System Power Supply for TV Series

# FET Controller Type
# 3ch System Power Supply ICs

**BD8601FV**

No.09034EAT01

## ●Description

BD8601FV has realized the high performance and reliability required as a power supply for thin-screen TV.
Due to the high-speed load response, it is most suitable for TV-purpose processors with increasingly high performance, and due to the wide phase margin it leaves a good margin for board pattern & constant setting and so facilitates its application design.
As a high-reliability design, it has various built-in protection circuits (overcurrent protection, output voltage abnormal protection, thermal protection, and off-latch function at the time of abnormality etc.), therefore as an advantage it does not easily damage in every possible abnormal condition such as all-pin short circuit test etc. and hence most suitable for thin-screen TV which requires the high reliability.

## ●Features

1) 3ch synchronous rectification step-down system DC/DC converter controller
2) 3ch independent ON/OFF. controllable
3) Soft start, soft off function
4) Concentrated protection control with built-in sequencer
5) Built-in low voltage protection function
6) Built-in overvoltage protection function
7) Built-in overcurrent protection function
8) Built-in RT terminal open/short protection function
9) Built-in duty clamp (90% ON) function
10) Frequency setting by external resistance is available.
11) Protection condition is output from PDET terminal.
12) Built-in external reset output function


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● **Electric characteristic**

(Ta=25℃, VIN1, VIN2, VIN3=5.0V, VCC=5.0V, and GND=0V unless otherwise specified.)

| Parameter | Symbol | specification value | | | UNIT | Condition |
|---|---|---|---|---|---|---|
| | | MIN | TYP | MAX | | |
| Circuit current 1 | $I_{Q1}$ | - | 3.5 | 8 | mA | CTL1,2,3=0V |
| Circuit current 2 | $I_{Q2}$ | - | 7 | 15 | mA | CTL1,2,3=VCC |
| < Error amplifier part Ch1,Ch2,Ch3> | | | | | | |
| Standard voltage （VREF) | $V_{REF}$ | 0.792 | 0.8 | 0.808 | V | Terminal FB and FC terminal short |
| Terminal FB Input bias current | $I_{FBB}$ | -1 | - | 1 | μA | $V_{FB}$=0.9V |
| Terminal FC Clamping voltage H | $V_{FCH}$ | 1.8 | - | - | V | $V_{FB}$=0.7V |
| Terminal FC Clamping voltage L | $V_{FCL}$ | - | - | 0.2 | V | $V_{FB}$=0.9V |
| Terminal FC Sink current | $I_{FCSINK}$ | 0.5 | - | - | mA | $V_{FB}$=0.9V, $V_{FC}$=0.4V |
| Terminal FC Source current | $I_{FCSOURCE}$ | - | - | -70 | μA | $V_{FB}$=0.7V, $V_{FC}$=1.6V |
| Open loop gain | $A_{VERR}$ | - | 100 | - | dB | |
| <OSC part > | | | | | | |
| Oscillation frequency | $F_{OSC}$ | 100 | - | 600 | kHz | |
| < Duty clamping part Ch1,Ch2,Ch3> | | | | | | |
| Max ON duty ratio | $F_{ONDUTY}$ | 70 | 85 | 95 | % | $V_{FB}$=0.7V |
| < Soft start part Ch1,Ch2,Ch3> | | | | | | |
| Charging current | $I_{SS}$ | -4.0 | -2.5 | -1.0 | μA | $V_{SS}$=1.0V |
| Terminal SS Threshold voltage | $V_{SSTH}$ | 1.0 | 1.1 | 1.2 | V | $V_{SS}$ voltage, $V_{FC}$=0.8V |
| Terminal SS Clamping voltage | $V_{SSCLM}$ | 1.6 | 1.9 | 2.2 | V | |
| Terminal SS Standby voltage | $V_{SSSTB}$ | 0.11 | 0.15 | 0.19 | V | $V_{SS}$ voltage (L→H) |
| Terminal SS Standby voltage Maximum hysteresis error | $V_{SSSTB\_HYS}$ | 5 | 50 | 100 | mV | |
| Terminal SS Discharge resistance | $R_{SS}$ | 49 | 70 | 91 | kΩ | |
| Terminal SS Protection circuit start voltage | $V_{SSPON}$ | 1.0 | 1.1 | 1.2 | V | $V_{SS}$ voltage (L→H) |
| Terminal SS Protection circuit start voltage Maximum hysteresis error | $V_{SSPON\_HYS}$ | 10 | 100 | 200 | mV | $V_{SS}$ voltage |
| < Low voltage, over voltage detection part Ch1,Ch2,Ch3> | | | | | | |
| Terminal FB Low voltage detection voltage | $V_{LVP}$ | 0.27 | 0.32 | 0.37 | V | $V_{FB}$ voltage |
| Terminal FB Low voltage detection Maximum hysteresis error | $V_{LVP\_HYS}$ | 10 | 100 | 200 | mV | $V_{FB}$ voltage |
| Terminal FB Overvoltage detection voltage | $V_{OVP}$ | 1.08 | 1.2 | 1.32 | V | $V_{FB}$ voltage |
| < Over current detection part Ch1,Ch2,Ch3> | | | | | | |
| Terminal LX input bias current | $I_{LXB}$ | -1 | 0 | 1 | uA | |
| Terminal OCP input bias current | $I_{OCPB}$ | 20 | 50 | 80 | uA | |
| < Reset detection part > | | | | | | |
| Terminal MONVCC reset detection voltage | $V_{RSTO}$ | 0.98 | 1.0 | 1.02 | V | $V_{MONVCC}$ voltage (H→L) |
| Terminal MONVCC input bias current | $I_{MONVCCB}$ | -1 | - | 1 | uA | |
| Terminal RSTDLY charging current | $I_{RSTDLY}$ | -15 | -10 | -5 | uA | |
| Terminal RESET L output voltage | $V_{OL\ RST}$ | - | - | 0.4 | V | $I_{OL}$=100uA |
| < Others> | | | | | | |
| Terminal PDET L output voltage | $V_{OL\ RDET}$ | - | - | 0.4 | V | $I_{OL}$=100uA |
| Terminal CTL input voltage H level voltage | $V_{IH\ CTL}$ | 2.0 | - | VCC | V | Terminal CTL1,2,3 |
| Terminal CTL input voltage L level voltage | $V_{IL\ CTL}$ | - | - | 0.5 | V | Terminal CTL1,2,3 |
| Terminal CTL input current | $I_{I\ CTL}$ | - | 85 | 120 | uA | Terminal CTL1,2,3, CTL=VCC |
| Terminal DRV H output voltage | $V_{OH\ DRV}$ | 8.5 | - | - | V | Terminal DRV1A,2A,3A,1B,2B,3B |
| Terminal DRV L output voltage | $V_{OL\ DRV}$ | - | - | 0.5 | V | Terminal DRV1A,2A,3A,1B,2B,3B |

$V_{FB}$ : FB terminal voltage, $V_{FC}$ : FC terminal voltage, $V_{SS}$ : SS terminal voltage, $V_{MONVCC}$ : MONVCC terminal voltage

Not designed for radiation resistance.

Current capability should not exceed Pd.


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● **Block diagram**

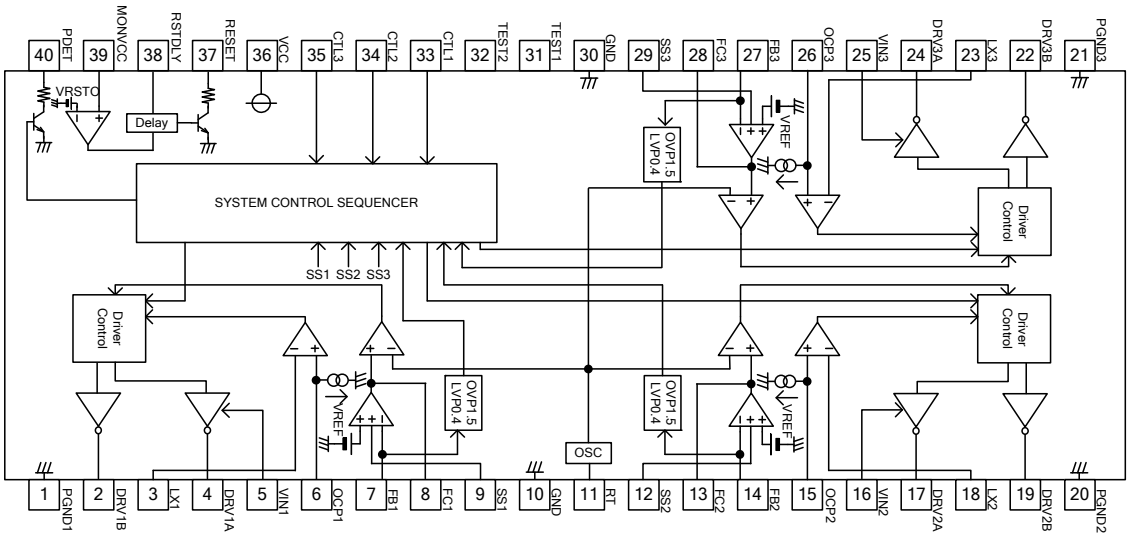


Figure 1 block char

● Terminal explanation

Table 1 terminal explanation

| No. | Symbol | Description | No. | Symbol | Description |
|---|---|---|---|---|---|
| 1 | PGND1 | Ch1 power GND (same potential as GND terminal) | 40 | PDET | Off latch signal output |
| 2 | DRV1B | Ch1 Nch drive output terminal | 39 | MONVCC | VCC monitor terminal |
| 3 | LX1 | Ch1 overcurrent detection terminal | 38 | RSTDLY | Reset delay adjustment capacity connection terminal |
| 4 | DRV1A | Ch1 Pch drive output terminal | 37 | RESET | Reset output terminal |
| 5 | VIN1 | Ch1 power supply input terminal | 36 | VCC | Power supply input terminal |
| 6 | OCP1 | Ch1 overcurrent detection level resistance connection terminal | 35 | CTL3 | Ch3 control terminal |
| 7 | FB1 | Ch1 voltage detection terminal | 34 | CTL2 | Ch2 control terminal |
| 8 | FC1 | Ch1 phase compensation terminal | 33 | CTL1 | Ch1 control terminal |
| 9 | SS1 | Ch1 soft start adjustment capacity connection terminal | 32 | TEST2 | Test terminal (connect to GND) |
| 10 | GND | GND (0V connection) | 31 | TEST1 | Test terminal (Connect to GND) |
| 11 | RT | Frequency adjustment resistance connection terminal | 30 | GND | GND (0V connection) |
| 12 | SS2 | Ch2 soft start adjustment capacity connection terminal | 29 | SS3 | Ch3 soft start adjustment capacity connection terminal |
| 13 | FC2 | Ch2 phase compensation terminal | 28 | FC3 | Ch3 phase compensation terminal |
| 14 | FB2 | Ch2 voltage detection terminal | 27 | FB3 | Ch3 voltage detection terminal |
| 15 | OCP2 | Ch2 overcurrent detection level resistance connection terminal | 26 | OCP3 | Ch3 overcurrent detection level resistance connection terminal |
| 16 | VIN2 | Ch2 power supply input terminal | 25 | VIN3 | Ch3 power supply input terminal |
| 17 | DRV2A | Ch2 Pch drive output terminal | 24 | DRV3A | Ch3 Pch drive output terminal |
| 18 | LX2 | Ch2 overcurrent detection terminal | 23 | LX3 | Ch3 overcurrent detection terminal |
| 19 | DRV2B | Ch2 Nch drive output terminal | 22 | DRV3B | Ch3 Nch drive output terminal |
| 20 | PGND2 | Ch2 power GND (same potential as terminal GND) | 21 | PGND3 | Ch3 power GND (same potential as terminal GND) |


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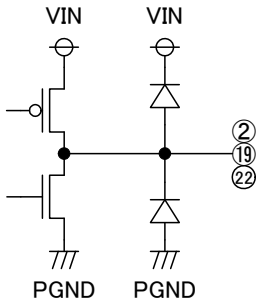
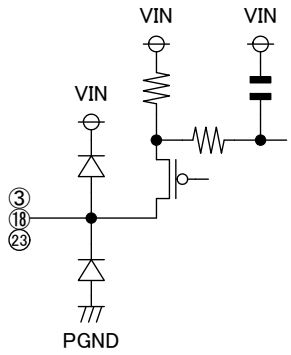
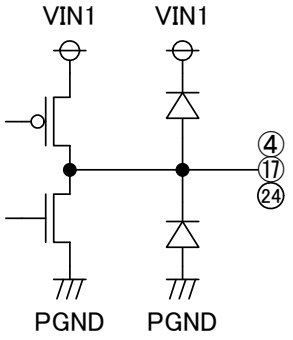
● Terminal equivalent circuit chart

| Terminal No. | Terminal name | Explanation | Terminal equivalent circuit chart |
|---|---|---|---|
| 1 | PGND1 | Ch1 Power GND<br>(GND Terminal and this potential) | |
| 20 | PGND2 | Ch2 Power GND<br>(GND Terminal and this potential) | |
| 21 | PGND3 | Ch3 Power GND<br>(GND Terminal and this potential) | |
| 2 | DRV1B | Ch1 Nch Driving output terminal |  |
| 19 | DRV2B | Ch2 Nch Driving output terminal | |
| 22 | DRV3B | Ch3 Nch Driving output terminal | |
| 3 | LX1 | Ch1 Over current detection terminal |  |
| 18 | LX2 | Ch2 Over current detection terminal | |
| 23 | LX3 | Ch3 Over current detection terminal | |
| 4 | DRV1A | Ch1 Pch Driving output terminal |  |
| 17 | DRV2A | Ch2 Pch Driving output terminal | |
| 24 | DRV3A | Ch3 Pch Driving output terminal | |
| 5 | VIN1 | Ch1 Power supply input terminal | |
| 16 | VIN2 | Ch2 Power supply input terminal | |
| 25 | VIN3 | Ch3 Power supply input terminal | |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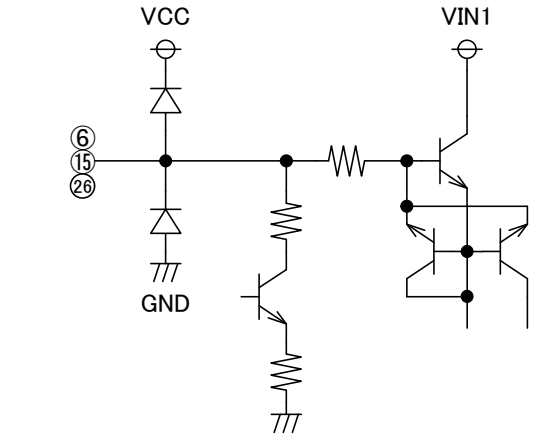
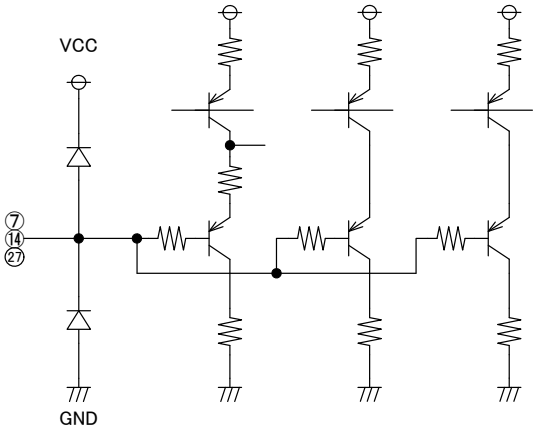
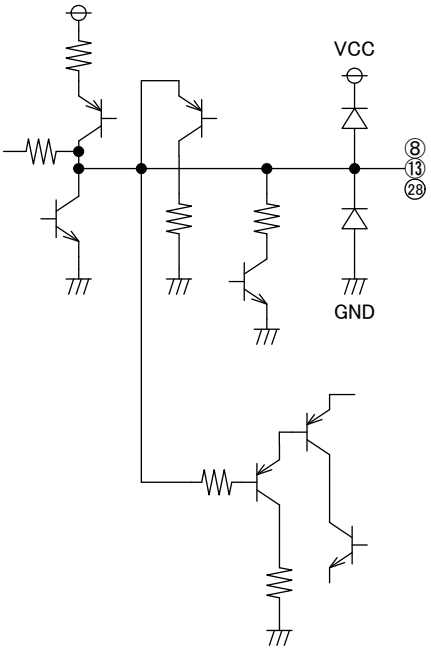
| Terminal No. | Terminal name | Explanation | Terminal equivalent circuit chart |
|---|---|---|---|
| 6 | OCP1 | Ch1 Over current detection level Set resistance connection terminal |   |
| 15 | OCP2 | Ch2 Over current detection level Set resistance connection terminal | |
| 26 | OCP3 | Ch3 Over current detection level Set resistance connection terminal | |
| 7 | FB1 | Ch1 Voltage detection terminal |   |
| 14 | FB2 | Ch2 Voltage detection terminal | |
| 27 | FB3 | Ch3 Voltage detection terminal | |
| 8 | FC1 | Ch1 Phase amends terminal |   |
| 13 | FC2 | Ch2 Phase amends terminal | |
| 28 | FC3 | Ch3 Phase amends terminal | |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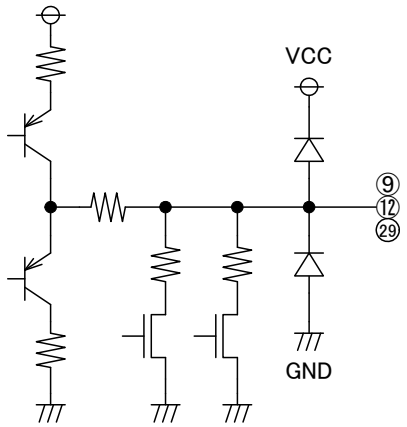
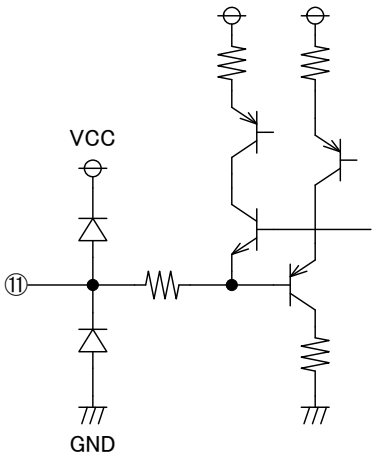
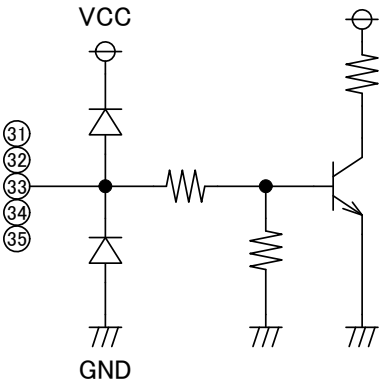
| Terminal No.. | Terminal name | Explanation | Terminal equivalent circuit chart |
|---|---|---|---|
| 9 | SS1 | Ch1 Soft start<br>Adjustment capacity connection terminal |  |
| 12 | SS2 | Ch2 Soft start<br>Adjustment capacity connection terminal | |
| 29 | SS3 | Ch3 Soft start<br>Adjustment capacity connection terminal | |
| 10 | GND | GND （0V Connection） | |
| 30 | GND | GND （0V Connection） | |
| 11 | RT | Frequency adjustment resistance connection terminal |  |
| 31 | TEST1 | Test terminal |  |
| 32 | TEST2 | Test terminal | |
| 33 | CTL1 | Ch1 Control terminal | |
| 34 | CTL2 | Ch2 Control terminal | |
| 35 | CTL3 | Ch3 Control terminal | |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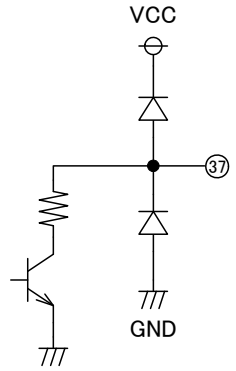
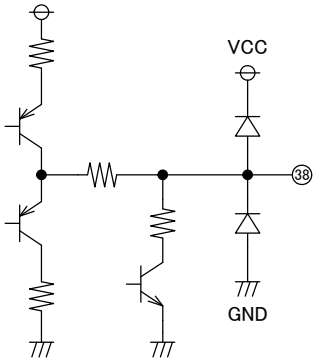
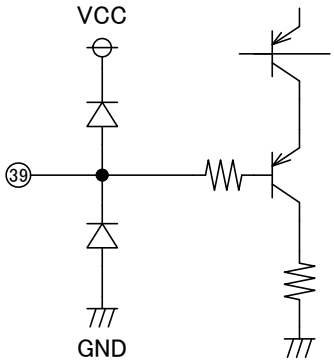
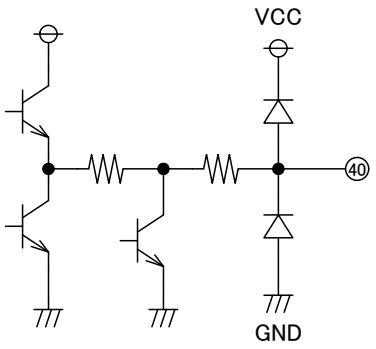
| Terminal No. | Terminal name | Explanation | Terminal equivalent circuit chart |
|---|---|---|---|
| 36 | VCC | Power supply input terminal | |
| 37 | RESET | Reset output terminal |  |
| 38 | RSTDLY | Reset Delay<br>Adjustment capacity connection terminal |  |
| 39 | MONVCC | VCC Monitor terminal |  |
| 40 | PDET | Off latch output terminal |  |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## ● Operation description

ON/OFF control

DC/DC converter controller ON/OFF function

DC/DC converter controller of each Ch can be independently controlled ON/OFF by CTL1, CTL2, and CTL3 terminal.
Analog circuit of Ch interlocked to each CTL terminal starts operation at ON control (on mode), and goes down to setting output voltage.
Analog circuit of Ch interlocked to each CTL terminal should be standby at OFF control (off mode), and output voltage becomes 0V.

Table2 DC/DC converter controller ON/OFF function

| CTL1 terminal voltage | Ch1 | CTL2 terminal voltage | Ch2 | CTL3 terminal voltage | Ch3 |
|---|---|---|---|---|---|
| >VIHCTL1 | ON control | >VIHCTL2 | ON control | >VIHCTL3 | ON control |
| <VILCTL1 | OFF control | <VILCTL2 | OFF control | <VILCTL3 | OFF control |

Soft start time set function

DC/DC converter controller of each Ch can do soft start without overshoot by charging soft start capacity (Css) connected between ss terminal and GND in each Ch by charging current at ON control.
The mute of the output is released when it reaches $V_{SS}$=0.15V ($V_{SSSTB}$), and the output voltage does the soft start operation from the point of $V_{SS}$=0.3V (typ) in proportion to the voltage of the terminal SS.
Also, soft start time (tss) can be set by setting soft start capacity arbitrarily.
Soft start time (tss) should be set at 3msec < tss < 30msec.

$$t_{SS} = \frac{V_{SSTH} \times C_{SS}}{I_{SS}}$$

Discharge function

DC/DC converter controller of each Ch can do soft off by discharging load discharged to soft start capacity connected between SS terminal to GND by discharging resistance at OFF control.
Soft off operates in proportion to the voltage of the terminal SS the output voltage from the point of VSS=0.8V (typ).

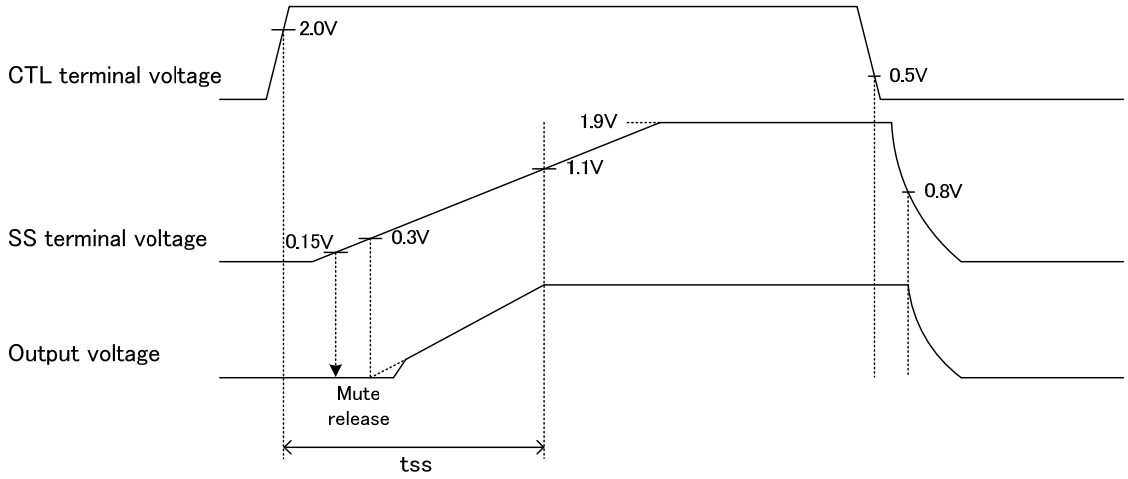


Figure 2 Wave form at ON/OFF control


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OSC oscillation frequency setting function

DRVA and DRVB output oscillation frequency of DC/DC converter controller of each Ch can be set by installing resistance between RT terminal and GND externally.

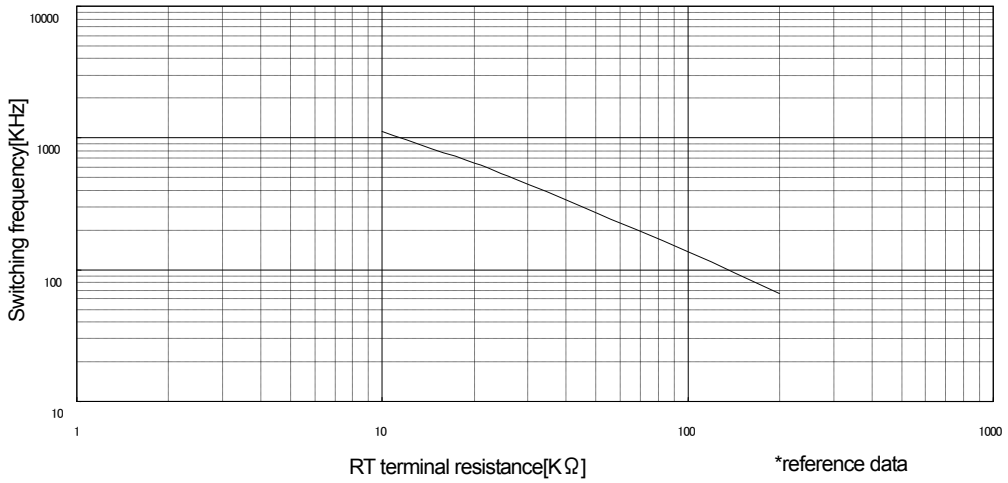


Figure 3 Terminal RT resistance-oscillation frequency

Off latch signal output function

PDET terminal outputs condition of off latch when protection operation of DC/DC converter controller of each Ch operates.

Table 3 PDET terminal off latch signal output function

| Protection operation | Terminal PDET |
|---|---|
| ON | LOW |
| OFF | Hi-Z |


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Reset output function

Reset output function observes voltage value from MONVCC terminal and does reset operation compared to internal reference level.

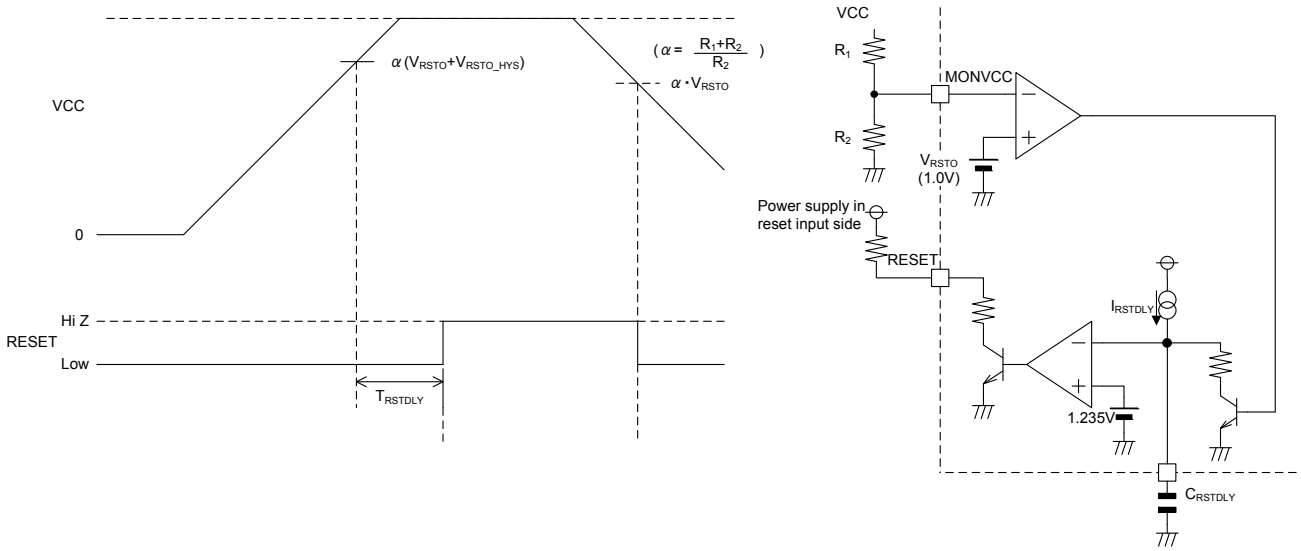
Set MONVCC terminal external resistance to make VCC voltage more than 5.0V at reset release.

Table 4 DC/DC converter controller ON/OFF function

| MONVCC terminal voltage | RESET terminal |
|---|---|
| <1.0V(typ) | LOW |
| >1.072V(typ) | Hi-Z |

Delay time until detecting reset release is settable by capacitor connected to RSTDLY terminal.

$$T_{RSTDLY} = \frac{1.235V \times C_{RSTDLY}}{I_{RSTDLY}}$$




TRSTDLY : Delay time until detecting reset release

Figure 4 reset operation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## ● Protection function

Protection circuit is effective for destruction prevention due to accident so that avoid using by continuous protection operation.

Low voltage protection function(LVP)

Low voltage protection function detects output voltage $V_O$ set in each Ch from FB terminal of each Ch and off-latched all DC/DC converter controller compared to internal reference level.

Low voltage protection function operates when FB terminal voltage falls below $V_{LVP}$ (=1.5 x VREF) and continues about more than 400μsec (typ).

Table 5 Low voltage protection function

| CTL terminal | SS terminal | FB terminal | Low voltage protection function | Low voltage protection operation |
|---|---|---|---|---|
| >$V_{IHCTL}$ | >1.1V(typ) | <$V_{LVP}$ | Enable | ON |
| | | >$V_{LVP}$+$V_{LVP\_HYS}$ | | OFF |
| | <1.0V(typ) | - | Disable | OFF |
| <$V_{ILCTL}$ | - | - | Disable | OFF |

*Constant voltage protection function is enabled when SS terminal voltage of each Ch becomes more than 1.1V (typ) in the transition to ON control (during soft start).

Overvoltage protection function(OVP)

Overvoltage protection function detects output voltage VO set in each Ch from FB terminal of each Ch and off-latched all DC/DC converter controller compared to internal reference level.

Overvoltage protection function operates when FB terminal voltage exceeds VOVP (=1.5 x VREF) and continues about more than 400μsec (typ).

Table 6 Overvoltage protection function

| CTL terminal | SS terminal | FB terminal | Overvoltage protection function | Overvoltage protection operation |
|---|---|---|---|---|
| >$V_{IHCTL}$ | >1.1V(typ) | >$V_{OVP}$ | Effective | ON |
| | | <$V_{OVP}$ | | OFF |
| | <1.0V(typ) | - | Invalidity | OFF |
| <$V_{ILCTL}$ | - | - | Invalidity | OFF |

*Overvoltage protection function is enabled when SS terminal voltage of each Ch becomes more than 1.1V (typ) in the transition to ON control (during soft start).


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Overcurrent protection function(OCP)

Overcurrent protection function compared drain voltage (LX terminal voltage) with OCP terminal voltage when external Pch POWER MOS is ON. When LX terminal voltage becomes lower than OCP terminal voltage, external MOS would be OFF. Up to 50uA (typ) of constant current from OCP terminal is synchronized. Overcurrent detection level (OCP terminal voltage) can be set arbitrarily by external resistance value.

Off latch by overcurrent protection function operates when LX terminal voltage falls below OCP terminal voltage and continues about more than 400μsec (typ).

Table 7 overcurrent protection function

| CTL terminal | SS terminal | LX terminal voltage | Overcurrent protection function | Overcurrent protection operation |
|---|---|---|---|---|
| >$V_{IHCTL}$ | >1.1V(typ) | <$V_{OCP}$ | Enable | ON |
| | | >$V_{OCP}$ | | OFF |
| | <1.0V(typ) | - | Disable | OFF |
| <$V_{ILCTL}$ | - | - | Disable | OFF |

*Set OCP terminal voltage to be more than VIN-2.5V (typ).

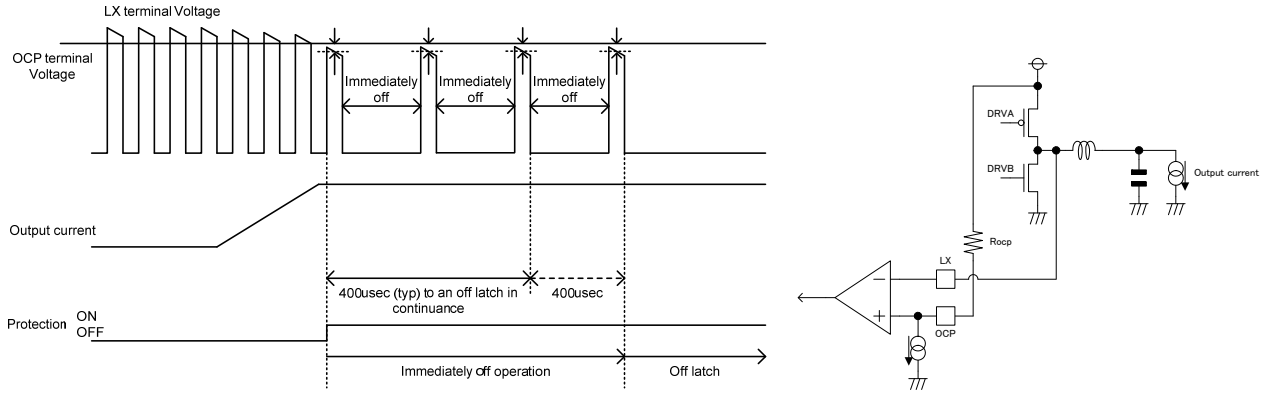


Figure 5. Overcurrent protection


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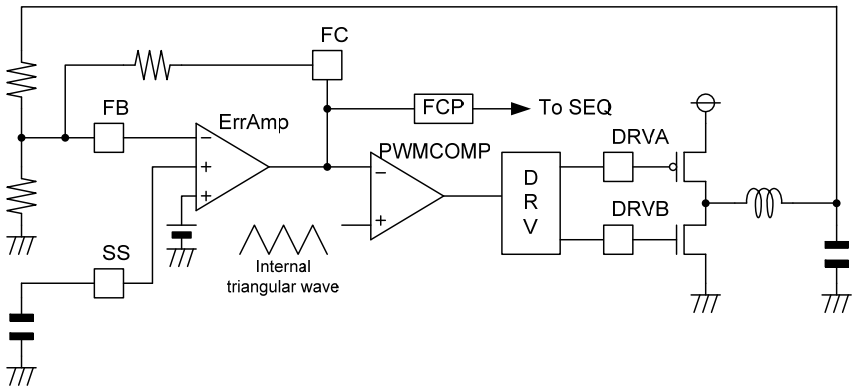
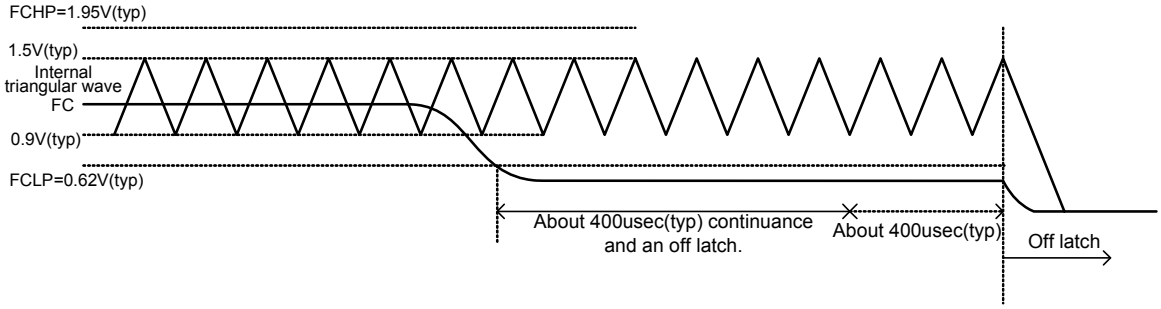
Terminal FC abnormality protection function




The terminal FC abnormality protection function Ofrattis it all DC/DC converter controller detecting the continuance of the state that FC which is the difference input of PWMCOMP does not intersect with an internal triangular wave.
The terminal FC abnormality protection function is exceeded 1.95V(typ) by the voltage of the terminal FC or operates when it falls below 0.62V(typ), and about 400usec(typ) or more continues.

| CTL terminal | SS terminal | Protection operation | FC terminal | Terminal FC abnormality protection operation |
|---|---|---|---|---|
| > $V_{IHCTL}$ | > 1.1V(typ) | Enable | > 1.95V(typ) | ON |
| | | | 0.62V(typ) < , < 1.95V(typ) | OFF |
| | < 1.0V(typ) | Disable | < 0.62V(typ) | ON |
| < $V_{IHCTL}$ | | | - | OFF |

*Terminal FC abnormality protection function is enabled when SS terminal voltage of each Ch becomes more than 1.1V (typ) in the transition to ON control (during soft start).

RT terminal open/short protection function

RT terminal open/shot protection function off-latches all DC/DC converter controller by detecting open/short condition internally from RT terminal to prevent from output voltage error caused by abnormal oscillation of internal triangular wave at RT terminal open/short.

RT terminal open/short protection function is regularly enabled after boot-up.
RT terminal open/short protection function operates when error detection condition continues about more than 400µsec (typ).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Soft start time-out function

Each Ch DC/DC converter controller off-latch-controls when $V_{SS}$ does not exceed $V_{SSPON}$ from $V_{SS} > V_{SSSTB}+V_{SSSTB\_HYS}$ after 50msec (typ) passed from soft start.

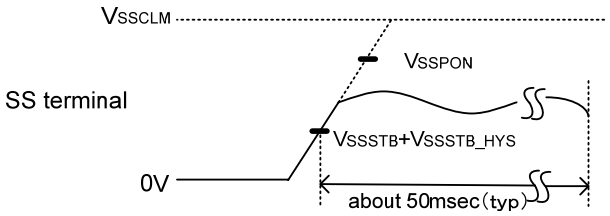


Figure 6. At soft start time-out

Error detection (off latch) release method

Each Ch DC/DC converter controller comes into off latch condition when protection function operates. Off latch can be released by the following method. Each Ch DC/DC converter controller becomes able to do ON control transition by releasing off latch.

1. Set all Ch CTL terminal voltage as $< V_{ILCTL}$ and continue that condition about more than 200usec (typ).
2. Drop down power supply VCC to below 4.5V.


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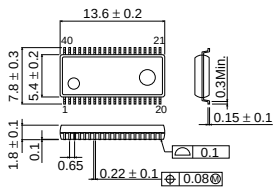
**●Ordering part number**

| B | D | 8 | 6 | 0 | 1 | F | P | - | E | 2 |
|---|---|---|---|---|---|---|---|---|---|---|

Part No. Part No. Package FP: SSOP-B40 Packaging and forming specification E2: Embossed tape and reel

## SSOP-B40

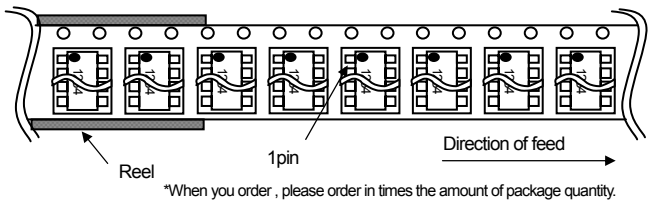
<Dimension>




(Unit:mm)

<Tape and Reel information>

| | |
|---|---|
| Tape | Embossed carrier tape |
| Quantity | 2000pcs |
| Direction of feed | E2<br>(The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand) |




*When you order , please order in times the amount of package quantity.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