

DATA SHEET

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

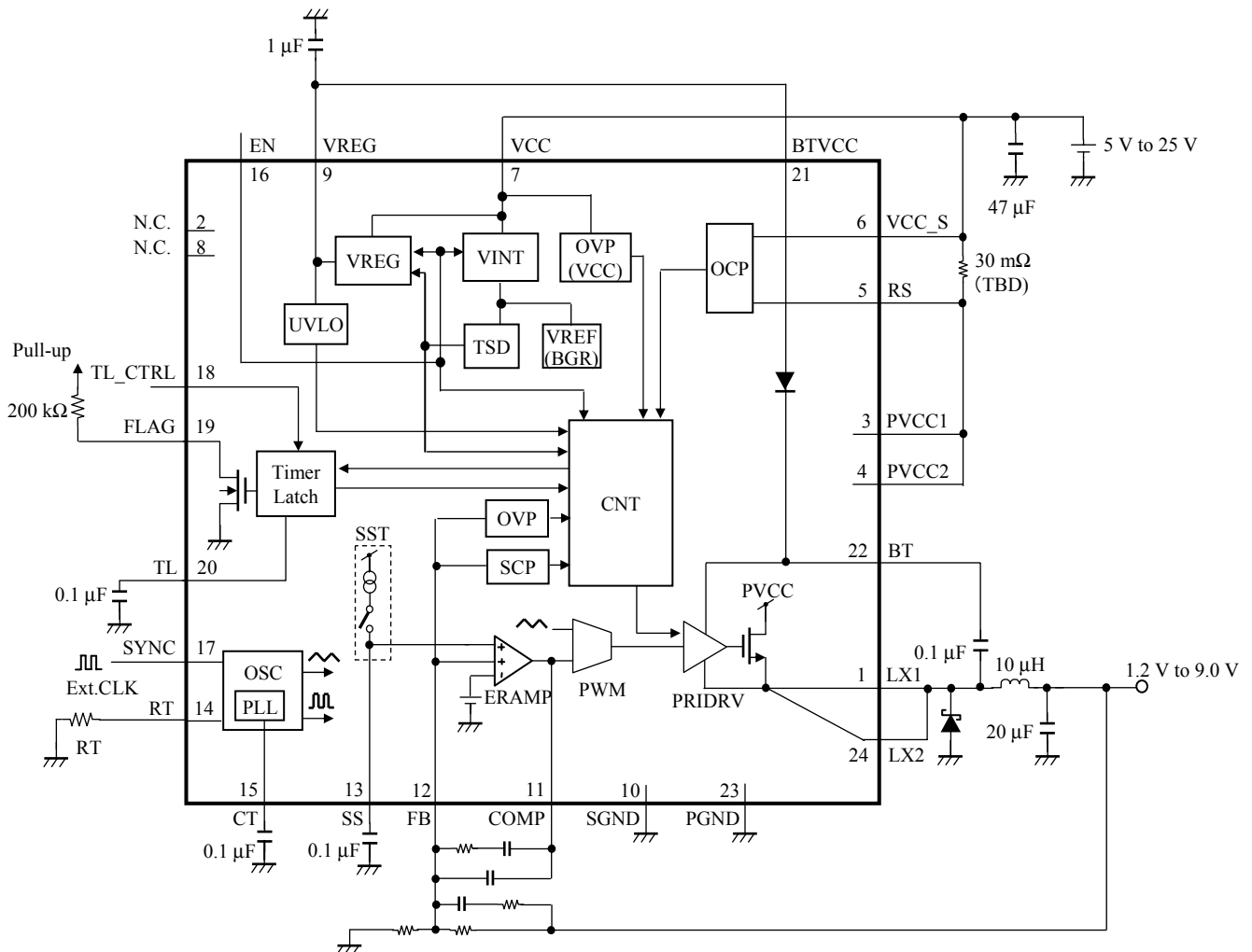
■ Package

- 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. $V_{CC} = PVCC1 = PVCC2$.

*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. $V_{CC} = PVCC1 = PVCC2$.
 - 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 $V_{CC} = 12\text{ V}$, $V_{OUT} = 5.0\text{ V}$

Note) $T_a = 25^\circ\text{C} \pm 2^\circ\text{C}$ 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 kΩ	440	490	540	kHz	—
10	Oscillator frequency range	F _{OUT2}		200	—	2 000	kHz	—
11	External sync frequency range	F _{SYNC}	RT = 130 kΩ Fout1 = 490 kHz	545	—	730	kHz	—

■ Electrical Characteristics at $V_{CC} = 12\text{ V}$, $V_{OUT} = 5.0\text{ V}$

Note) $T_a = 25^\circ\text{C} \pm 2^\circ\text{C}$ unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
Over-current protection								
12	Over-current threshold voltage	V _{OC} P	(VCC_S-VRS)	60	75	90	mV	*1
Over-voltage protection								
13	Over-voltage threshold voltage for VFB	V _{OV} P1	For FB	1.14	1.22	1.30	V	—
14	Over-voltage threshold voltage for VCC	V _{OV} P2	For VCC	30	34	38	V	—
Internal regulator								
15	Internal regulator output voltage	V _{REG}	C _{REG} = 1 μF	4.5	5.0	5.3	V	—
GND short protection								
16	Short detection voltage	V _{SC} P	monitor FB	0.15	0.3	0.45	V	—

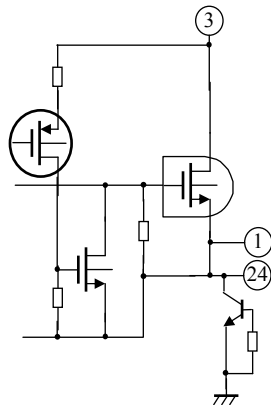
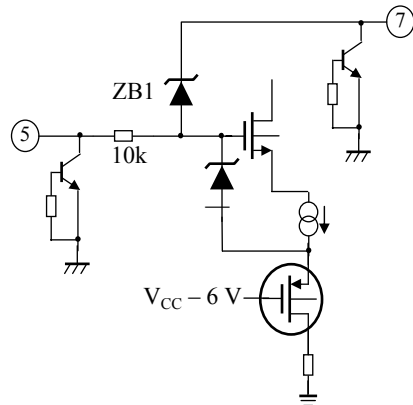
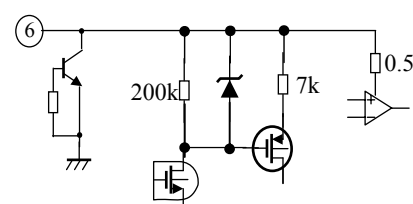
Note) *1 : This parameter is tested with DC measurement.

■ Technical Data


- IO block circuit diagram and pin function descriptions

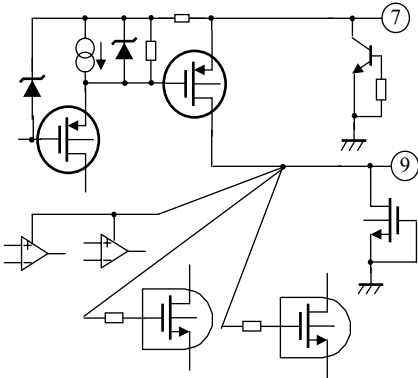
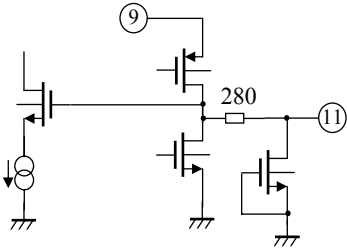
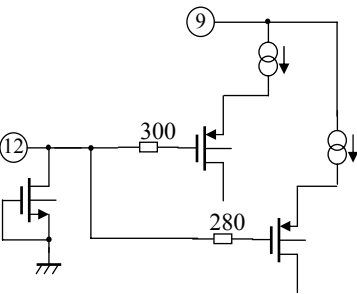
Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

(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

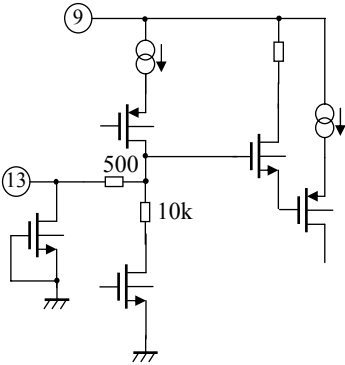
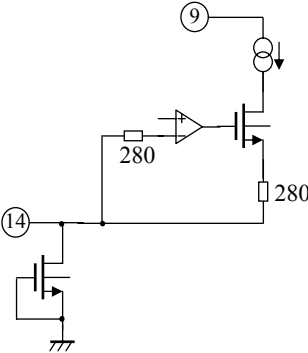
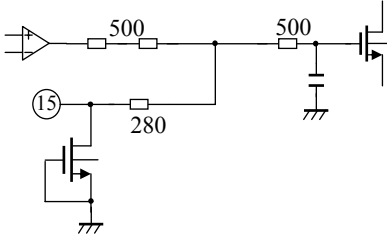
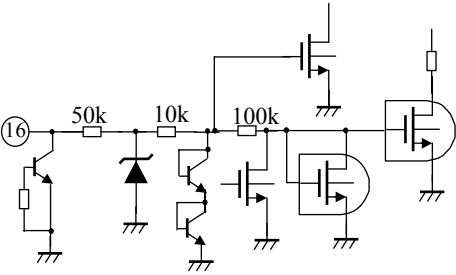
■ Technical Data (continued)
• IO block circuit diagram and pin function descriptions (continued)

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

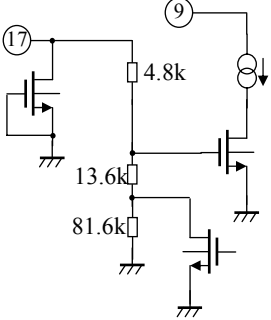
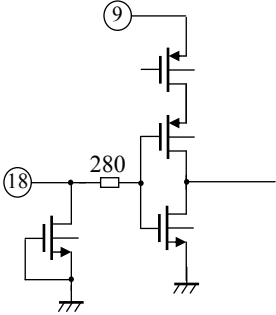
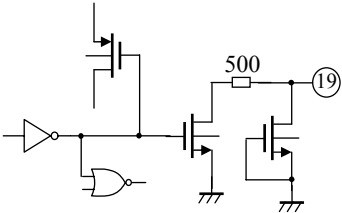
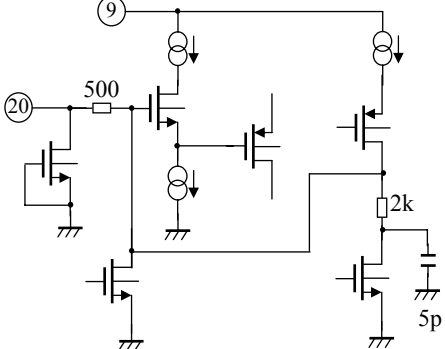
■ Technical Data (continued)
• IO block circuit diagram and pin function descriptions (continued)

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

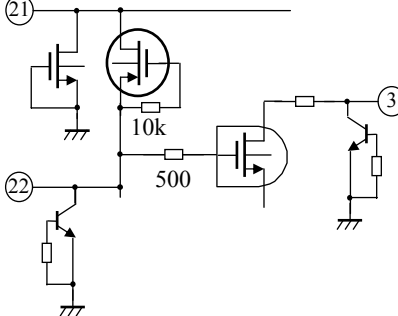
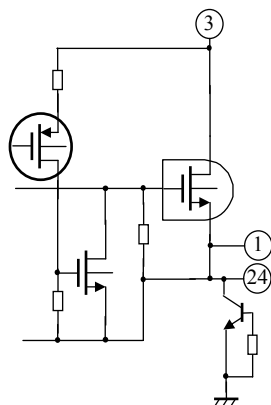
■ Technical Data (continued)
• IO block circuit diagram and pin function descriptions (continued)

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

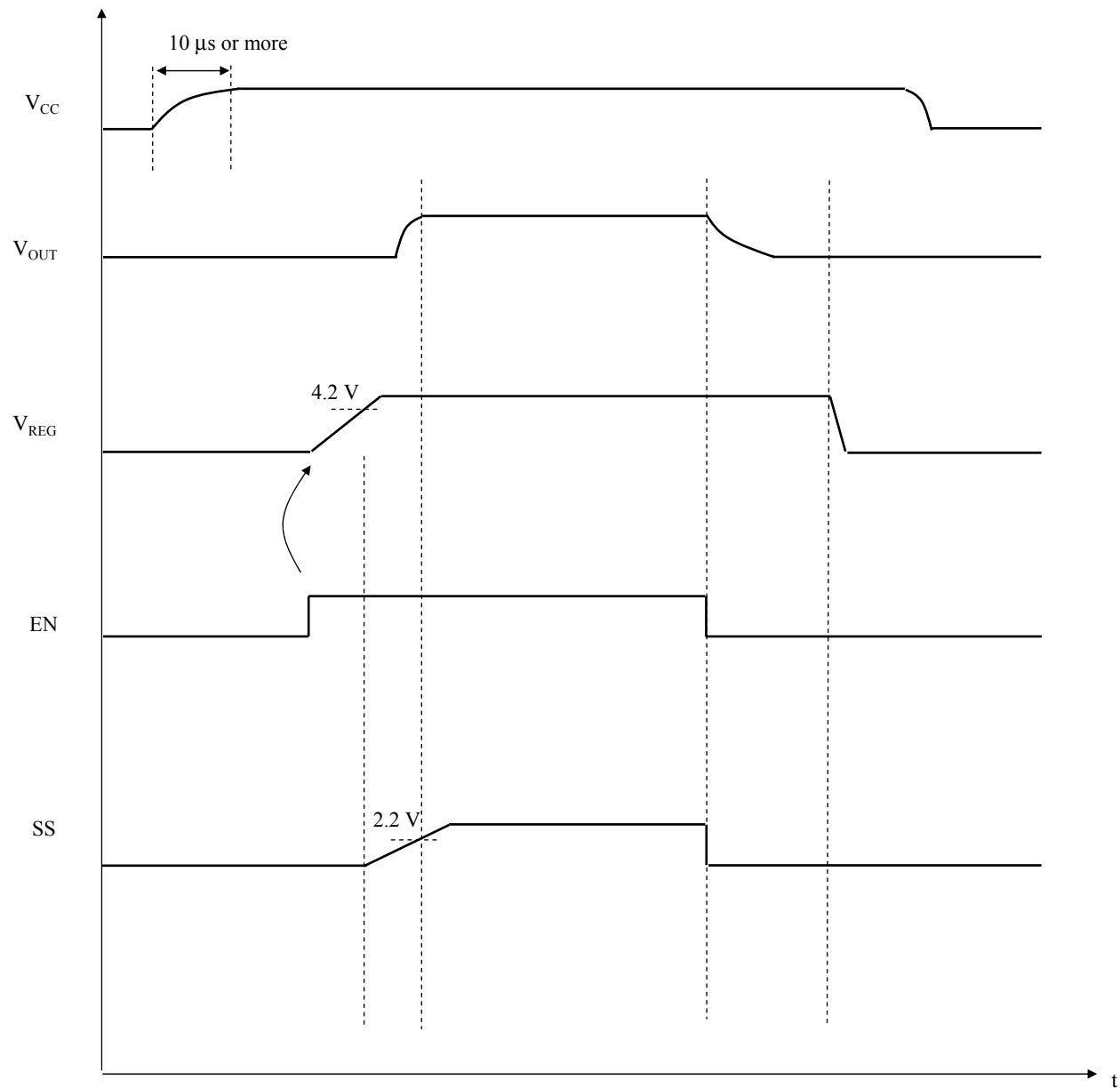


Figure 1.1 Power ON/OFF Timing (1)

- Technical Data (continued)
 - Power ON/OFF timing (continued)
- 5. ON/OFF operation sequence by V_{CC} control (EN pin is connected to V_{CC}).

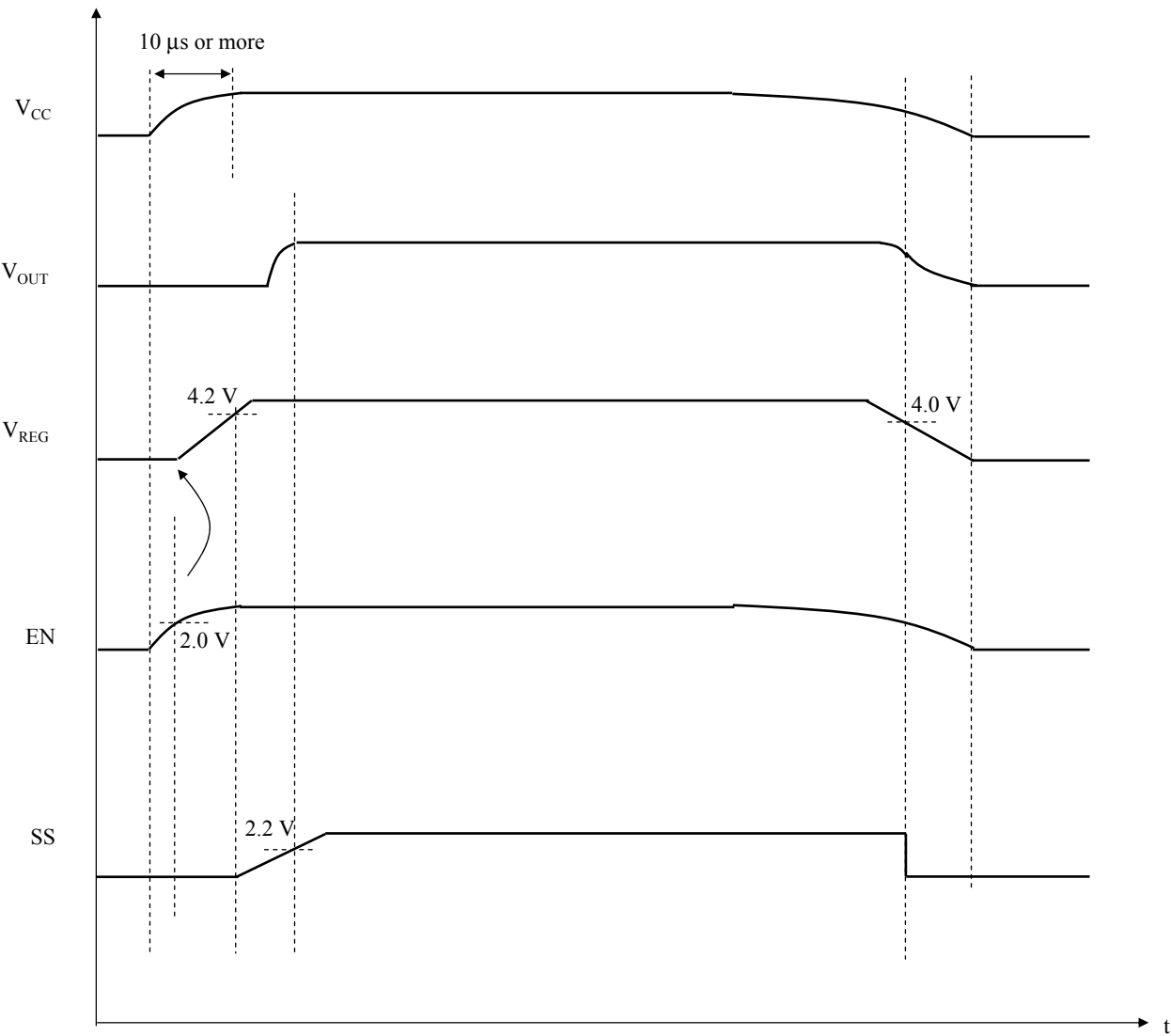
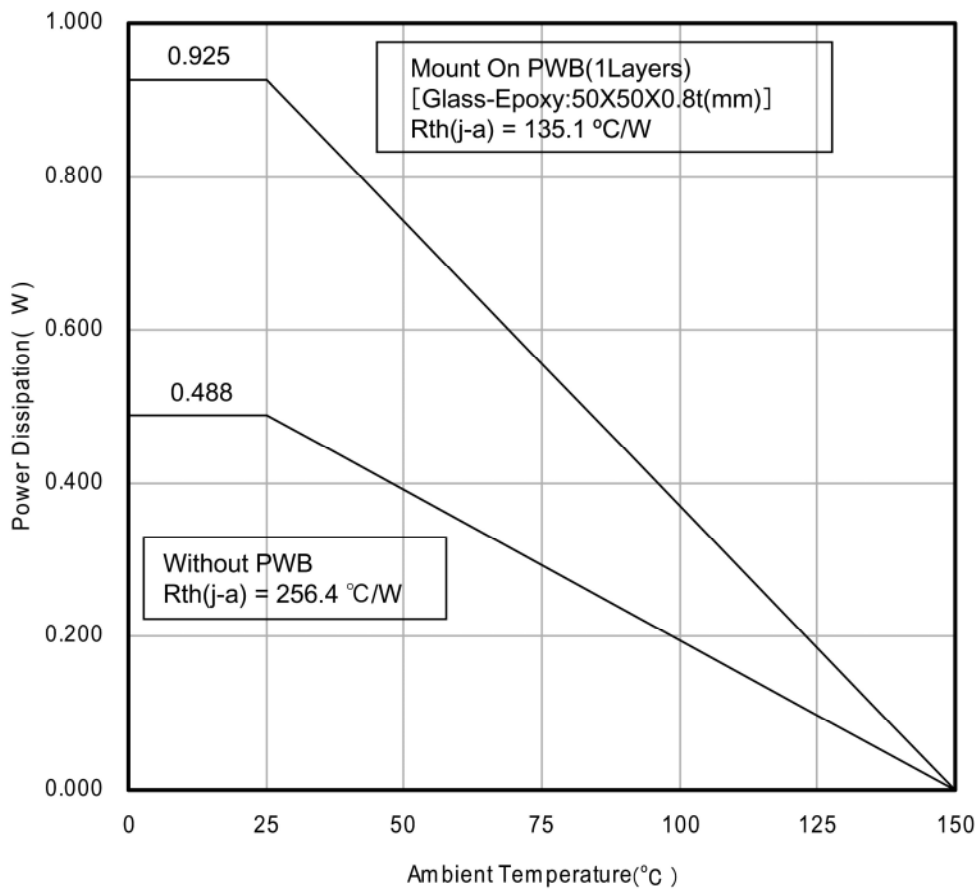


Figure 1.2 Power ON/OFF Timing (2)

- 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

- (1) If any of the products or technical information described in this book is to be exported or provided to non-residents, the laws and regulations of the exporting country, especially, those with regard to security export control, must be observed.
- (2) The technical information described in this book is intended only to show the main characteristics and application circuit examples of the products. No license is granted in and to any intellectual property right or other right owned by Panasonic Corporation or any other company. Therefore, no responsibility is assumed by our company as to the infringement upon any such right owned by any other company which may arise as a result of the use of technical information described in this book.
- (3) The products described in this book are intended to be used for general applications (such as office equipment, communications equipment, measuring instruments and household appliances), or for specific applications as expressly stated in this book.
Consult our sales staff in advance for information on the following applications:
 - Special applications (such as for airplanes, aerospace, automotive equipment, traffic signaling equipment, combustion equipment, life support systems and safety devices) in which exceptional quality and reliability are required, or if the failure or malfunction of the products may directly jeopardize life or harm the human body.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 products described in this book for any special application, unless our company agrees to your using the products in this book for any special application.
- (4) The products and product specifications described in this book are subject to change without notice for modification and/or improvement. At the final stage of your design, purchasing, or use of the products, therefore, ask for the most up-to-date Product Standards in advance to make sure that the latest specifications satisfy your requirements.
- (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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