 | mA |
| CTL input voltage | Vctı | CTL1 to CTL6 pin | - | - | AVDD | V |
| VSEL input voltage | $V_{\text {sel }}$ | VSEL34, DVSEL6 pin | - | - | 6 | V |
| FSEL input voltage | Vfsel | FSEL4 pin | - | - | 6 | V |
| SS input voltage | Vss | SS1, SS2 pin | - | - | $\mathrm{V}_{B}$ | V |

* : The MB39C308 is designed with assumed operating conditions, which is $60 \%$ of the maximum output current on the each channel and being operated with recommended input voltage range.

WARNING: The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.
Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure. No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their representatives beforehand.

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## ELECTRICAL CHARACTERISTICS

$\left(\mathrm{Ta}=+25^{\circ} \mathrm{C}, \mathrm{AVDD}=\mathrm{PVDD} 1\right.$ to PVDD7 $\left.=7.2 \mathrm{~V}\right)$

| Parameter |  | Symbol | Condition | Value |  |  | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Min |  | Typ | Max |  |
| Reference voltage block <br> [VREF] | Reference voltage |  | Vref | VREF pin $=0 \mathrm{~mA}$ | 2.45 | 2.5 | 2.55 | V |
|  | Line regulation | VREF Line | AVDD pin $=5.5 \mathrm{~V}$ to 12.6 V | -10 | - | + 10 | mV |
|  | Load regulation | VREF Load | VREF pin $=0 \mathrm{~mA}$ to -1 mA | -15 | - | + 15 | mV |
| Bias voltage block [VB] | Bias voltage | Vvв | $\begin{aligned} & 5.5 \mathrm{~V} \leq \mathrm{AVDD} \leq 12.6 \mathrm{~V} \\ & \mathrm{VB} \text { pin }=0 \mathrm{~mA} \end{aligned}$ | 4.8 | 5 | 5.2 | V |
|  | Load regulation | $\begin{aligned} & \hline \text { VB } \\ & \text { Load } \end{aligned}$ | VB pin $=0 \mathrm{~mA}$ to -1 mA | -15 | - | + 15 | mV |
| Under-voltage lockout protection circuit block [ UVLO ] | Threshold voltage | Vtıh | AVDD pin | 4.5 | 5.0 | 5.2 | V |
|  | Hysteresis width | Vhu | AVDD pin | 0.05 | 0.1 | 0.4 | V |
| Over-temperature protection circuit block [OTP] | Shutdown temperature | Тотрн |  | - | + 150*1 | - | ${ }^{\circ} \mathrm{C}$ |
|  | Hysteresis width | TH |  | - | $+25^{* 1}$ | - | ${ }^{\circ} \mathrm{C}$ |
| Input over voltage protection circuit block [IVP] | Threshold voltage | Vivph | AVDD pin | 12.6 | 13.0 | 13.4 | V |
|  | Release voltage | Vivpl | AVDD pin | 12.5 | 12.85 | 13.3 | V |
|  | Hysteresis width | $V_{\text {HII }}$ | AVDD pin | - | 0.15 | - | V |
| Oscillator block [OSC] | Oscillation frequency*2 | fosc | $\begin{aligned} & \mathrm{CH} 1 \text { to CH3, CH5, CH6 } \\ & \mathrm{CH} 4 \text { : FSEL4 pin = "H" Level } \end{aligned}$ | 0.56 | 0.7 | 0.84 | MHz |
|  |  |  | CH4 : FSEL4 pin = "L" Level | 0.28 | 0.35 | 0.42 | MHz |
| Control block [CTL1 to CTL6] | Output on level | $\mathrm{V}_{\mathrm{H}}$ | CTL1 to CTL6 pin | 2 | - | - | V |
|  | Output off level | VIL | CTL1 to CTL6 pin | - | - | 0.8 | V |
|  | Input current | Істьн | CTL1 to CTL6 pin $=3 \mathrm{~V}$ | 23 | 30 | 43 | $\mu \mathrm{A}$ |
|  |  | Ictul | CTL1 to CTL6 pin $=0 \mathrm{~V}$ | - | - | 1 | $\mu \mathrm{A}$ |

(Continued)
$\left(\mathrm{Ta}=+25^{\circ} \mathrm{C}, \mathrm{AVDD}=\mathrm{PVDD} 1\right.$ to PVDD7 $=7.2 \mathrm{~V}$ )

| Parameter |  | Symbol | Condition | Value |  |  | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Min |  | Typ | Max |  |
| Output voltage select block [VSEL34, DVSEL6] | VSEL34, "H" level |  | VLGH | VSEL34, DVSEL6 pin | 2 | - | - | V |
|  | VSEL34, "L" level | VLgL | VSEL34, DVSEL6 pin | - | - | 0.8 | V |
|  | Input current | IsELH | $\begin{aligned} & \text { VSEL34, DVSEL6 } \\ & \text { pin = 3 V } \end{aligned}$ | 23 | 30 | 43 | $\mu \mathrm{A}$ |
|  |  | Iselu | $\begin{aligned} & \text { VSEL34, DVSEL6 } \\ & \text { pin = 0 V } \end{aligned}$ | - | - | 1 | $\mu \mathrm{A}$ |
| Power good detection circuit block [PG1 to PG6, ALLPG] | Low side threshold voltage | Vpgl | FB1 to FB6 pin $\uparrow$ PG1 to PG6 pin | $\begin{aligned} & \text { Vo } \times \\ & 0.85 \end{aligned}$ | $\begin{gathered} \hline \text { Vo } \times \\ 0.9 \end{gathered}$ | $\begin{aligned} & \hline \text { Vo } \times \\ & 0.95 \end{aligned}$ | V |
|  | High side threshold voltage | Vpgh | FB1 to FB6 pin 飞 PG1 to PG6 pin | $\begin{aligned} & \hline \text { Vo } \times \\ & 1.05 \end{aligned}$ | $\begin{gathered} \hline \text { Vo } \times \\ 1.1 \end{gathered}$ | $\begin{aligned} & \hline \text { Vo } \times \\ & 1.15 \end{aligned}$ | V |
|  | Hysteresis width | $\mathrm{V}_{\mathrm{H}}$ | - | - | $\begin{aligned} & \hline \text { Vo } \times \\ & 0.03 \end{aligned}$ | - | V |
|  | PG output low voltage | VoL | ```PG1 to PG6, ALLPG pin = 1 mA``` | - | 0.1 | 0.3 | V |
|  | PG leak current | ILKPG | $\begin{aligned} & \text { PG1 to PG6, ALLPG pin = } \\ & 6 \mathrm{~V} \end{aligned}$ | - | - | 1 | $\mu \mathrm{A}$ |
| Common block | AVDD standby current | Iavdos | $\begin{aligned} & \text { CTL1 to CTL6 pin }=0 \mathrm{~V} \text {, } \\ & \text { AVDD pin }=12.6 \mathrm{~V} \end{aligned}$ | - | - | 1 | $\mu \mathrm{A}$ |
|  | AVDD power supply current | Iavdd | CTL1 to CTL6 pin $=3 \mathrm{~V}$ | - | 0.25 | - | mA |
| CH1 block [CH1] | CH1 output voltage | Vo1 | FB1 pin | 4.75 | 5 | 5.25 | V |
|  | PVDD1 standby current | Ipvodis | $\begin{aligned} & \text { CTL1 } \text { pin }=0 \mathrm{~V}, \\ & \text { PVDD1 } \text { pin }=12.6 \mathrm{~V} \end{aligned}$ | - | - | 15 | $\mu \mathrm{A}$ |
|  | CH1 efficiency | $\eta L 1$ | $\begin{aligned} & 0.05 \times 10(\operatorname{Max})<\mathrm{lo}< \\ & 0.3 \times 10(\operatorname{Max}) \end{aligned}$ | $87^{* 3}$ | - | - | \% |
|  |  | $\eta \mathrm{T} 1$ | $\begin{aligned} & 0.3 \times 10(\operatorname{Max})<10< \\ & 0.6 \times 10(\operatorname{Max}) \end{aligned}$ | 92*3 | - | - | \% |
|  |  | $\eta \mathrm{F} 1$ | $0.6 \times 10$ (Max) < lo< lo (Max) | 92*3 | - | - | \% |
|  | OUT1H source current | IsourceH1 | $\begin{aligned} & \text { Duty } \leq 5 \% \text {, CB1 pin }=5 \mathrm{~V}, \\ & \text { LX1 pin }=0 \mathrm{~V}, \\ & \text { OUT1H pin }=0 \mathrm{~V} \end{aligned}$ | - | $-400{ }^{* 1}$ | - | mA |
|  | OUT1H sink current | IsinkH1 | $\begin{aligned} & \text { Duty } \leq 5 \%, \text { CB1 pin }=5 \mathrm{~V}, \\ & \text { LX1 pin }=0 \mathrm{~V}, \\ & \text { OUT1H pin }=5 \mathrm{~V} \end{aligned}$ | - | 400*1 | - | mA |
|  | OUT1L source current | IsourceN1 | $\begin{aligned} & \text { Duty } \leq 5 \%, \text { VB pin }=5 \mathrm{~V}, \\ & \text { LX1 pin }=0 \mathrm{~V}, \\ & \text { OUT1L pin }=0 \mathrm{~V} \end{aligned}$ | - | $-400{ }^{* 1}$ | - | mA |

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$\left(\mathrm{Ta}=+25^{\circ} \mathrm{C}, \mathrm{AVDD}=\mathrm{PVDD} 1\right.$ to $\left.\mathrm{PVDD7}=7.2 \mathrm{~V}\right)$

| Parameter |  | Symbol | Condition | Value |  |  | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Min |  | Typ | Max |  |
| CH1 block [CH1] | OUT1L sink current |  | IsinkN1 | $\begin{aligned} & \text { Duty } \leq 5 \%, \text { VB pin }=5 \mathrm{~V}, \\ & \text { LX1 pin }=0 \mathrm{~V}, \\ & \text { OUT1L pin }=5 \mathrm{~V} \\ & \hline \end{aligned}$ | - | 400*1 | - | mA |
|  | OUT1H on resistance | Rон1 | OUT1H pin $=-15 \mathrm{~mA}$ | - | 12 | 18 | $\Omega$ |
|  |  | RoL1 | OUT1H pin $=15 \mathrm{~mA}$ | - | 12 | 18 | $\Omega$ |
|  | OUT1L on resistance | Rон1 | OUT1L pin $=-15 \mathrm{~mA}$ | - | 12 | 18 | $\Omega$ |
|  |  | RoL1 | OUT1L pin $=15 \mathrm{~mA}$ | - | 12 | 18 | $\Omega$ |
|  | Vo1 output over voltage threshold | Vo1 | FB1 pin | 5.9*1 | $6^{* 1}$ | $6.1^{* 1}$ | V |
|  | Vo1 over current limit | locp1 | $\begin{aligned} & \operatorname{lo1} \\ & \operatorname{Ron}_{\mathrm{H}}=32 \mathrm{~m} \Omega, \mathrm{~L}=3.3 \mu \mathrm{H} \end{aligned}$ | $3.4 *$ | 4.0*1 | $4.6{ }^{\text {*1 }}$ | A |
|  | FB1 input resistance | RFb1 | FB1 pin | - | 340 | - | k $\Omega$ |
|  | Soft Start time | SS1 | $\begin{aligned} & \text { FB1 pin } \\ & \text { SS1 = SS2 = AGND pin } \end{aligned}$ | 1.19 | 1.4 | 1.61 | ms |
| CH2 block [CH2] | CH2 output voltage | Vo2 | FB2 pin | 3.135 | 3.3 | 3.465 | V |
|  | PVDD2 standby current | Ipvodes | $\begin{aligned} & \text { CTL2 pin = } 0 \mathrm{~V}, \\ & \text { PVDD2 pin }=12.6 \mathrm{~V} \end{aligned}$ | - | - | 15 | $\mu \mathrm{A}$ |
|  | CH2 efficiency | $\eta\llcorner 2$ | $\begin{aligned} & 0.05 \times 10(\text { Max })<10< \\ & 0.3 \times 10(\text { Max }) \end{aligned}$ | $87^{* 3}$ | - | - | \% |
|  |  | $\eta$ T2 | $\begin{aligned} & 0.3 \times \mathrm{lo}(\operatorname{Max})<\mathrm{lo}< \\ & 0.6 \times \mathrm{lo}(\text { Max }) \end{aligned}$ | 92*3 | - | - | \% |
|  |  | ๆF2 | $0.6 \times 10$ (Max) < $10<10$ (Max) | $92^{* 3}$ | - | - | \% |
|  | OUT2H source current | IsourceH2 | $\begin{aligned} & \text { Duty } \leq 5 \%, \text { CB2 pin }=5 \mathrm{~V}, \\ & \text { LX2 pin }=0 \mathrm{~V}, \\ & \text { OUT2H pin }=0 \mathrm{~V} \end{aligned}$ | - | - 400 | - | mA |
|  | OUT2H sink current | IsinkH2 | $\begin{aligned} & \text { Duty } \leq 5 \%, \text { CB2 pin }=5 \mathrm{~V}, \\ & \text { LX2 pin }=0 \mathrm{~V}, \\ & \text { OUT2H pin }=5 \mathrm{~V} \\ & \hline \end{aligned}$ | - | 400 | - | mA |
|  | OUT2L source current | IsourceN2 | $\begin{aligned} & \text { Duty } \leq 5 \%, \text { VB pin }=5 \mathrm{~V}, \\ & \text { LX2 pin }=0 \mathrm{~V}, \\ & \text { OUT2L pin }=0 \mathrm{~V} \end{aligned}$ | - | - 400 | - | mA |
|  | OUT2L sink current | IsinkN2 | $\begin{aligned} & \text { Duty } \leq 5 \%, \text { VB pin }=5 \mathrm{~V}, \\ & \text { LX2 pin }=0 \mathrm{~V}, \\ & \text { OUT2L pin }=5 \mathrm{~V} \end{aligned}$ | - | 400 | - | mA |
|  | OUT2H on resistance | Rон2 | OUT2H pin $=-15 \mathrm{~mA}$ | - | 12 | 18 | $\Omega$ |
|  |  | Roı2 | OUT2H pin $=15 \mathrm{~mA}$ | - | 12 | 18 | $\Omega$ |
|  | OUT2L on resistance | Roн2 | OUT2L pin $=-15 \mathrm{~mA}$ | - | 12 | 18 | $\Omega$ |
|  |  | Roı2 | OUT2L pin $=15 \mathrm{~mA}$ | - | 12 | 18 | $\Omega$ |

(Continued)
$\left(\mathrm{Ta}=+25^{\circ} \mathrm{C}, \mathrm{AVDD}=\mathrm{PVDD} 1\right.$ to $\left.\mathrm{PVDD7}=7.2 \mathrm{~V}\right)$

| Parameter |  | Symbol | Condition | Value |  |  | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Min |  | Typ | Max |  |
| CH2 block <br> [CH2] | Vo2 output over voltage threshold |  | Vo2 | FB2 pin | 3.894*1 | 3.96*1 | 4.026*1 | V |
|  | Vo2 over current limit | locp2 | $\begin{aligned} & \text { lo2 } \\ & \text { RonH1 }=16 \mathrm{~m} \Omega, \mathrm{~L}=3.3 \mu \mathrm{H} \end{aligned}$ | $6.7^{* 1}$ | 7.9*1 | 9.0*1 | A |
|  | FB2 input resistance | Rfb2 | FB2 pin | - | 220 | - | k $\Omega$ |
|  | Soft start time | SS2 | $\begin{aligned} & \text { FB2 pin } \\ & \text { SS1 = SS2 = AGND pin } \end{aligned}$ | 1.19 | 1.4 | 1.61 | ms |
| CH3 block [CH3] | CH3 output voltage | Vo3 | ```VSEL34 = "H" Level, FB3 pin``` | 1.71 | 1.8 | 1.89 | V |
|  |  |  | $\begin{aligned} & \text { VSEL34 = "L" Level, } \\ & \text { FB3 pin } \end{aligned}$ | 1.425 | 1.5 | 1.575 | V |
|  | High-side FET on-resistance | Rолнз | $\begin{aligned} & \mathrm{LX} 3 \mathrm{pin}=-100 \mathrm{~mA}, \\ & \mathrm{~V}_{\mathrm{Gs}}=5 \mathrm{~V} \end{aligned}$ | - | 65*1 | - | $\mathrm{m} \Omega$ |
|  | Low-side FET on-resistance | Ronız | $\begin{aligned} & \text { LX3 pin = } 100 \mathrm{~mA}, \\ & \mathrm{~V}_{\mathrm{Gs}}=5 \mathrm{~V} \end{aligned}$ | - | 40*1 | - | $\mathrm{m} \Omega$ |
|  | PVDD3 standby current | Ipvodis | $\begin{aligned} & \text { CTL34 pin }=0 \mathrm{~V}, \\ & \text { PVDD3 pin }=12.6 \mathrm{~V} \end{aligned}$ | - | - | 15 | $\mu \mathrm{A}$ |
|  | CH3 efficiency | $\eta$ L31 | $\begin{aligned} & \text { VSEL34 pin = "H" Level, } \\ & \text { Vo3 }=1.8 \mathrm{~V} \\ & 0.05 \times \mathrm{lo}(\mathrm{Max})<\mathrm{lo}< \\ & 0.3 \times \mathrm{lo}(\text { Max }) \end{aligned}$ | 85*3 | - | - | \% |
|  |  | $\eta$ L32 | $\begin{aligned} & \text { VSEL34 pin }=\text { "L" Level, } \\ & \text { Vo3 }=1.5 \mathrm{~V} \\ & 0.05 \times \mathrm{lo}(\mathrm{Max})<\mathrm{lo}< \\ & 0.3 \times \mathrm{lo}(\mathrm{Max}) \end{aligned}$ | $82^{* 3}$ | - | - | \% |
|  |  | $\eta$ T31 | $\begin{aligned} & \text { VSEL34 pin }=\text { "H" Level, } \\ & \text { Vo3 }=1.8 \mathrm{~V} \\ & 0.3 \times \text { lo }(\mathrm{Max})<\mathrm{lo}< \\ & 0.6 \times \text { lo }(\mathrm{Max}) \end{aligned}$ | $87^{* 3}$ | - | - | \% |
|  |  | $\eta$ T32 | $\begin{aligned} & \text { VSEL34 pin }=\text { "L" Level, } \\ & \text { Vo3 }=1.5 \mathrm{~V} \\ & 0.3 \times \mathrm{lo}(\operatorname{Max})<\mathrm{lo}< \\ & 0.6 \times \mathrm{lo}(\operatorname{Max}) \end{aligned}$ | $85^{* 3}$ | - | - | \% |
|  |  | $\eta$ F31 | $\begin{aligned} & \text { VSEL34 pin = "H" Level, } \\ & \text { Vo3 = } 1.8 \mathrm{~V} \\ & 0.6 \times \text { lo }(\text { Max })<\text { lo }<\text { lo } \\ & (\text { Max }) \end{aligned}$ | 87*3 | - | - | \% |
|  |  | ๆF32 | $\begin{aligned} & \text { VSEL34 pin = "L" Level, } \\ & \text { Vo3 = } 1.5 \mathrm{~V} \\ & 0.6 \times \text { lo }(\mathrm{Max})<\mathrm{lo}<\mathrm{lo} \\ & (\mathrm{Max}) \end{aligned}$ | 85*3 | - | - | \% |

(Continued)

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$\left(\mathrm{Ta}=+25^{\circ} \mathrm{C}, \mathrm{AVDD}=\mathrm{PVDD} 1\right.$ to $\mathrm{PVDD7}=7.2 \mathrm{~V}$ )

| Parameter |  | Symbol | Condition | Value |  |  | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Min |  | Typ | Max |  |
| CH4 block [CH4] | Vo4 over current limit |  | locp4 | lo4, $\mathrm{L}=1.5 \mu \mathrm{H}, \mathrm{fosc}=700 \mathrm{kHz}$ | 1.92*1 | $2.4{ }^{* 1}$ | $2.88{ }^{* 1}$ | A |
|  | FB4 input resistance | Rfb4 | FB4 pin | - | 750 | - | k $\Omega$ |
|  | Soft start time | SS4 | $\begin{aligned} & \text { FB4 pin, } \\ & \text { SS1 = SS2 = AGND pin } \end{aligned}$ | 1.19 | 1.4 | 1.61 | ms |
|  | FSEL4, "H" level | Vfleht | FSEL4 pin | 2 | - | - | V |
|  | FSEL4, "L" level | Vflgl4 | FSEL4 pin | - | - | 0.8 | V |
|  | FSEL4 input current | IfsELH4 | FSEL4 pin $=3 \mathrm{~V}$ | 23 | 30 | 43 | $\mu \mathrm{A}$ |
|  |  | Ifselu4 | FSEL4 pin $=0 \mathrm{~V}$ | - | - | 1 | $\mu \mathrm{A}$ |
| CH5 block [CH5] | CH5 output voltage | Vo5 | FB5 pin | 1.425 | 1.5 | 1.575 | V |
|  | High-side FET on-resistance | Ronн5 | $\begin{aligned} & \text { LX5 pin }=-100 \mathrm{~mA}, \\ & \text { Vgs }=5 \mathrm{~V} \end{aligned}$ | - | $65^{* 1}$ | - | $\mathrm{m} \Omega$ |
|  | Low-side FET on-resistance | Ronı5 | $\begin{aligned} & \text { LX5 pin = } 100 \mathrm{~mA}, \\ & \mathrm{~V}_{\mathrm{GS}}=5 \mathrm{~V} \end{aligned}$ | - | 40*1 | - | $\mathrm{m} \Omega$ |
|  | PVDD5 standby current | Ipvodss | $\begin{aligned} & \text { CTL5 pin }=0 \mathrm{~V}, \\ & \text { PVDD5 } \text { pin }=12.6 \mathrm{~V} \\ & \hline \end{aligned}$ | - | - | 15 | $\mu \mathrm{A}$ |
|  | CH5 efficiency | $\eta$ L5 | $\begin{aligned} & 0.05 \times \mathrm{lo}(\text { Max })<\mathrm{lo}< \\ & 0.3 \times \mathrm{lo}(\text { Max }) \end{aligned}$ | $82^{* 3}$ | - | - | \% |
|  |  | $\eta$ T5 | $\begin{aligned} & 0.3 \times 10(\text { Max })<10< \\ & 0.6 \times 10(\text { Max }) \end{aligned}$ | 85*3 | - | - | \% |
|  |  | ๆF5 | $0.6 \times 10$ (Max) < lo < lo (Max) | 85*3 | - | - | \% |
|  | Vo5 output over voltage threshold | Vovp5 | FB5 pin | 1.77*1 | 1.8*1 | $1.83 * 1$ | V |
|  | Vo5 over current limit | locp5 | $\begin{aligned} & \mathrm{lo5}, \\ & \mathrm{~L}=1.5 \mu \mathrm{H} \end{aligned}$ | $2.8{ }^{* 1}$ | 3.5*1 | 4.2*1 | A |
|  | FB5 input resistance | Rfbs | FB5 pin | - | 250 | - | $\mathrm{k} \Omega$ |
|  | Soft start time | SS5 | $\begin{aligned} & \text { FB5 pin, } \\ & \text { SS1 = SS2 = AGND pin } \end{aligned}$ | 1.19 | 1.4 | 1.61 | ms |
| CH6 block [CH6] | CH6 output voltage | Vo6 | $\begin{aligned} & \text { DVSEL6 = "H" Level, } \\ & \text { FB6 pin } \end{aligned}$ | 1.045 | 1.1 | 1.155 | V |
|  |  |  | $\begin{aligned} & \text { DVSEL6 = "L" Level, } \\ & \text { FB6 pin } \end{aligned}$ | 0.9975 | 1.05 | 1.1025 | V |
|  | High-side FET on-resistance | Rомн6 | $\begin{aligned} & \mathrm{LX} 6 \mathrm{pin}=-100 \mathrm{~mA}, \\ & \text { VGs }=5 \mathrm{~V} \end{aligned}$ | - | $61^{* 1}$ | - | $\mathrm{m} \Omega$ |
|  | Low-side FET on-resistance | Ronı6 | $\begin{aligned} & \mathrm{LX} 6 \mathrm{pin}=100 \mathrm{~mA}, \\ & \mathrm{~V} \text { Gs }=5 \mathrm{~V} \end{aligned}$ | - | $35^{* 1}$ | - | $\mathrm{m} \Omega$ |
|  | PVDD6 standby current | Ipvodis | $\begin{aligned} & \text { CTL6 pin }=0 \mathrm{~V}, \\ & \text { PVDD6 pin }=12.6 \mathrm{~V} \\ & \hline \end{aligned}$ | - | - | 15 | $\mu \mathrm{A}$ |

(Continued)

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(Continued)
$\left(\mathrm{Ta}=+25^{\circ} \mathrm{C}, \mathrm{AVDD}=\mathrm{PVDD} 1\right.$ to PVDD7 $\left.=7.2 \mathrm{~V}\right)$

| Parameter |  | Symbol | Condition | Value |  |  | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Min |  | Typ | Max |  |
| CH6 block [CH6] | CH6 efficiency |  | $\eta$ L61 | $\begin{aligned} & \hline \text { DVSEL6 pin }=\text { "H" Level, } \\ & \text { Vo6 }=1.1 \mathrm{~V} \\ & 0.05 \times \mathrm{lo}(\text { Max })<\mathrm{lo}< \\ & 0.3 \times \mathrm{lo}(\text { Max }) \end{aligned}$ | 80*3 | - | - | \% |
|  |  | $\eta$ L62 | $\begin{aligned} & \hline \text { DVSEL6 pin = "L" Level, } \\ & \text { Vo6 }=1.05 \mathrm{~V} \\ & 0.05 \times 1 \mathrm{lo}(\mathrm{Max})<\mathrm{lo}< \\ & 0.3 \times 1 \mathrm{lo}(\mathrm{Max}) \end{aligned}$ | $80^{* 3}$ | - | - | \% |
|  |  | $\eta$ T61 | $\begin{aligned} & \hline \text { DVSEL6 pin }=\text { "H" Level, } \\ & \text { Vo6 }=1.1 \mathrm{~V} \\ & 0.3 \times 1 \mathrm{lo}(\mathrm{Max})<\mathrm{lo}< \\ & 0.6 \times \mathrm{lo}(\text { Max }) \end{aligned}$ | $82^{* 3}$ | - | - | \% |
|  |  | $\eta$ T62 | $\begin{aligned} & \hline \text { DVSEL6 pin }=\text { "L" Level, } \\ & \text { Vo6 }=1.05 \mathrm{~V} \\ & 0.3 \times 1 \mathrm{lo}(\text { Max })<1 \mathrm{lo}< \\ & 0.6 \times \mathrm{lo}(\text { Max }) \\ & \hline \end{aligned}$ | $82^{* 3}$ | - | - | \% |
|  |  | $\eta$ F61 | $\begin{aligned} & \text { DVSEL6 pin = "H" Level, } \\ & \text { Vo6 = } 1.1 \mathrm{~V} \\ & 0.6 \times \text { lo }(\text { Max })<10<10(\text { Max }) \end{aligned}$ | 81*3 | - | - | \% |
|  |  | ๆF62 | $\begin{aligned} & \text { DVSEL6 pin = "L" Level, } \\ & \text { Vo6 = } 1.05 \mathrm{~V} \\ & 0.6 \times \text { lo }(\text { Max })<\text { lo }<\text { lo (Max) } \end{aligned}$ | $81^{* 3}$ | - | - | \% |
|  | Vo6 output over voltage threshold | Vovp6 | DVSEL6 pin = "H" Level, Vo6 = 1.1 V , FB6 pin | 1.298*1 | 1.32*1 | $1.342^{* 1}$ | V |
|  |  |  | DVSEL6 pin = "L" Level, Vo6 $=1.05 \mathrm{~V}$, FB 6 pin | 1.239*1 | 1.26*1 | 1.281*1 | V |
|  | Vo6 over current limit | locp6 | $\begin{aligned} & \mathrm{lo6}, \\ & \mathrm{~L}=1.5 \mu \mathrm{H} \end{aligned}$ | 4.0*1 | $5.0{ }^{* 1}$ | 6.0*1 | A |
|  | FB6 input resistance | Rfbg | FB6 pin | - | 350 | - | k $\Omega$ |
|  | Soft start time | SS6 | $\begin{aligned} & \text { FB6 pin, } \\ & \text { SS1 = SS2 = AGND pin } \end{aligned}$ | 1.19 | 1.4 | 1.61 | ms |

*1: This parameter isn't be specified. This should be used as a reference to support designing the circuits.
*2 : FSEL4 pin is typically recommended to set to "H" level for fosc $=700 \mathrm{kHz}$ setting. When Vo4 is preset to 0.75 V , the ON duty becomes so small at high input voltage. Then, there is a case CH 4 output regulation becomes worse at light load condition. In that case, please set FSEL4 pin to "L" level for fosc $=350 \mathrm{kHz}$ setting.
*3: This is a reference value, which is evaluated by the recommended EVB circuit. This should be used as a reference to support designing the circuits.

## CHANNEL CONTROL FUNCTION

The each channel is turned on and off depending on the voltage levels at the CTL1 pin, CTL2 pin, CTL34 pin, CTL5 pin and CTL6 pin.

- Channel On/Off Setting Conditions

| CTL1 | CTL2 | CTL34 | CTL5 | CTL6 | CH1 | CH2 | CH3 | CH4 | CH5 | CH6 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| L | L | L | L | L | OFF | OFF | OFF | OFF | OFF | OFF |
| H | L | L | L | L | ON | OFF | OFF | OFF | OFF | OFF |
| L | H | L | L | L | OFF | ON | OFF | OFF | OFF | OFF |
| L | L | H | L | L | OFF | OFF | ON | ON | OFF | OFF |
| L | L | L | H | L | OFF | OFF | OFF | OFF | ON | OFF |
| L | L | L | L | H | OFF | OFF | OFF | OFF | OFF | ON |
| H | H | H | H | H | ON | ON | ON | ON | ON | ON |

## POWER GOOD FUNCTION

The Power Good function is shown in the following figure. The ALLPG pin and the PGx pins are connected to the open drain of the NMOS, and are used by connecting the resistor. When the CTLx pin is turned on, and the output voltage becomes within $7 \%$ of the preset voltage, the PGx pin is changed from " L " to " H ". PGx = " H " means the status of Power Good. When the change of the output voltage exceeds $10 \%$ of the preset voltage, the PGx pin becomes "L". And when the output voltage becomes within $7 \%$ of the preset voltage, the PGx pin becomes " H ". Moreover, when all of the channels from CH 3 to CH 6 are the Power Good, the ALLPG pin becomes "H".


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## PROTECTION

## <1> Under Voltage Lock Out Protection (UVLO)

The UVLO prevents IC malfunctions or system damage and the degradation caused by the excessive voltage or instantaneous voltage drop of the power supply voltage (AVDD), bias voltage (VB), internal reference voltage (VREF).
The UVLO turns off all the high- and low-side FETs of CH1 to CH 6 when the AVDD pin drops below 5.0 V (Typ). The UVLO is released when the AVDD pin is above 5.1 V (Typ). This is the non-latch type protection.

## <2> Input Over Voltage Protection (IVP)

The circuit prevents IC malfunctions or system damage and the degradation caused by the excessive voltage or instantaneous voltage drop of the power supply voltage (AVDD).
The IVP turns off all the high- and low-side FETs of CH1 to CH6 when the AVDD pin exceeds 13.0 V (Typ). The IVP is released when the AVDD pin drops below 12.85 V (Typ). This is the non-latch type protection.

## <3> Over Temperature Protection (OTP)

The OTP prevents thermal damages on ICs. The IVP function turns off all the high- and low-side FETs of CH1 to CH 6 when the junction temperature exceeds $+150^{\circ} \mathrm{C}$ (Typ). The OPT is released when the temperature drops below $+125^{\circ} \mathrm{C}$ (Typ). This is the non-latch type protection.

## <4> Output Short Circuit Protection (SCP)

The SCP function stops outputting data when the output voltage falls and protects the devices connected to outputs.
The SCP timer will start to count when either of output voltages CH 1 to CH 6 falls due to the output short-circuit to GND or excessive currents. The SCP function starts to operate the latch protection and turns off all the highand low-side FETs when the output voltage continues to fall to 1.4 ms (Typ).
Follow either of the steps to release the latch of output short circuit protection.

- After all of CTL signals from CH1 to CH6 are set to "L" level, turn on the each CTL signal again.
- When the voltage of the AVDD pin is below the threshold voltage of the UVLO, and then the voltage of the AVDD pin becomes higher than the threshold voltage of UVLO again, the each output will start up.
<5> Output Over Voltage Protection (OVP)
The OVP protects the devices which are connected to outputs when the output voltage rises. When either output voltage of the CH 1 to CH 6 is higher than $120 \%$ of each channel's preset voltage (Typ), the OVP turns off all the high- and low-side FETs of the channels (However, the only CH4 is turned off the high-side FET and turned on the low-side FET. The CH4 logic is different from other channels as it is controlled with PWM). The OVP is released when the output voltage is below $103 \%$ of the preset voltage (Typ). This is the non-latch type protection.
<6> Over Current Protection (OCP)
The OCP function controls the output current. When drain-to-source current excessively increases, the OCP controls the output current to the preset value for each channel. Then, because of the OCP functions, the output voltage usually drops. As a result, the SCP stop the all outputs with the latch setting. The OCP functions only for the corresponding channels only, however, the SCP stops all of the channels in the end.


## DESCRIPTION OF SOFT-START AND SOFT-STOP OPERATION

Soft-start function is featured to avoid inrush current when each channels is turned-on. When the CTL1, CTL2, CTL34, CTL5 and CTL6 are set to "H" level, ramped-up voltage is fed on an inverting input of an error amplifier of a channel. Start-time of the soft-start can be predefined and the start time is kept constant independent from a load of the output of the channels. When the CTL1, CTL2, CTL34, CTL5 and CTL6 are set to "L" level, rampeddown voltage is fed on an inverting input of an error amplifier of a channel then the output voltage goes low. Stop-time of the Soft-stop can be predefined and the stop-time is kept constant independent from a load of the output of the channel.
The time of both soft-start and soft-stop can be predefined with combination of the level on the SS1 and the SS2 pins as shown in the "• Soft-Start/Soft-Stop time (tson/tsoff) Setting Conditions", and external capacitors and resistors aren't required

- Soft-Start/Soft-Stop time (tson/tsoff) Setting Conditions

| SS1 pin | SS2 pin | Soft-Start time <br> (tson) (Typ) | Soft-Stop time <br> (tsoff) (Typ) | Unit |
| :--- | :--- | :---: | :---: | :---: |
| Connecting to AGND pin | Connecting to AGND pin | 1.4 | 1.4 | ms |
| Connecting to AGND pin | Connecting to VREF pin | 2.2 | 2.2 | ms |
| Connecting to AGND pin | Connecting to VB pin | 2.9 | 2.9 | ms |
| Connecting to VREF pin | Connecting to AGND pin | 3.5 | 3.5 | ms |
| Connecting to VREF pin | Connecting to VREF pin | 4.1 | 4.1 | ms |
| Connecting to VREF pin | Connecting to VB pin | 5.1 | 5.1 | ms |
| Connecting to VB pin | Connecting to AGND pin | 5.9 | 5.9 | ms |
| Connecting to VB pin | Connecting to VREF pin | 7.3 | 7.3 | ms |
| Connecting to VB pin | Connecting to VB pin | 8.2 | 8.2 | ms |

[^1](4) When CTL34 is set to " H " or " L ".


## PRESET FUNCTION OF CH3/CH4/CH6 OUTPUT VOLTAGE

The preset output voltage of CH 3 and CH 4 are selected by VSEL34 pin condition. Please refer the following table. The preset output voltage of CH 6 is selected by DVSEL6 pin condition. Please refer the following table.

- $\mathrm{CH} 3 / \mathrm{CH} 4 / \mathrm{CH} 6$ Preset Output Voltage Conditions

| CONNECTION | VREF | GND |
| :---: | :---: | :---: |
| VSEL34 | Vo3 $=1.8 \mathrm{~V}$ setting | Vo3 $=1.5 \mathrm{~V}$ setting |
|  | Vo4 $=0.9 \mathrm{~V}$ setting | Vo4 $=0.75 \mathrm{~V}$ setting |
| DVSEL6 | Vo6 $=1.1 \mathrm{~V}$ setting | Vo6 $=1.05 \mathrm{~V}$ setting |

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## TYPICAL CHARACTERISTICS

- Maximum Power Dissipation vs. Operating Ambient Temperature


The Allowable power dissipation is shown in the "• Maximum Power Dissipation vs. Operating Ambient Temperature". The maximum power dissipation depends on the thermal capability of the given package, and the ambient temperature.
Sum of power dissipation of each channel ( CH 1 to CH 6 ) should not exceed the maximum rating. Expected power loss of the each channel's over load current are shown in the "• Power Loss Curve for each channel".

- The condition of the thermal model
$\square$
- Power Loss Curve for each channel



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## NOTES FOR UNCONNECTED PINS

## 1. PIN CONNECTION WHEN NOT USING CH1 or CH2

When CH 1 or CH 2 are not used, connect the PVDD pins to power supply, connect the PG pins, CTL pins and FB pins to Analog ground (AGND), leave OUTH pins, OUTL pins, CB pins and LX pins open and connect the PGND pins to Power ground.

- CH 1 is not used

- CH 2 is not used



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## 2. PIN CONNECTION WHEN NOT USING CH3 and CH4

When CH 3 and CH 4 are not used, connect the PVDD pins to power supply, connect the FSEL4 pin, VSEL34 pin, PG pins, CTL34 pins and FB pins to Analog ground (AGND), leave CB pins and LX pins open and connect the PGND pins to Power ground.

- CH 3 and CH 4 are not used



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## 3. PIN CONNECTION WHEN NOT USING CH4, BUT USING CH3

When CH 4 is not used but CH 3 is used, connect the PVDD4 pins to VB pin through around $5 \mathrm{k} \Omega$ resistor, connect the PG4 pin to Analog ground (AGND), connect $0.1 \mu \mathrm{~F}$ capacitor between CB4 and LX4 pins and connect the PGND4 pin to Power ground, connect FSEL4 and FB4 pins to VREF pin.

- CH 4 is not used, but CH 3 is used


Note : Both CH 3 and CH 4 become active when CTL34 is on. Connect the pins like shown up above when CH 4 is not used but CH3 is used. PVDD4 must not be open.

## 4. PIN CONNECTION WHEN NOT USING CH5

When CH5 is not used, connect the PVDD5 pins to power supply, connect the PG5, CTL5 and FB5 pins to Analog ground (AGND), leave CB5 and LX5 pins open and connect the PGND5 pin to Power ground.

- CH5 is not used



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## 5. PIN CONNECTION WHEN NOT USING CH6

When CH6 is not used, connect the PVDD6 pins to power supply, connect the PG6, CTL6, FB6 and DVSEL6 pins to Analog ground (AGND), leave CB6 and LX6 pins open and connect the PGND6 pin to Power ground.

- CH 6 is not used
$\square$


## 6. PIN CONNECTION WHEN NOT USING POWERGOOD FUNCTION

When the Power good function is not used, connect the PG pins or ALLPG pin to Analog ground (AGND).

- PG or ALLPG are not used



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## APPLICATION NOTE

## - Inductor Selection

See the " RECOMMENDED OPERATING CONDITIONS" for the recommended inductance. Furthermore, to confirm whether the current flowing through the inductor is within the rated value, the maximum value of the current flowing through the inductor needs to be found. The maximum current flowing through the inductor can be found from the following formula.
$\mathrm{IL}_{\text {max }} \geq \mathrm{I}_{\text {max }}+\frac{\Delta \mathrm{IL}}{2}$

$$
\Delta I L=\frac{V_{D D}-V_{0}}{L} \times \frac{V_{0}}{V_{D D} \times \text { fosc }}
$$

ILmax : Maximum current through inductor [ A ]
Іомах : Maximum load current [A]
$\Delta I L$ : Inductor ripple current peak-to-peak value [A]
VDD : Switching power supply voltage [V]
Vo : Output setting voltage [V]
fosc : Switching frequency [Hz]


- FET Selection (CH1, CH2)

This IC operation requires the voltage which is generated between drain and source on the high-side FET. Set the on resistance of high-side FET within the below range for reference.
CH1 high-side FET on resistance : $24 \mathrm{~m} \Omega$ to $40 \mathrm{~m} \Omega$
CH 2 high-side FET on resistance : $12 \mathrm{~m} \Omega$ to $20 \mathrm{~m} \Omega$
The current limit value for over current protection (OCP) is determined by the high-side FET on resistance in use. The current limit value is obtained by the following formula.

$$
\begin{aligned}
& \text { lo1_OCP }=\frac{0.141}{\text { RoN1 }^{2}}-\frac{0.5}{\mathrm{~L} \times \text { fosc }} \times \frac{\left(\mathrm{V}_{\mathrm{DD}}-\mathrm{V}_{\mathrm{O} 1}\right) \times \mathrm{V}_{\mathrm{O} 1}}{\mathrm{~V}_{\mathrm{DD}}} \\
& \mathrm{loz}_{\mathrm{OCP}}=\frac{0.133}{\text { RON } 2}-\frac{0.5}{\mathrm{~L} \times \text { fosc }} \times \frac{\left(\mathrm{V}_{\mathrm{DD}}-\mathrm{V}_{\mathrm{O} 2}\right) \times \mathrm{V}_{\mathrm{O} 2}}{\mathrm{~V}_{\mathrm{DD}}} \\
& \mathrm{~V}_{\mathrm{DD}}: \text { Switching system power supply voltage }[\mathrm{V}] \\
& \mathrm{V}_{\mathrm{O}} \quad: \text { Output setting voltage }[\mathrm{V}] \\
& \text { RoN }: \text { High-side FET on resistance }[\Omega] \\
& \mathrm{L} \quad: \text { Inductor value }[\mathrm{H}] \\
& \text { fosc }: \text { Switching frequency }[\mathrm{Hz}]
\end{aligned}
$$

Also, 2.5 V drive products are recommended for the high-side FET. A bootstrap diode is recommended to connect to the high-side FET for the use of 4 V drive products (see "• Bootstrap Diode Selection" for the detail).

In order to judge whether the electrical current flowing through the FET is within the rated value, the maximum value of the current flowing through the FET needs to be found. The maximum current flowing through the FET can be found from the following formula.

Iomax $\geq$ Iomax $+\frac{\Delta \mathrm{IL}}{2}$
Idmax : Maximum value of FET drain current [A]
Iomax : Maximum load current [A]
$\Delta \mathrm{IL}$ : Inductor ripple current peak-to-peak value [A]

Furthermore, in order to judge whether the power dissipation of the FET is within the rated value, the power dissipation of the FET needs to be found. The power dissipation of the high-side FET can be found from the following formula.
Phisidefet $=$ Pron + Psw

Phisidefet : High-side FET power dissipation [W]
Pron : High-side FET conducting power dissipation [W]
Psw : High-side FET SW power dissipation [W]

## MB39C308

High-side FET conducting power dissipation

$$
\text { Pron }=(\text { lomax })^{2} \times \frac{V_{O}}{V_{D D}} \times \text { RoN }
$$

Pron : High-side FET conducting power dissipation [W]
Iomax : Maximum load current [A]
$V_{D D}$ : Switching system power supply voltage [V]
Vo : Output setting voltage [V]
Ron : High-side FET on resistance [ $\Omega$ ]

High-side FET switching power dissipation

$$
\mathrm{P}_{\mathrm{sw}}=\frac{\mathrm{V}_{\mathrm{DD}} \times \mathrm{fosc} \times(\mathrm{lbtm} \times \mathrm{tr}+\mathrm{Itop} \times \mathrm{tf})}{2}
$$

Psw : Switching power dissipation [W]
VDD : Switching system power supply voltage [V]
fosc : Switching frequency $(\mathrm{Hz})$
lbtm : Inductor ripple current bottom value [A]
Itop : Inductor ripple current top value [A]
tr : High-side FET turn-on time [s]
tf : High-side FET turn-off time [s]
tr and tf can be found simply from the following formula.

$$
\operatorname{tr}=\frac{\operatorname{Qgd} \times 12}{5-\mathrm{Vth}} \quad \mathrm{tf}=\frac{\mathrm{Qgd} \times 12}{\mathrm{Vth}}
$$

Qgd : Gate-Drain charge of High-side FET [C]
Vth : High-side FET threshold voltage [V]
The power dissipation of the Low-side FET can be found from the following formula.

$$
P_{\text {LosidefET }}=P_{\text {Ron }}=(\text { lomax })^{2} \times\left(1 \frac{V_{O}}{V_{D D}}\right) \times \text { Ron }
$$

Pron : Low-side FET conducting power dissipation [W]
Iomax : Maximum load current [A]
Vod : Switching power supply voltage [V]
Vo : Output setting voltage [V]
Ron : Low-side FET on resistance [ $\Omega$ ]

Note : The transition voltage of the voltage between the drain and source of the Low-side FET is generally small and the switching power loss is negligible. Therefore it has been omitted from this formula.

## - Input Capacitor Selection

Because this IC uses the C-Mode system, it is recommended to use ceramic capacitors with a small ESR. See the " RECOMMENDED OPERATING CONDITIONS" for the value of the capacitance.

## - Output Capacitor Selection

Because this IC uses the C-Mode system, it is recommended to use ceramic capacitors with a small ESR. See the " RECOMMENDED OPERATING CONDITIONS" for the value of the capacitance.

- Bootstrap Diode Selection

It is not necessary to connect diode to the outside device normally because this device contains a bootstrap diode. However, it is recommended to add a shotkey barrier diode (SBD) when 4 V drive products is used for CH 1 and CH 2 switching FET. In this case, select the smallest forward current possible and connect as the figure below.

- When adding bootstrap SBD to CH1
$\square$
The current to drive on the gate of high-side FET flows to the SBD of the bootstrap diode. The average current can be found by the following formula. However, set the current which does not exceed the maximum rating.
$\mathrm{ID} \geq \mathrm{Qg} \times$ fosc
ID : Forward current [A]
Qg : Total gate electric charge of high-side FET [C]
fosc : Switching frequency [ Hz ]

The voltage rating of bootstrap capacitor can be found by the following formula.
$\mathrm{V}_{\text {__boot }}>\mathrm{V}_{\mathrm{dD}}$
Vr_вoot : Bootstrap diode DC reverse voltage [V]
$V_{D D}$ : Switching power supply voltage [V]

## MB39C308

## - Bootstrap Capacitor Selection

Although the default bootstrap capacitor (the capacitor between CB and LX) is $0.1 \mu \mathrm{~F}$, this may need to be adjusted if the FET used on CH 1 and CH 2 have a large Qg. The bootstrap capacitor needs to be able to charge sufficiently to drive the gate of the High-side FET. As a rough guide, select a capacitor with a minimum value of capacitance that is able to accumulate approximately 10 times the charge of the Qg of the High-side FET.

$$
\begin{aligned}
& \mathrm{C}_{\text {св }} \geq 10 \times \frac{\mathrm{Qg}}{\mathrm{~V}_{\text {Св }}} \\
& \mathrm{C}_{\text {СB }}: \text { Bootstrap capacitance }[\mathrm{F}] \\
& \mathrm{Qg}: \text { High-side SWFET gate charge }[\mathrm{C}] \\
& \mathrm{V}_{\text {СB }}: \text { CB voltage }(4.3 \mathrm{~V})
\end{aligned}
$$

- VB Capacitor Selection

Although the default VB capacitor is $1 \mu \mathrm{~F}$, this may need to be adjusted if the FET used on CH 1 and CH 2 have a large Qg. The VB capacitor needs to be able to charge sufficiently to drive the gate of the High-side FET. As a rough guide, select a capacitor with a minimum value of capacitance that is able to accumulate approximately 50 times the charge of the Qg of the High-side FET.

$$
\mathrm{C}_{\mathrm{VB}} \geq 50 \times\left(\frac{\mathrm{QgH}_{12}+9.3 \times 10^{-9}}{\mathrm{~V}_{\mathrm{CB}}}+\frac{\mathrm{QgL}_{12}+23 \times 10^{-9}}{\mathrm{~V}_{\mathrm{VB}}}\right)
$$

Cvi : VB capacitance [F]
$\mathrm{QgH}_{12}$ : Total gate charge of High-side FET for CH 1 and CH 2 [C] (Total when $\mathrm{Vgs}=4.3 \mathrm{~V}$ )
QgL12 : Total gate charge of Low-side FET for CH 1 and $\mathrm{CH} 2[\mathrm{C}]$ (Total when $\mathrm{Vgs}=5 \mathrm{~V}$ )
Vvi : VB voltage (5 V)
Vсв : CB voltage (4.3 V)

## MB39C308

- Power Dissipation and Thermal Design

Although these does not need to be examined in most cases because the IC is highly efficient, Dissipation and the thermal design may need to be investigate if the IC is used with high power supply voltages, high oscillator frequencies, high loads, or at high temperatures.
The internal IC power dissipation (Pic) can be found from the following formula.
PIC $=\mathrm{V}_{\text {DD }} \times\left(\mathrm{IDD}+\mathrm{Qg}_{12}+32 \times 10^{-9}\right) \times \mathrm{fosc}+$ PHisidefET3 $-6+$ PLosideFET3 -6
Pıc : Internal IC power dissipation [W]
VDD : Power supply voltage (Viv) [V]
lod : Power supply current [A] ( $250 \mu \mathrm{~A}$ Typ)
$\mathrm{Qg}_{12} \quad$ :Total gate charge of High-side FET $\left(\mathrm{V}_{\mathrm{GS}}=4.3 \mathrm{~V}\right)$ and Low-side $\mathrm{FET}\left(\mathrm{V}_{\mathrm{GS}}=5 \mathrm{~V}\right)$ for CH 1 and CH 2 [C]
fosc : Switching frequency [Hz]
Рнisidefets-6 : Total High-side SWFET power dissipation of internal High-side FET [W]
PLosideFET3-6 : Total Low-side SWFET power dissipation of internal Low-side FET [W]

Furthermore, the power dissipation of the High-side FET of each built-in channel can be found from the following formula.
Phisidefet $=$ Pron + Psw
Phisidefet : High-side FET power dissipation [W]
Pron : High-side FET conducting power dissipation [W]
Psw : High-side FET switching power dissipation [W]
High-side FET conducting power dissipation

$$
\mathrm{P}_{\text {RON }}=(\text { lomax })^{2} \frac{\mathrm{~V}_{0}}{\mathrm{~V}_{\mathrm{DD}}} \times \text { RoN }
$$

Pron : High-side FET conducting power dissipation [W]
Iomax : Maximum load current [A]
$V_{D D}$ : Switching power supply voltage [V]
Vo : Output setting voltage [V]
Ron : On resistance of High-side FET [ $\Omega$ ]

## MB39C308

High-side FET switching power dissipation

```
\(\mathrm{P}_{\mathrm{sw}}=\frac{\mathrm{V}_{\mathrm{DD}} \times \mathrm{fosc} \times(\mathrm{lbtm} \times \mathrm{tr}+\mathrm{Itop} \times \mathrm{tf})}{2}\)
Psw : SW power dissipation [W]
\(V_{D D}\) : Switching system power supply voltage [V]
fosc : Oscillation frequency ( Hz )
```

lbtm : Inductor ripple current bottom value [A]
Itop : Inductor ripple current top value [A]
tr : High-side FET turn-on time [s]
tf : High-side FET turn-off time [s]
tr and tf are simply given by the following values.

$$
\mathrm{tr}=4 \mathrm{~ns} \quad \mathrm{tf}=4 \mathrm{~ns}
$$

The power dissipation of the Low-side FET can be found from the following formula.

$$
P_{\text {Ron }}=(\text { lomax })^{2} \times\left(1-\frac{V_{0}}{V_{D D}}\right) \times R_{\text {on }}
$$

Pron : Low-side FET conducting power dissipation [W]
Iomax : Maximum load current [A]
$V_{D D}$ : Switching system power supply voltage [V]
Vo : Output setting voltage [V]
Ron : Low-side FET on resistance [ $\Omega$ ]
Note : The transition voltage of the voltage between the drain and source of the Low-side FET is generally small and the switching power loss is negligible. Therefore it has been omitted from this formula.

The junction temperature ( T j ) can be found from the following formula.
$\mathrm{Tj}=\mathrm{Ta}+\theta \mathrm{ja} \times \mathrm{P} \mathrm{C}$
Tj : Junction temperature $\left[{ }^{\circ} \mathrm{C}\right]\left(+125^{\circ} \mathrm{C}\right.$ Max)
Ta : Ambient temperature [ ${ }^{\circ} \mathrm{C}$ ]
日ja : PFBGA-208 package thermal resistance ( $34^{\circ} \mathrm{C} / \mathrm{W}$ )
Pic: IC power dissipation [W]

## REFERENCE DATA

- Efficiency vs. load current



## MB39C308

- Load regulation

(Continued)


## MB39C308

- Line regulation

(Continued)
FUjITSU
(Continued)





## MB39C308

- Waveforms at load step response

(Continued)


CH 4 (fosc $=700 \mathrm{kHz}, \mathrm{Vo4}=0.9 \mathrm{~V}$ )
lo4 $=0 \mathrm{~A} \Leftrightarrow 1.5 \mathrm{~A}$, lo4 slew rate $=1.5 \mathrm{~A} / \mathrm{us}$

$\mathrm{CH} 5(\mathrm{Vo5}=1.5 \mathrm{~V})$
lo5 $=0 \mathrm{~A} \Leftrightarrow 2.5 \mathrm{~A}$, lo5 slew rate $=2.5 \mathrm{~A} / \mathrm{\mu s}$


CH6 (Vo6 = 1.05 V )
lo6 $=0 \mathrm{~A} \Leftrightarrow 3.5 \mathrm{~A}$, lo6 slew rate $=3.5 \mathrm{~A} / \mu \mathrm{s}$


CH6 (Vo6 = 1.1 V )
lo6 $=0 \mathrm{~A} \Leftrightarrow 3.5 \mathrm{~A}$, lo6 slew rate $=3.5 \mathrm{~A} / \mu \mathrm{s}$


## MB39C308

- Waveform at Soft-start and Soft-stop



## MB39C308

(Continued)


## PARTS LIST

| Sym- bol | Part name | Model name | Specification | Package | Vendor | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| M1 | IC | MB39C308 | - | PFBGA-208 | FML | - |
| Q1 | N-ch Dual MOSFET | ECH8607 | $\begin{gathered} \mathrm{VDS}=30 \mathrm{~V}, \\ \mathrm{ID}=5 \mathrm{~A}(\mathrm{Max}) \end{gathered}$ | ECH8 | SANYO | Ch1 <br> High \& Low-side |
| Q2-1 | N-ch MOSFET | FDMA420NZ | $\begin{gathered} \hline \mathrm{VDS}=20 \mathrm{~V}, \\ \mathrm{ID}=5.7 \mathrm{~A} \\ (\mathrm{Max}) \end{gathered}$ | MLP2x2-6L | FAIRCHILD | Ch2 <br> High-side |
| Q3-1 | N-ch MOSFET | FDMA420NZ | $\begin{gathered} \hline \mathrm{VDS}=20 \mathrm{~V}, \\ \mathrm{ID}=5.7 \mathrm{~A} \\ (\mathrm{Max}) \end{gathered}$ | MLP2x2-6L | FAIRCHILD | $\begin{gathered} \text { Ch2 } \\ \text { Low-side } \end{gathered}$ |
| Q2-2 | N-ch MOSFET | - | - | SOT-6 | - | (Ch2 <br> High-side) |
| Q3-2 | N-ch MOSFET | - | - | TSOP-6 | - | (Ch2 <br> Low-side) |
| R1 | Resistor | RR0816P-104-D | $100 \mathrm{k} \Omega$ | 1608 | SSM | PG |
| R2 | Resistor | RR0816P-104-D | $100 \mathrm{k} \Omega$ | 1608 | SSM | PG |
| R3 | Resistor | RR0816P-104-D | $100 \mathrm{k} \Omega$ | 1608 | SSM | PG |
| R4 | Resistor | RR0816P-104-D | $100 \mathrm{k} \Omega$ | 1608 | SSM | PG |
| R5 | Resistor | RR0816P-104-D | $100 \mathrm{k} \Omega$ | 1608 | SSM | PG |
| R6 | Resistor | RR0816P-104-D | $100 \mathrm{k} \Omega$ | 1608 | SSM | PG |
| R7 | Resistor | RR0816P-104-D | $100 \mathrm{k} \Omega$ | 1608 | SSM | PG |
| R8 | Resistor | - | Pattern short | - | - | VSEL34 |
| R9 | Resistor | - | Pattern short | - | - | FSEL4 |
| C1 | Ceramic Capacitor | C3225JB0J107M | $100 \mu \mathrm{~F}(6.3 \mathrm{~V})$ | 3225 | TDK | VO |
| C2 | Ceramic Capacitor | C3225JB0J107M | $100 \mu \mathrm{~F}(6.3 \mathrm{~V})$ | 3225 | TDK | Vo |
| C3 | Ceramic Capacitor | GRM31CR60G107ME39L | $100 \mu \mathrm{~F}(4 \mathrm{~V})$ | 3216 | MURATA | VO |
| C4 | Ceramic Capacitor | GRM31CR60G107ME39L | $100 \mu \mathrm{~F}(4 \mathrm{~V})$ | 3216 | MURATA | VO |
| C5 | Ceramic Capacitor | GRM31CR60G107ME39L | $100 \mu \mathrm{~F}(4 \mathrm{~V})$ | 3216 | MURATA | Vo |
| C6-1 | Ceramic Capacitor | GRM31CR60G107ME39L | $100 \mu \mathrm{~F}(4 \mathrm{~V})$ | 3216 | MURATA | VO |
| C6-2 | Ceramic Capacitor | GRM31CR60G107ME39L | $100 \mu \mathrm{~F}(4 \mathrm{~V})$ | 3216 | MURATA | Vo |
| C7 | Ceramic Capacitor | C2012JB1C475K | $4.7 \mu \mathrm{~F}(16 \mathrm{~V})$ | 2012 | TDK | PVDD |
| C8 | Ceramic Capacitor | C2012JB1C475K | $4.7 \mu \mathrm{~F}(16 \mathrm{~V})$ | 2012 | TDK | PVDD |
| C9 | Ceramic Capacitor | C2012JB1C475K | $4.7 \mu \mathrm{~F}(16 \mathrm{~V})$ | 2012 | TDK | PVDD |
| C10 | Ceramic Capacitor | C2012JB1C475K | $4.7 \mu \mathrm{~F}(16 \mathrm{~V})$ | 2012 | TDK | PVDD |
| C11 | Ceramic Capacitor | C2012JB1C475K | $4.7 \mu \mathrm{~F}(16 \mathrm{~V})$ | 2012 | TDK | PVDD |
| C12 | Ceramic Capacitor | C2012JB1C475K | $4.7 \mu \mathrm{~F}(16 \mathrm{~V})$ | 2012 | TDK | PVDD |

(Continued)

## MB39C308

(Continued)

| Symbol | Part name | Model name | Specification | Package | Vendor | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C13 | Ceramic Capacitor | C1608JB1E224K | $0.22 \mu \mathrm{~F}(25 \mathrm{~V})$ | 1608 | TDK | CB |
| C14 | Ceramic Capacitor | C1608JB1E224K | $0.22 \mu \mathrm{~F}(25 \mathrm{~V})$ | 1608 | TDK | CB |
| C15 | Ceramic Capacitor | C1608JB1H104K | $0.1 \mu \mathrm{~F}(50 \mathrm{~V})$ | 1608 | TDK | CB |
| C16 | Ceramic Capacitor | C1608JB1H104K | $0.1 \mu \mathrm{~F}(50 \mathrm{~V})$ | 1608 | TDK | CB |
| C17 | Ceramic Capacitor | C1608JB1H104K | $0.1 \mu \mathrm{~F}(50 \mathrm{~V})$ | 1608 | TDK | CB |
| C18 | Ceramic Capacitor | C1608JB1H104K | $0.1 \mu \mathrm{~F}(50 \mathrm{~V})$ | 1608 | TDK | CB |
| C19 | Ceramic Capacitor | C1608JB1C105K | $1 \mu \mathrm{~F}(16 \mathrm{~V})$ | 1608 | TDK | AVDD |
| C20 | Ceramic Capacitor | C1608JB1C105K | $1 \mu \mathrm{~F}(16 \mathrm{~V})$ | 1608 | TDK | PVDD7 |
| C21 | Ceramic Capacitor | C1608JB1C105K | $1 \mu \mathrm{~F}(16 \mathrm{~V})$ | 1608 | TDK | VB |
| C22 | Ceramic Capacitor | C1608JB1A475K | $4.7 \mu \mathrm{~F}(10 \mathrm{~V})$ | 1608 | TDK | VREF |
| L1 | Inductor | RLF7030-3R3M4R1 | $3.3 \mu \mathrm{H}(4.1 \mathrm{~A})$ | SMD | TDK | - |
| L2 | Inductor | MPLC0730L3R3 | $3.3 \mu \mathrm{H}(5.7 \mathrm{~A})$ | SMD | NEC | - |
| L3 | Inductor | RLF7030-1R5N6R1 | $1.5 \mu \mathrm{H}(6.1 \mathrm{~A})$ | SMD | TDK | - |
| L4 | Inductor | RLF7030-1R5N6R1 | $1.5 \mu \mathrm{H} \mathrm{(6.1A)}$ | SMD | TDK | - |
| L5 | Inductor | RLF7030-1R5N6R1 | $1.5 \mu \mathrm{H} \mathrm{(6.1} \mathrm{A)}$ | SMD | TDK | - |
| L6 | Inductor | RLF7030-1R5N6R1 | $1.5 \mu \mathrm{H}(6.1 \mathrm{~A})$ | SMD | TDK | - |
| PIN | Wiring Terminal | WT-2-1 | - | - | Mac-Eight | - |

FML
: FUJITSU MICROELECTRONICS LIMITED
SANYO : SANYO Electric Co.,Ltd.
FAIRCHILD
: Fairchild Semiconductor Japan Ltd.
SSM : SUSUMU Co., Ltd
TDK : TDK Corporation
MURATA : Murata Manufacturing Co., Ltd.
NEC TOKIN : NEC TOKIN Corporation
Mac-Eight : Mac-Eight Co.,Ltd.

## PRINTED CIRCUIT BOARD LAYOUT

Design of the PCB layout is important to make the suitable operation, suppressing noise or high efficiency ratio. Refer to the evaluation board layout of MB39C308EVB-01 and consider the following guideline when designing the layout of a circuit board.

## 1. Common items for each channel and peripheral components

- Ground and design for radiation of heat

At least, place the GND layer (PGND) in one of PCB internal layers. Place the through holes next to the GND pin of IC and each component, and connect them to the GND layer with low impedance.
Place the AGND which is separated from the GND layer with flowing large current if possible. Connect the bypass-capacitors of VREF and AVDD and the AGND pin of IC to the AGND. Connect AGND pin of IC to the GND layer by one point connection as close as possible so as not to flow a large current to the AGND. Connect GND pins of VB bypass-capacitor and the switching components to the GND layer directly.

Connect each thermal pin to the GND layer via the through hole so that the heat can be dissipated efficiency. It is an ideal to place a through hole on a pad in the footprint of each thermal pin. Furthermore, it is also effective to place the GND plane on the back side of the substrate of the trace mounted on IC.

- Bypass capacitors and boot strap capacitors

Place the bypass-capacitors connected to the VREF, AVDD, VB, PVDD7 pins next to each pin of IC. Furthermore, connect the bypass-capacitors with the shortest path on surface layer to each pin. Place GND pins of bypasscapacitors connected to VB and PVDD7 pins to the PGND7 pin with the shortest path.
Place the bootstrap capacitors for each channel next to CBx and LXx pins.

- Example layout

(.) Pad of IC
$\therefore$ Through hole

$x$ : Number of each channel
- Feedback line

Place the feed back lines to FB pins for each channel away from switching components and lines, because the feed back line is sensitive to noise.

## MB39C308

- Printed circuit board design rule for PFBGA



## 2. External switching FET channel (CH1, CH2)

For the loop consisting of the input capacitor (Cis), high-side FET and low-side FET of each channel, take the most care of making the current loop as tight as possible.
The input capacitor ( $\mathrm{C}_{\mathrm{I}}$ ), high-side FET and low-side FET, inductor ( L ) and output capacitor ( C o) should be connected to the surface layer as much as possible using short and thick connections. In addition, avoid making connections to theses components via the through hole.
Large transient current flows through the connections between the FET gate and OUT1H,OUT1L,OUT2H and OUT2L pins. Make this lines as short and thick as possible (ex. 0.5 mm width).
PVDD1, PVDD2, LX1, LX2 pins sense the voltage between drain and source at high-side FET. Connect the PVDD1 or PVDD2 pin to the drain pin of high-side FET directly. Avoid connecting to the other part on the line. Connect the LX1 or LX2 pin to the source pin of high-side FET directly. Connect the bootstrap capacitor as in the following graph and avoid connecting to the other part on the line. Furthermore, large transient current also flows through the connection to the LX pin. Make the line as short and thick as possible (exp: PVDD1, PVDD2, LX1, LX2 lines are 0.5 mm width).
When not connecting the PVDD and the LX pins to the drain or the source pin of the high-side FET as the layout below, an error may occur in PWM/PFM switch current value and the OCP setting value because of the error occurred in the current sense value.

- Example layout

Connect the PVDD pin to the drain pin of high-side FET directly so as to sense the drain voltage at highside FET. The line shouldn't be connected to the other parts.


Connect the LX pin to the source pin of highside FET directly so as to sense the source voltage at high-side FET. The line shouldn't be connected to the other parts except the bootstrap capacitor.

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## 3. Internal switching FET channel (CH3 to CH6)

Place the input capacitor ( $\mathrm{C}_{11}$ ) for each channel next to PVDDx and PGNDx pins as in the following graph.
The PVDDx, LXx, PGNDx pins, input capacitor ( $\mathrm{CIIN}^{\prime}$ ), inductor ( L ) and output capacitor ( Co ) should be connected to the surface layer as much as possible using short and thick connections. Avoid connecting these components via the through hole.

- Example layout



## USAGE PRECAUTION

## 1. Do not configure the IC over the maximum ratings

If the IC is used over the maximum ratings, the LSI may be permanently damaged.
It is preferable for the device to normally operate within the recommended usage conditions. Usage outside of these conditions can have a bad effect on the reliability of the LSI.
2. Use the devices within recommended operating conditions

The recommended operating conditions are under which the LSI is guaranteed to operate.
The electrical ratings are guaranteed when the device is used within the recommended operating conditions and under the conditions stated for each item.

## 3. Printed circuit board ground lines should be set up with consideration for common impedance

4. Take appropriate measures against static electricity

- Containers for semiconductor materials should have anti-static protection or be made of conductive material.
- After mounting, printed circuit boards should be stored and shipped in conductive bags or containers.
- Work platforms, tools, and instruments should be properly grounded.
- Working personnel should be grounded with resistance of $250 \mathrm{k} \Omega$ to $1 \mathrm{M} \Omega$ between body and ground.


## 5. Do not apply negative voltages

The use of negative voltages below -0.3 V may create parasitic transistors on LSI lines, which can cause malfunctions.

## 6. Warnings when connecting the load

During DC/DC operation, if the output is connected by hard switching to a capacitance that greatly exceeds the DC/DC output capacitance, the output voltage may oscillate and the protection function may be detected due to the instant voltage drop. Take note of the following points.

- Connecting to the load capacitor

A P-ch FET is normally used as a load switch, and a gate resistor is inserted as shown below for the switch to turn on gradually and to prevent rush current.


ORDERING INFORMATION

| Part number | Package | Remarks |
| :---: | :---: | :---: |
| MB39C308BGF | 208-ball plastic PFBGA <br> (BGA-208P-M02) |  |

## EV BOARD ORDERING INFORMATION

| EV board part No. | EV board version No. | Remarks |
| :---: | :---: | :---: |
| MB39C308EVB-11 | Board rev.1.0 | PFBGA-208 |

## RoHS COMPLIANCE INFORMATION OF LEAD (Pb) FREE VERSION

The LSI products of Fujitsu Microelectronics with "E1" are compliant with RoHS Directive , and has observed the standard of lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls (PBB) , and polybrominated diphenyl ethers (PBDE) .
A product whose part number has trailing characters " $E 1$ " is RoHS compliant.

## MARKING FORMAT (LEAD FREE VERSION)



## MB39C308BGF

RECOMMENDED CONDITIONS OF MOISTURE SENSITIVITY LEVEL
[Fujitsu Microelectronics Recommended Mounting Conditions]

| Item | Condition |  |
| :---: | :---: | :---: |
| Mounting Method | IR (infrared reflow), Manual soldering (partial heating method) |  |
| Mounting times | 2 times |  |
| Storage period | Before opening |  |
|  | From opening to the 2nd <br> reflow | Less than 6 days <br> Manufacture. |
|  | When the storage period after <br> opening was exceeded | Please processes within 6 days <br> after baking (125 $\left.{ }^{\circ} \mathrm{C}, 24 \mathrm{H}\right)$ |
| Storage conditions | $5^{\circ} \mathrm{C}$ to $30^{\circ} \mathrm{C}, 70 \% \mathrm{RH}$ or less (the lowest possible humidity) |  |

## [Temperature Profile for FJ Standard IR Reflow]

(1) IR (infrared reflow)

(a) Temperature Increase gradient: Average $1^{\circ} \mathrm{C} / \mathrm{s}$ to $4^{\circ} \mathrm{C} / \mathrm{s}$
(b) Preliminary heating
: Temperature $170^{\circ} \mathrm{C}$ to $190^{\circ} \mathrm{C}, 60 \mathrm{~s}$ to 180 s
(c) Temperature Increase gradient
: Average $1^{\circ} \mathrm{C} / \mathrm{s}$ to $4^{\circ} \mathrm{C} / \mathrm{s}$
(d) Actual heating
: Temperature $250^{\circ} \mathrm{C}$ Max; $245^{\circ} \mathrm{C}$ or more, 10 s or less
(d')
: Temperature $230^{\circ} \mathrm{C}$ or more, 40 s or less
or
Temperature $225^{\circ} \mathrm{C}$ or more, 60 s or less
or
Temperature $220^{\circ} \mathrm{C}$ or more, 80 s or less
(e) Cooling : Natural cooling or forced cooling

Note : Temperature : the top of the package body
(2) Manual soldering (partial heating method)

Conditions : Temperature $400^{\circ} \mathrm{C}$ Max
Times : 5 s max/pin

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[^0]:    * : It is the reference value at the typical EVB.

[^1]:    *: Accuracy : Typ $\pm 15 \%$

