

DATA SHEET

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| Part No. | AN33013UA |
| Package Code No. | SSOP024-P-0300F |

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AN33013UA

1-channel DC-DC Controller IC

■ Overview

AN33013UA is a DC-DC controller which can be configured for step-down configuration. The operating input voltage is between 5 V to 25 V.

■ Features

- Internal reference voltage is within $\pm 2\%$ accuracy
- Switching frequency is adjustable within the range of 200 kHz to 2 MHz by an external resistor
- Standby mode consumes less than 1 μA current
- Adjustable output voltage
- Output over voltage protection (OVP) function
- Output ground short protection function
- Over-current protection (OCP) with adjustable threshold.
- Power supply under-voltage lockout (UVLO) function
- Adjustable soft-start function

■ Application

- Car navigation and car audio

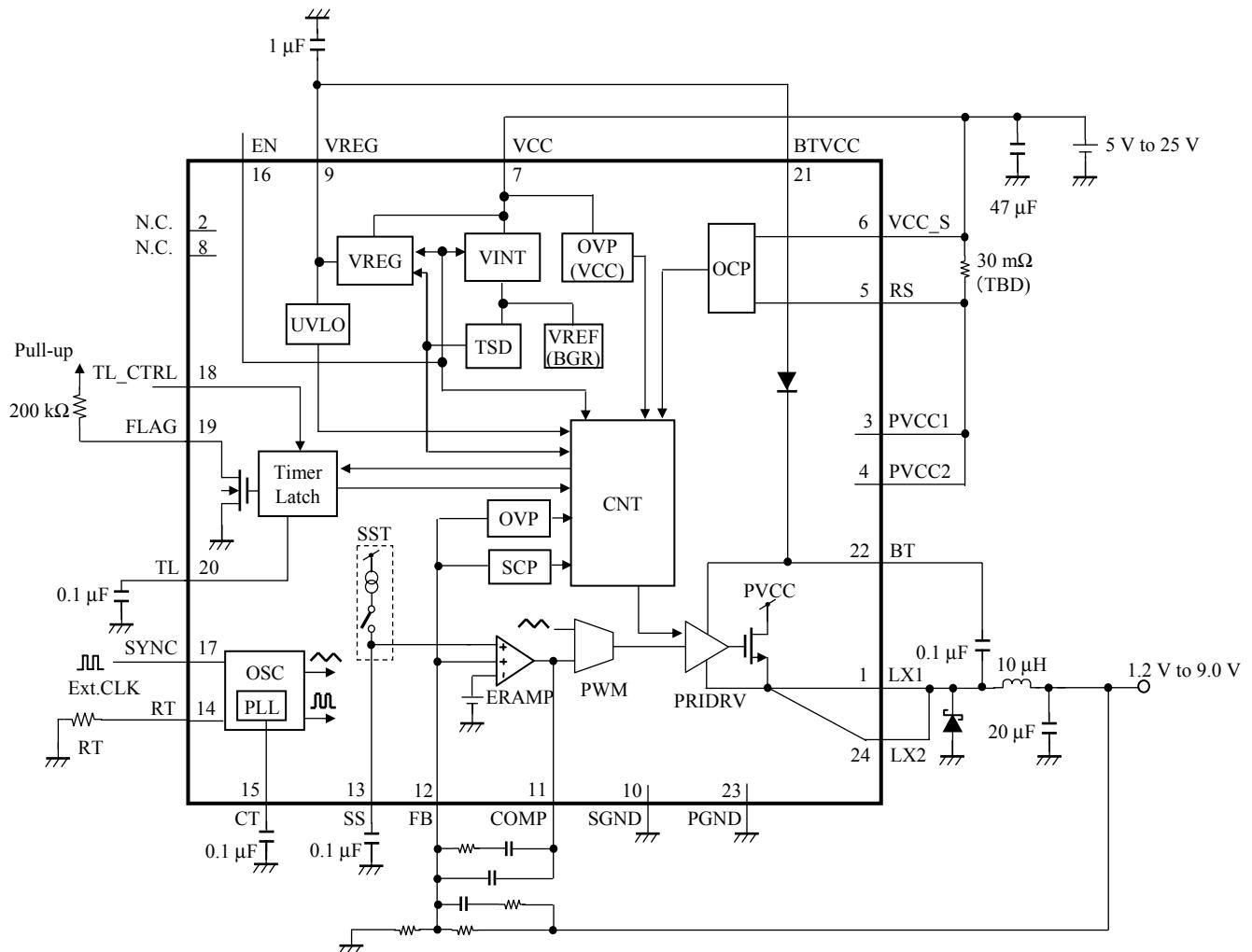
■ Package

- 24 Pin Plastic Shrink Small Outline Package (SSOP Type)

■ Type

- Bi-CMOS IC

■ Application Circuit Example (Block Diagram)



Notes)

- This application circuit is an example. The operation of mass production set is not guaranteed. Perform enough evaluation and verification on the design of mass production set.
- This block diagram is for explaining functions. The part of the block diagram may be omitted, or it may be simplified.

■ Pin Descriptions

| Pin No. | Pin name | Type | Description |
|---------|----------|--------------|--|
| 1 | LX1 | Output | Connect to an external inductor and schottky diode |
| 2 | NC | — | No connection |
| 3 | PVCC1 | Power Supply | Power supply pin for internal driver |
| 4 | PVCC2 | Power Supply | Power supply pin for internal driver |
| 5 | RS | Input | Connection to current sensing port for OCP |
| 6 | VCC_S | Input | VCC pin connection to current sensing port for OCP |
| 7 | VCC | Power Supply | Power supply pin |
| 8 | NC | — | No connection |
| 9 | VREG | Output | Connect to an external capacitor for internal regulator |
| 10 | SGND | Ground | Ground pin |
| 11 | COMP | Output | Error amplifier output |
| 12 | FB | Input | Error amplifier negative input |
| 13 | SS | Input | Soft-start capacitor connection pin |
| 14 | RT | Input | Connect to an external resistor for adjustment of oscillation frequency |
| 15 | CT | Output | Low Pass filter function pin for PLL |
| 16 | EN | Input | Enable pin |
| 17 | SYNC | Input | External clock input for adjustment of oscillation frequency |
| 18 | TL_CTRL | Input | Connect to high to enable over current shut-down function |
| 19 | FLAG | Output | Error flag output pin |
| 20 | TL | Input | Connect to an external capacitor for adjustment of over-current detection time |
| 21 | BTVCC | Input | Boot strap input pin |
| 22 | BT | Input | Connect to an external capacitor for Boot strap |
| 23 | PGND | Ground | Power ground pin |
| 24 | LX2 | Output | Connect to an external inductor and schottky diode |

■ Absolute Maximum Ratings

Note) Absolute maximum ratings are limit values which do not result in damages to this IC, and IC operation is not guaranteed at these limit values.

| A No. | Parameter | Symbol | Rating | Unit | Notes |
|-------|-------------------------------|-----------|-------------|------|-------|
| 1 | Supply voltage | V_{CC} | 40 | V | *1 |
| 2 | Supply current | I_{CC} | 1.5 | A | *2 |
| 3 | Power dissipation | P_D | 253 | mW | *3 |
| 4 | Operating ambient temperature | T_{opr} | -40 to +85 | °C | *4 |
| 5 | Storage temperature | T_{stg} | -55 to +150 | °C | *4 |

Notes)*1 : The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

V_{CC} is voltage for VCC, PVCC1, PVCC2. VCC = PVCC1 = PVCC2.

*2 : Without power dissipation (P_D) and area of safety operation (ASO) constraint.

$I_{CC} = I_{VCC} + I_{PVCC1} + I_{PVCC2} + I_{PVCC3}$.

*3 : The power dissipation shown is the value at $T_a = 85^\circ\text{C}$ for the independent (unmounted) IC package without a heat sink.

When using this IC, refer to $P_D - T_a$ diagram in the ■ Technical Data and design the heat radiation with sufficient margin so that the allowable value might not be exceeded based on the conditions of power supply voltage, load, and ambient temperature.

*4 : Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for $T_a = 25^\circ\text{C}$.

■ Operating Supply Voltage Range

| Parameter | Symbol | Range | Unit | Notes |
|----------------------|----------|---------|------|-------|
| Supply voltage range | V_{CC} | 5 to 25 | V | * |

Note) * : The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

■ Allowable Current and Voltage Range

Notes)

- Allowable current and voltage ranges are limit ranges which do not result in damages to this IC, and IC operation is not guaranteed within these limit ranges.
- Voltage values, unless otherwise specified, are with respect to GND.
GND is voltage for SGND and PGND. SGND = PGND.
- V_{CC} is voltage for VCC, PVCC1 and PVCC2. VCC = PVCC1 = PVCC2.
- Do not apply external currents or voltages to any pin not specifically mentioned.

| Pin No. | Pin name | Rating voltage | Unit | Notes |
|---------|----------|-----------------------------------|------|-------|
| 1 | LX1 | – 0.3 to (V_{CC} + 0.3) | V | *1 |
| 5 | RS | – 0.3 to (V_{CC} + 0.3) | V | *1 |
| 9 | VREG | – 0.3 to 5.5 | V | — |
| 11 | COMP | – 0.3 to 5.5 | V | — |
| 12 | FB | – 0.3 to 5.5 | V | — |
| 13 | SS | – 0.3 to 5.5 | V | — |
| 14 | RT | – 0.3 to 5.5 | V | — |
| 15 | CT | – 0.3 to 5.5 | V | — |
| 16 | EN | – 0.3 to (V_{CC} + 0.3) | V | *1 |
| 17 | SYNC | – 0.3 to 5.5 | V | — |
| 18 | TL_CTRL | – 0.3 to 5.5 | V | — |
| 19 | FLAG | – 0.3 to 5.5 | V | — |
| 20 | TL | – 0.3 to 5.5 | V | — |
| 21 | BTVCC | – 0.3 to 5.5 | V | — |
| 22 | BT | – 0.3 to (V_{CC} + V_{REG}) | V | *1 |
| 24 | LX2 | – 0.3 to (V_{CC} + 0.3) | V | *1 |

Note) *1 : (V_{CC} + 0.3) V, (V_{CC} – V_{REG}) V must not exceed 40 V.

■ Electrical Characteristics at $V_{CC} = 12$ V, $V_{OUT} = 5.0$ VNote) $T_a = 25^\circ\text{C} \pm 2^\circ\text{C}$ unless otherwise specified.

| B No. | Parameter | Symbol | Conditions | Limits | | | Unit | Notes |
|------------------------------------|-------------------------------|------------|---|--------|------|-------|---------------|-------|
| | | | | Min | Typ | Max | | |
| Circuit current consumption | | | | | | | | |
| 1 | Quiescent current | I_{CQ} | $FB = 1.1$ V $EN = 3.3$ V No switching | — | 0.7 | 1.4 | mA | — |
| 2 | Standby current | I_{STBY} | $EN = 0.4$ V | — | 0.01 | 1 | μA | — |
| 3 | Enable Low input threshold | V_{IL1} | — | — | — | 0.4 | V | — |
| 4 | Enable High input threshold | V_{IH1} | — | 2.0 | — | — | V | — |
| 5 | EN pin input current | V_{IC} | $EN = 3.3$ V | — | 33 | 70 | μA | — |
| BGR | | | | | | | | |
| 6 | Feedback voltage | V_{REF} | FB connected to COMP | 0.98 | 1.0 | 1.02 | V | — |
| SYNCHRONIZATION (SYNC) | | | | | | | | |
| 7 | Low input threshold | V_{IL2} | — | — | — | 0.4 | V | — |
| 8 | High input threshold | V_{IH2} | — | 2.0 | — | — | V | — |
| Oscillator | | | | | | | | |
| 9 | Oscillator frequency | F_{OUT1} | $RT = 130$ k Ω | 440 | 490 | 540 | kHz | — |
| 10 | Oscillator frequency range | F_{OUT2} | | 200 | — | 2 000 | kHz | — |
| 11 | External sync frequency range | F_{SYNC} | $RT = 130$ k Ω $F_{out1} = 490$ kHz | 545 | — | 730 | kHz | — |

■ Electrical Characteristics at $V_{CC} = 12$ V, $V_{OUT} = 5.0$ VNote) $T_a = 25^\circ\text{C} \pm 2^\circ\text{C}$ unless otherwise specified.

| B No. | Parameter | Symbol | Conditions | Limits | | | Unit | Notes |
|-------------------------|--|------------|---------------------------|--------|------|------|------|-------|
| | | | | Min | Typ | Max | | |
| Over-current protection | | | | | | | | |
| 12 | Over-current threshold voltage | V_{OCP} | (VCC_S-VRS) | 60 | 75 | 90 | mV | *1 |
| Over-voltage protection | | | | | | | | |
| 13 | Over-voltage threshold voltage for VFB | V_{OVP1} | For FB | 1.14 | 1.22 | 1.30 | V | — |
| 14 | Over-voltage threshold voltage for VCC | V_{OVP2} | For VCC | 30 | 34 | 38 | V | — |
| Internal regulator | | | | | | | | |
| 15 | Internal regulator output voltage | V_{REG} | $C_{REG} = 1 \mu\text{F}$ | 4.5 | 5.0 | 5.3 | V | — |
| GND short protection | | | | | | | | |
| 16 | Short detection voltage | V_{SCP} | monitor FB | 0.15 | 0.3 | 0.45 | V | — |

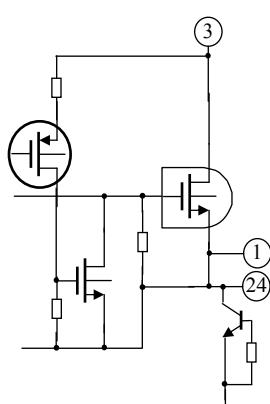
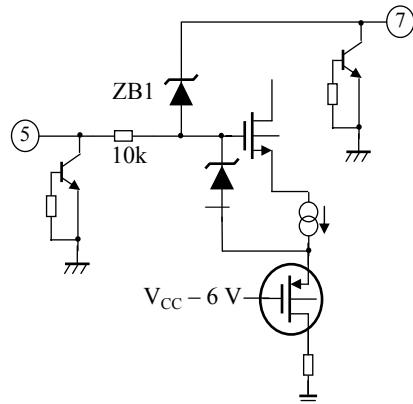
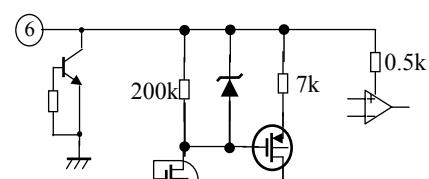
Note) *1 : This parameter is tested with DC measurement.

■ Technical Data

• IO block circuit diagram and pin function descriptions

Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

(NOTE)  : PGND  : SGND

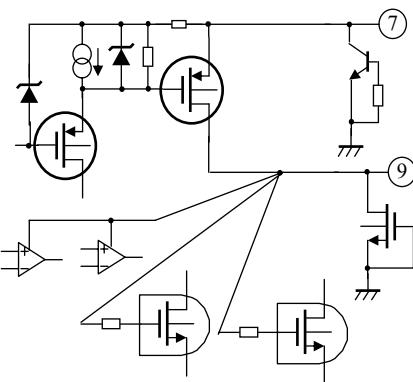
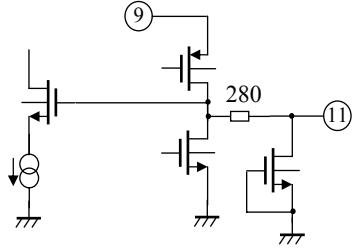
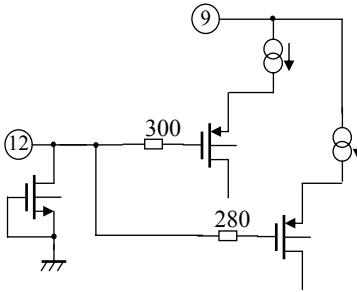
| Pin No. | Pin name | Waveform and voltage | Internal circuit | Impedance | Description |
|---------|----------|---------------------------|---|-----------|--|
| 1 | LX1 | -0.5 V to V _{CC} |  | Hi-Z | Connect to an external inductor and shottky diode |
| 3 | PVCC1 | DC 12 V | — | — | Power supply pin for internal driver |
| 4 | PVCC2 | DC 12 V | — | — | Power supply pin for internal driver |
| 5 | RS | DC 12 V |  | Hi-Z | Connection to current sensing port for OCP |
| 6 | VCC_S | DC 12 V |  | Hi-Z | VCC pin connection to current sensing port for OCP |

■ Technical Data (continued)

• IO block circuit diagram and pin function descriptions (continued)

Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

(NOTE)  : PGND  : SGND

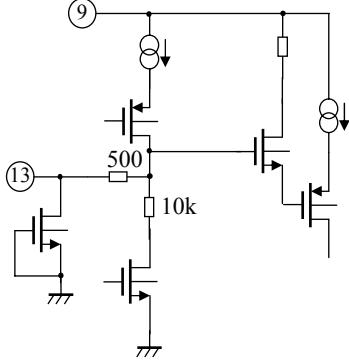
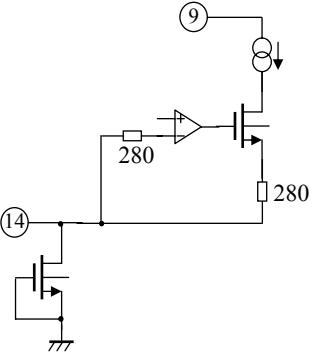
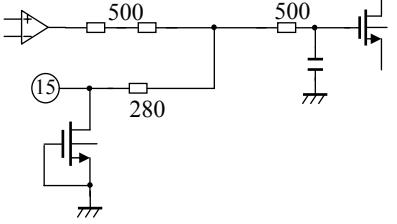
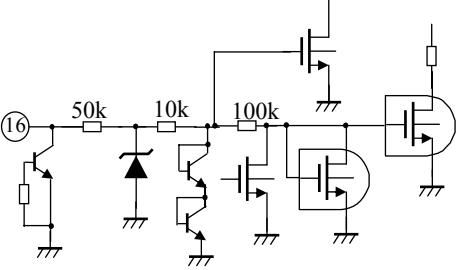
| Pin No. | Pin name | Waveform and voltage | Internal circuit | Impedance | Description |
|---------|----------|----------------------|---|-----------|---|
| 7 | VCC | DC 12 V | — | — | Power supply pin |
| 9 | VREG | DC 4.9 V |  | Hi-Z | Connect to an external capacitor for internal regulator |
| 10 | SGND | 0 V | — | — | Ground pin |
| 11 | COMP | max. 5 V |  | Hi-Z | Error amplifier output |
| 12 | FB | DC 1.0 V |  | Hi-Z | Error amplifier negative input |

■ Technical Data (continued)

• IO block circuit diagram and pin function descriptions (continued)

Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

(NOTE)  : PGND  : SGND

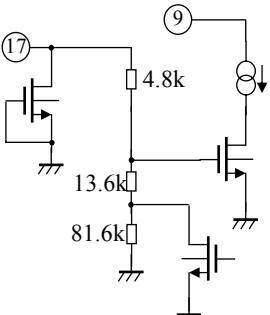
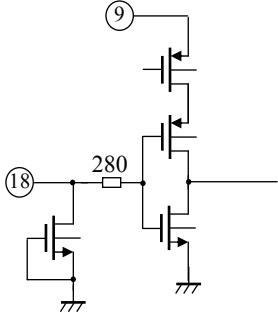
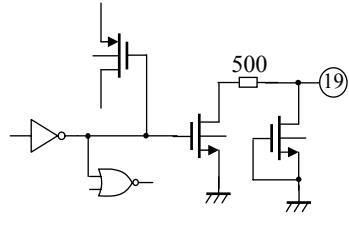
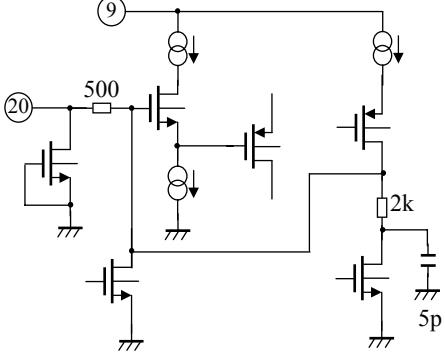
| Pin No. | Pin name | Waveform and voltage | Internal circuit | Impedance | Description |
|---------|----------|------------------------------------|--|-----------|---|
| 13 | SS | 0 V to V _{REG} |  | Hi-Z | Soft-start capacitor connection pin |
| 14 | RT | 0 V to V _{REG} |  | Hi-Z | Connect to an external resistor for adjustment of oscillation frequency |
| 15 | CT | 0 V to V _{REG} |  | Hi-Z | Low Pass filter function pin for PLL |
| 16 | EN | 0 V to V _{CC} (max. 25 V) |  | 160 kΩ | Enable pin |

■ Technical Data (continued)

• IO block circuit diagram and pin function descriptions (continued)

Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

(NOTE)  : PGND  : SGND

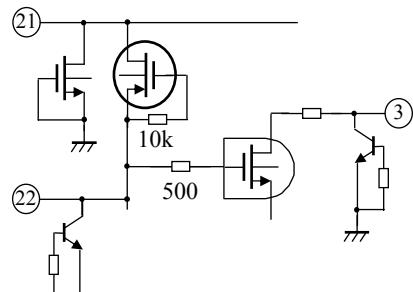
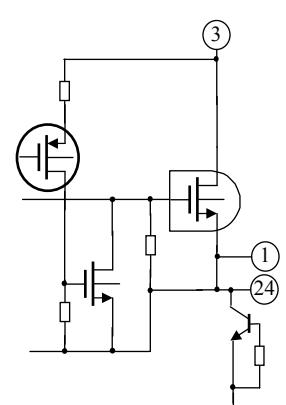
| Pin No. | Pin name | Waveform and voltage | Internal circuit | Impedance | Description |
|---------|----------|-------------------------|---|-----------|--|
| 17 | SYNC | 0 V to V _{REG} |  | 100 kΩ | External clock input for adjustment of oscillation frequency |
| 18 | TL_CTRL | 0 V to V _{REG} |  | Hi-Z | Connect to high to enable over current shut-down function |
| 19 | FLAG | 0 V to V _{REG} |  | Hi-Z | Error flag output pin |
| 20 | TL | 0 V to V _{REG} |  | Hi-Z | Connect to an external capacitor for adjustment of over-current detection time |

■ Technical Data (continued)

• IO block circuit diagram and pin function descriptions (continued)

Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

(NOTE)  : PGND  : SGND

| Pin No. | Pin name | Waveform and voltage | Internal circuit | Impedance | Description |
|---------|----------|---------------------------------|---|-----------|---|
| 21 | BTVCC | 0 V to V_{REG} |  | Hi-Z | Boot strap input pin |
| 22 | BT | V_{REG} to $V_{CC} + V_{REG}$ | | Hi-Z | Connect to an external capacitor for Boot strap |
| 23 | PGND | 0 V | — | — | Power ground pin |
| 24 | LX2 | 0 V to V_{CC} |  | Hi-Z | Connect to an external inductor and shottky diode |

■ Technical Data (continued)

- Power ON/OFF timing

AN33013UA consists of one channel and it can be turned ON and OFF by using the EN pin.

EN > 2.8 V: Enabled

EN < 0.4 V: Disabled

1. Power ON Sequence:

- V_{CC} rises to a desired voltage level.
(A 10 μ s rise time or more is recommended to control and limit any abnormal current flow via the power transistor when V_{CC} is rising.)
- Apply a voltage level of 2.8 V or higher at EN pin after V_{CC} is steady and the DC-DC will begin to operate.
(It is possible to connect the EN pin to V_{CC} through a resistor, and, in that case, when V_{CC} rises, DC-DC will begin to operate.)
- When V_{REG} voltage reaches 4.9 V and above, and after a delay time (charging time of the soft start capacitor) decided by an external capacitor, the DC-DC will start to operate.

2. Power OFF Sequence:

- To turn OFF the DC-DC output, apply a voltage of 0.4 V or lower to EN pin.
- V_{OUT} will drop after EN pin becomes Low.
(The discharge time is dependent on the applied load current and the feedback resistance connected at the output.)
- The DC-DC will turn OFF if the V_{CC} level becomes low even before EN pin becomes low.
The above scenario occurs when the V_{REG} voltage decreases to 4.2 V or less.
(However, the DC-DC output voltage will also decrease with V_{CC} when the V_{CC} level drops below a certain minimum level required to maintain the output voltage level.)

3. Points to take note of when re-starting the DC-DC:

- Please allow a waiting time of 10 ms or more for the discharge time of the soft start capacitor when starting up the DC-DC again after turning it OFF.

The output voltage might overshoot without the soft start function working properly if the DC-DC is re-started immediately after it is turned OFF.

■ Technical Data (continued)
• Power ON/OFF timing (continued)
4. EN pin ON/OFF operation sequence

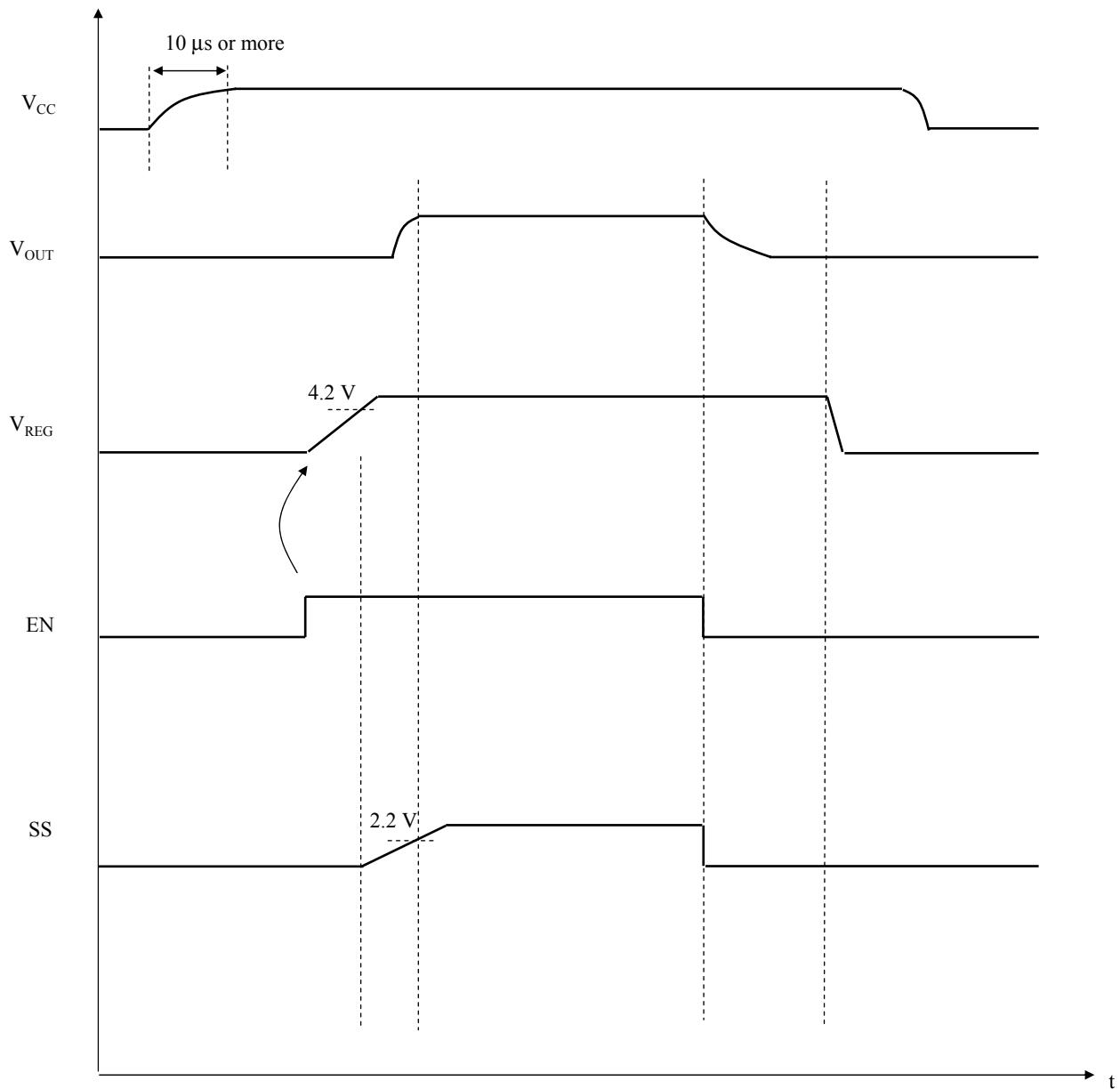


Figure 1.1 Power ON/OFF Timing (1)

■ Technical Data (continued)**• Power ON/OFF timing (continued)**

5. ON/OFF operation sequence by V_{CC} control (EN pin is connected to V_{CC}).

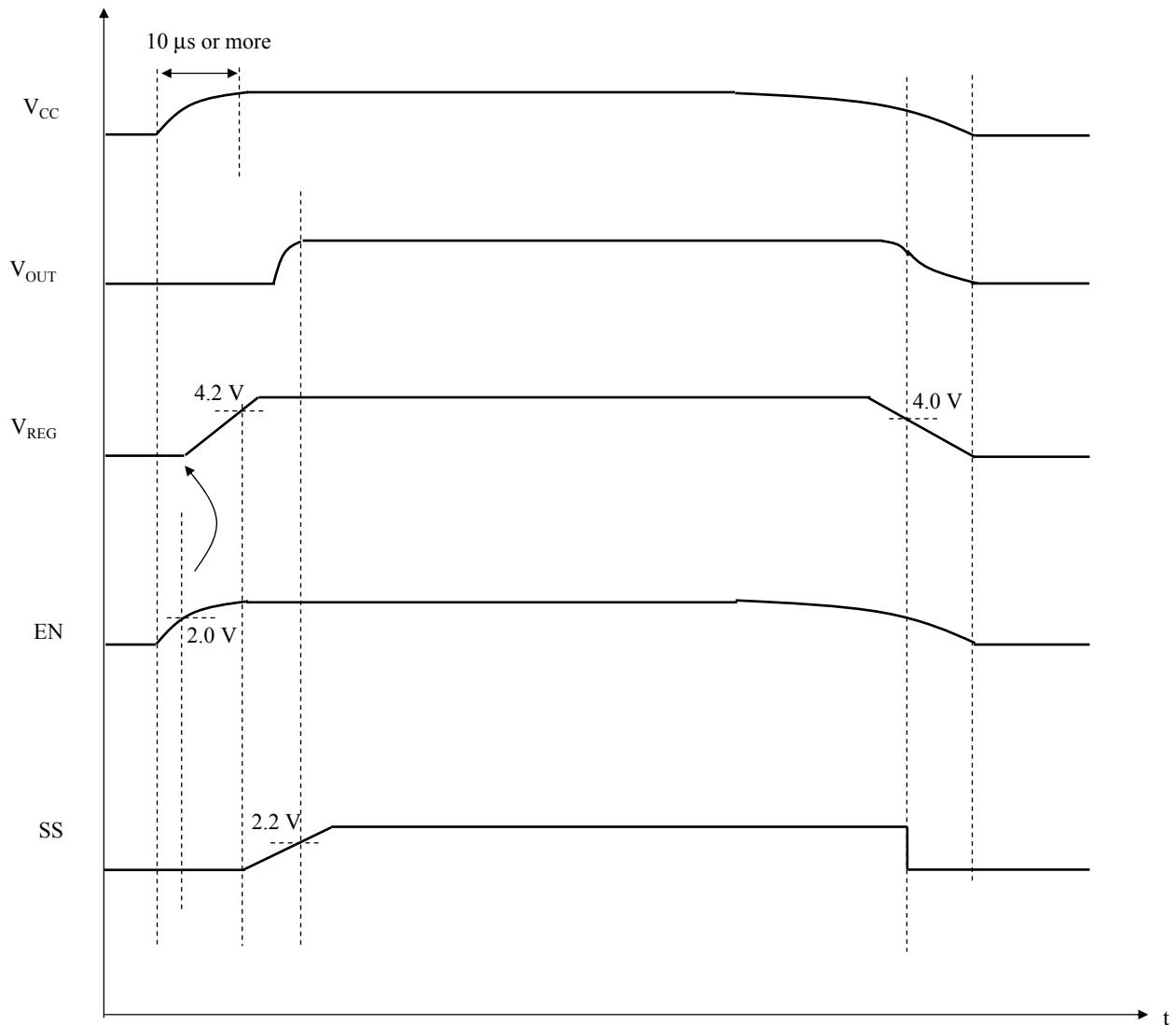
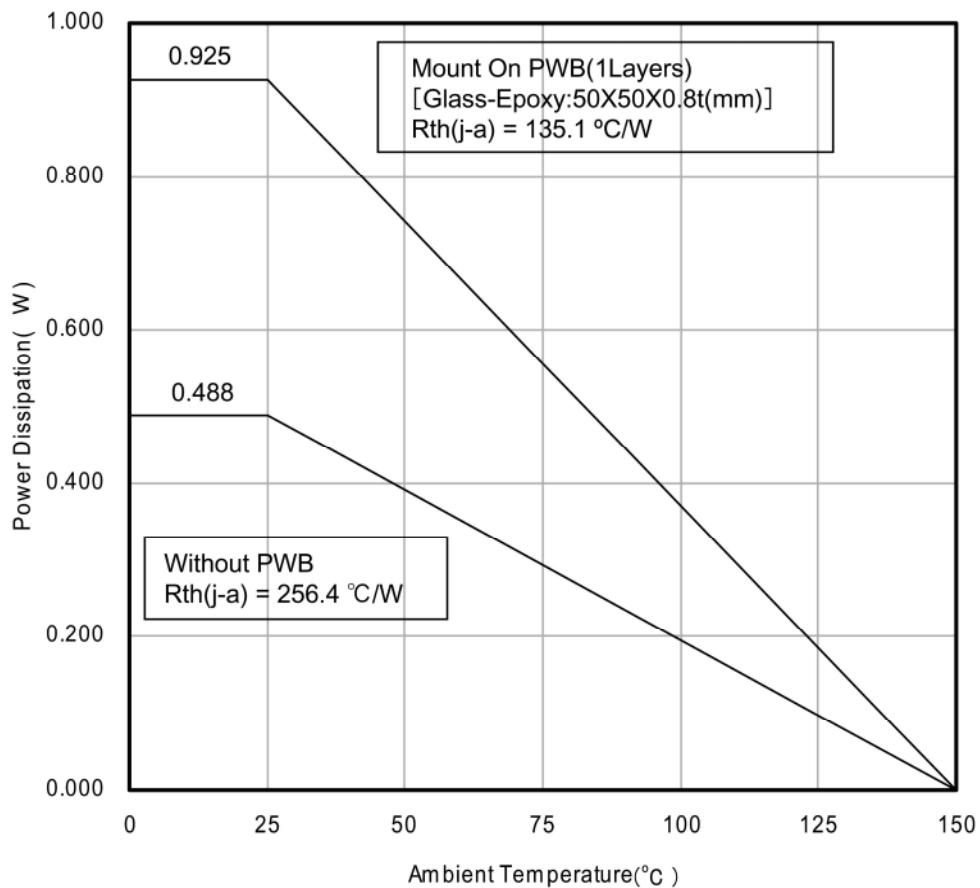


Figure 1.2 Power ON/OFF Timing (2)

■ Technical Data

- P_D — T_a diagram



■ Usage Notes**• Special attention and precaution in using**

1. This IC is intended to be used for general electronic equipment.

Consult our sales staff in advance for information on the following applications:

- Special applications in which exceptional quality and reliability are required, or if the failure or malfunction of this IC may directly jeopardize life or harm the human body.

- Any applications other than the standard applications intended.

(1) Space appliance (such as artificial satellite, and rocket)

(2) Traffic control equipment (such as for automobile, airplane, train, and ship)

(3) Medical equipment for life support

(4) Submarine transponder

(5) Control equipment for power plant

(6) Disaster prevention and security device

(7) Weapon

(8) Others : Applications of which reliability equivalent to (1) to (7) is required

It is to be understood that our company shall not be held responsible for any damage incurred as a result of or in connection with your using the IC described in this book for any special application, unless our company agrees to your using the IC in this book for any special application.

2. Pay attention to the direction of LSI. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might smoke or ignite.
3. Pay attention in the PCB (printed-circuit-board) pattern layout in order to prevent damage due to short circuit between pins. In addition, refer to the Pin Description for the pin configuration.
4. Perform a visual inspection on the PCB before applying power, otherwise damage might happen due to problems such as a solder-bridge between the pins of the semiconductor device. Also, perform a full technical verification on the assembly quality, because the same damage possibly can happen due to conductive substances, such as solder ball, that adhere to the LSI during transportation.
5. Take notice in the use of this product that it might break or occasionally smoke when an abnormal state occurs such as output pin-V_{CC} short (Power supply fault), output pin-GND short (Ground fault), or output-to-output-pin short (load short) .
And, safety measures such as an installation of fuses are recommended because the extent of the above-mentioned damage and smoke emission will depend on the current capability of the power supply.
6. When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.
7. When using the LSI for new models, verify the safety including the long-term reliability for each product.
8. When the application system is designed by using this LSI, be sure to confirm notes in this book.
Be sure to read the notes to descriptions and the usage notes in the book.
9. Take notice in the use of this product that it might ignite or occasionally smoke when the 5.5 V rating pin is short to the 35 V rating(5.5 V or more) pin.
The 5.5 V rating pin are VREG, FB, COMP, SS, CT, RT, SYNC, TL_CTRL, FLAG, TL, and BTVCC.
The 35 V rating pin are VCC, VCC_S, PVCC1, PVCC2, RS, BT, LX1, LX2, and EN.
10. Take notice in the use of this product that it might break or occasionally smoke when an abnormal state occurs such as BT pin-V_{CC} short (Power supply fault), LX pin-GND short (Ground fault).

Request for your special attention and precautions in using the technical information and semiconductors described in this book

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- (5) When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.
- (6) Comply with the instructions for use in order to prevent breakdown and characteristics change due to external factors (ESD, EOS, thermal stress and mechanical stress) at the time of handling, mounting or at customer's process. When using products for which damp-proof packing is required, satisfy the conditions, such as shelf life and the elapsed time since first opening the packages.

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