

$V_{IN} = 5$ to 25 V, $V_{OUT} = 1.2$ to 22 V, 2-channel DC-DC Controller IC with Step down regulation

FEATURES

- 2-channel DC-DC Step Down Regulator Circuit that employs Voltage Mode Switching Control System
- Internal reference voltage is within $\pm 2\%$ accuracy
- Input Voltage Range : VCC: 5 V ~ 25 V
- Adjustable Output Voltage Range with external Resistor : 1.2 V ~ 22 V (Note)
- Adjustable Switching Frequency with external Resistor : 200 kHz ~ 2 MHz
- Standby mode consumes less than 1 μ A current
- Output over voltage protection function (OVP1)
- Output ground short protection function
- Input over voltage protection (OVP2) function
- Over current protection with adjustable threshold.
- Under voltage lockout function (UVLO)
- Thermal Shut Down function
- Adjustable soft-start function
- Channel-to-channel Phase reversal function
- SSOP024-P-0300F
 (Size : 8.1 mm X 7.8 mm, 0.65 mm pitch),
 24pin Plastic Shrink Small Outline Package (SSOP Type)

(Note) F=490kHz. Please refer Page 10

DESCRIPTION

AN33012UA is 2-channel DC-DC Controller IC with Step down Regulation that employs the voltage mode switching control system, and drives P-channel external power MOSFET stages.

This IC can be operated with wide input voltage range and is build in several protection functions, so this IC can provide high reliability power supply system.

Since it is possible to use up to 2 MHz switching frequency and output current is adjustable by P-channel external power MOSFET, this IC realizes downsizing of set and reducing in the number of external parts.

Output voltage is adjustable by user.

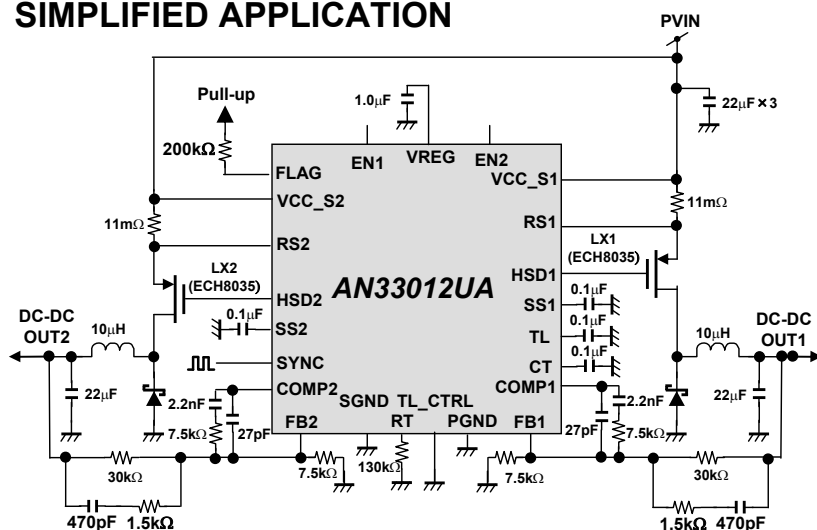
Output current is dependent on external FET.

APPLICATIONS

High Input Voltage Power Systems such as

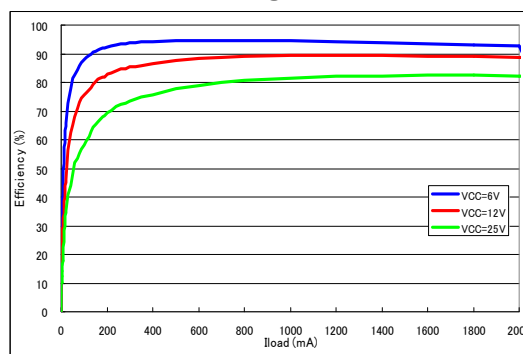
- Car-Audio system
- Car-Navigation system
- OA Equipment
- Home Appliances etc.

SIMPLIFIED APPLICATION



Notes) This application circuit is an example. The operation of mass production set is not guaranteed. You should perform enough evaluation and verification on the design of mass production set. You are fully responsible for the incorporation of the above application circuit and information in the design of your equipment.

EFFICIENCY CURVE



Condition)

$V_{in} = 6, 12, 25$ V, $V_{out} = 5$ V,

LX1/LX2 : ECH8035 (SANYO)

$L_o = 10 \mu$ H, $C_o = 22 \mu$ F, Frequency = 490 kHz

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit	Notes
Supply voltage	V_{CC}	50	V	*1
Operating free-air temperature	T_{opr}	- 40 to + 85	°C	*2
Operating junction temperature	T_j	- 40 to + 150	°C	*2
Storage temperature	T_{stg}	- 55 to + 150	°C	*2
Input Voltage Range	$V_{CC_S1}, V_{RS1},$ V_{CC_S2}, V_{RS2}	$(V_{CC} - 5.5)$ to $(V_{CC} + 0.3)$	V	*1 *3
	V_{EN1}, V_{EN2}	- 0.3 to $(V_{CC} + 0.3)$	V	*1 *4
	$V_{RT}, V_{TL}, V_{SS1}, V_{SS2},$ $V_{FB1}, V_{FB2}, V_{TL_CTRL}, V_{SYNC}$	- 0.3 to 5.5	V	*1
Output Voltage Range	$V_{FLAG}, V_{COMP1}, V_{COMP2}, V_{CT}$	- 0.3 to 5.5	V	*1
	V_{HSD1}, V_{HSD2}	$(V_{CC} - 5.5)$ to $(V_{CC} + 0.3)$	V	*1 *3
ESD	V_{HBM} (Human Body Model)	2	kV	—
	V_{MM} (Machine Model)	200	V	—

Notes) Do not apply external currents and voltages to any pin not specifically mentioned.

This product may sustain permanent damage if subjected to conditions higher than the above stated absolute maximum rating. This rating is the maximum rating and device operating at this range is not guaranteeable as it is higher than our stated recommended operating range. When subjected under the absolute maximum rating for a long time, the reliability of the product may be affected. V_{cc} is voltage for VCC.

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

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

*3: $(V_{cc} - 5.5)$ V must not be exceeded - 0.3 V, and $(V_{cc} + 0.3)$ V must not be exceeded 50 V

*4: $(V_{cc} + 0.3)$ V must not be exceeded 50 V.

POWER DISSIPATION RATING

PACKAGE	θ_{j-a}	θ_{j-c}	PD ($T_a = 25\text{ °C}$)	PD ($T_a = 85\text{ °C}$)	注
24 Pin Plastic Shrink Small Outline Package (SSOP Type)	135.1 °C / W	11.8 °C / W	0.925 W	0.481 W	*1

Note). For the actual usage, please refer to the PD- T_a characteristics diagram in the package specification, follow the power supply voltage, load and ambient temperature conditions to ensure that there is enough margin and the thermal design does not exceed the allowable value.

*1:Glass Epoxy Substrate(1 Layer) [Glass-Epoxy: 50 X 50 X 0.8t(mm)]



CAUTION

Although this has limited built-in ESD protection circuit, but permanent damage may occur on it. Therefore, proper ESD precautions are recommended to avoid electrostatic damage to the MOS gates

RECOMMENDED OPERATING CONDITIONS

Parameter	Pin Name	Min.	Typ.	Max.	Unit	Notes
Supply voltage range	V_{CC}	5	12	25	V	*1
Input Voltage Range	V_{CC_S1}	$V_{CC} - 5.5$	—	$V_{CC} + 0.3$	V	*1 *2
	V_{RS1}					
	V_{CC_S2}					
	V_{RS2}	- 0.3	—	$V_{CC} + 0.3$	V	*1 *3
	V_{EN1}					
	V_{EN2}	- 0.3	—	5.5	V	*1
	V_{FB1}					
	V_{FB2}					
	V_{TL_CTRL}					
	V_{SYNC}					
Output Voltage Range	V_{HSD1}	$V_{CC} - 5.5$	—	$V_{CC} + 0.3$	V	*1 *2
	V_{HSD2}					
	V_{COMP1}	- 0.3	—	5.5	V	*1
	V_{COMP2}					
	V_{CT}					
	V_{TL}					
	V_{RT}					
	V_{SS1}					
	V_{SS2}					
Input Voltage Range	V_{FLAG}	- 0.3	—	5.5	V	*1

Note) Do not apply external currents and voltages to any pin not specifically mentioned.

Voltage values, unless otherwise specified, are with respect to GND. GND is voltage for SGND, PGND. SGND = PGND
 V_{CC} is voltage for VCC.

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

*2 : ($V_{CC} - 5.5$) V must not be exceeded - 0.3 V, and ($V_{CC} + 0.3$) V must not be exceeded 50 V

*3 : ($V_{CC} + 0.3$) V must not be exceeded 50 V.

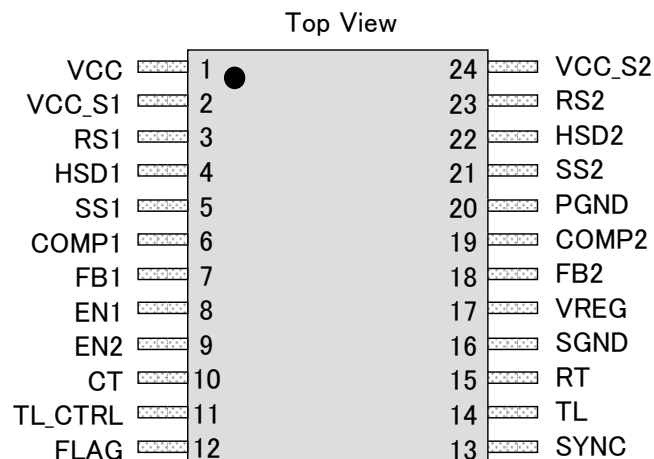
ELECTRICAL CHARACTERISTICS

Co = 22 μF, Lo = 10 μH, VOUT Setting = 5.0 V, VCC = 12 V, RT = 130 kΩ,
Ta = 25 °C ± 2 °C unless otherwise noted.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current Consumption							
Quiescent current	ICQ	No external MOS VFB = 1.1 V VEN1 = VEN2 = High (3.3V)	—	1.3	2.2	mA	—
Standby current	ISTBY	VEN1 = VEN2 = Low (0V)	—	—	1	μA	—
BGR							
Feedback voltage	VREF	FB connected to COMP with gain of 1.5 times	0.98	1.0	1.02	V	—
Enable (EN1,EN2)							
Low input threshold	VIL1	—	—	—	0.4	V	—
High input threshold	VIH1	—	2.0	—	—	V	*1
EN1 terminal input current	VIC1	VEN1 = 3.3 V VEN2 = 0 V	8	20	50	μA	—
EN2 terminal input current	VIC2	VEN1 = 0 V VEN2 = 3.3 V	8	20	50	μA	—
SYNCHRONIZATION (SYNC)							
Low input threshold	VIL2	—	—	—	0.4	V	—
High input threshold	VIH2	—	2.0	—	—	V	—
Oscillator							
Oscillator frequency	FOUT1	RT = 130 kΩ	440	490	540	kHz	—
Oscillator frequency range	FOUT2		200	—	2000	kHz	—
External sync frequency range	FSYNC	RT = 130 kΩ FOUT1 = 490 kHz	545	—	730	kHz	—
Over-current protection							
Over-current threshold voltage	VOC	(VCC_S - VRS)	36	50	64	mV	*2
Over-voltage protection							
Over-voltage threshold voltage for VFB	VOVP1	For FB	1.14	1.22	1.30	V	—
Over-voltage threshold voltage for VCC	VOVP2	For VCC	30	34	38	V	—
Internal regulator							
Internal regulator output voltage	VREG	CREG = 1 μF	4.5	4.9	5.3	V	—
GND short protection							
Short detection voltage	VSCP	monitor VFB	0.15	0.3	0.45	V	—

Note) *1 : Allowable voltage difference between EN1 and EN2 is ±0.3V when both channels are high.
*2 : This parameter is tested with DC measurement.

PIN CONFIGURATION



PIN FUNCTIONS

Pin No.	Pin name	Type	Description
1	VCC	Power Supply	Power supply pin
2	VCC_S1	Input	Connection to channel 1 current sensing port for OCP
3	RS1	Input	Connection to channel 1 current sensing port for OCP
4	HSD1	Output	Channel 1 gate driver for an external Upper-side Pch MOSFET
5	SS1	Input	Channel 1 soft-start capacitor connection pin
6	COMP1	Output	Channel 1 error amplifier output
7	FB1	Input	Channel 1 error amplifier negative input
8	EN1	Input	Channel 1 enable pin
9	EN2	Input	Channel 2 enable pin
10	CT	Output	Low Pass filter function pin for PLL
11	TL_CTRL	Input	Connect to high to disable shut-down function by OCP/SCP
12	FLAG	Output	Error flag output pin
13	SYNC	Input	External clock input for adjustment of oscillation frequency
14	TL	Input	Connect to an external capacitor for adjustment of OCP/SCP detection time
15	RT	Input	Connect to an external resistor for adjustment of oscillation frequency
16	SGND	Ground	Ground pin
17	VREG	Output	Connect to an external capacitor for internal regulator
18	FB2	Input	Channel 2 error amplifier negative input
19	COMP2	Output	Channel 2 error amplifier output
20	PGND	Ground	Power ground pin
21	SS2	Input	Channel 2 soft-start capacitor connection pin
22	HSD2	Output	Channel 2 gate driver for an external Upper-side Pch MOSFET
23	RS2	Input	Connection to channel 2 current sensing port for OCP
24	VCC_S2	Input	Connection to channel 2 current sensing port for OCP

Notes) Concerning detail about pin description, please refer to OPERATION and APPLICATION INFORMATION section.

OPERATION

1. Power ON/OFF sequence

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

AN33012UA consists of two channels and it can be turned ON and OFF by using the EN1 pin and EN2 pin.

EN1 \geq 2.0 V and EN2 \leq 0.4V : Channel 1 is Enabled and Channel 2 is Disabled

EN2 \geq 2.0 V and EN1 \leq 0.4V : Channel 2 is Enabled and Channel 1 is Disabled

EN1 \geq 2.0 V and EN2 \geq 2.0V : Both channels are Enabled

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 2.0 V or higher at EN1 pin and EN2 pin after V_{CC} is steady and the DC-DC will begin to operate.

(It is possible to connect the EN1 pin and EN2 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 4.3 V and above, and after a delay time (charging time of the soft start capacitor) decided by an external capacitor, the DC-DC output will start to rise.

2. Power OFF Sequence :

– To turn OFF the DC-DC output, apply a voltage of 0.4 V or lower to EN1 pin and EN2 pin.

– V_{OUT} will drop after EN1 pin and EN2 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 EN1 pin and EN2 pin become low.

The above scenario occurs when the V_{REG} voltage decreases to 4.0 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.

4) Points to take note of when shut down:

– Please apply a voltage of Low level or lower to EN PIN when turn OFF the DC-DC.

5) Points to take note of pin connection :

– VREG is utilized for internal circuits. Do not use it as power supply for other device.

– Please put the external parts of RT pin and CT pin as closed as possible in the LSI terminal and arrange in such a way that the effect of noise will be reduced, such noise coming from LX pin and etc.

OPERATION (Continued)

2. Start / Stop Control Timing Chart

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

- ON/OFF operation sequence by EN1/EN2 pin control.

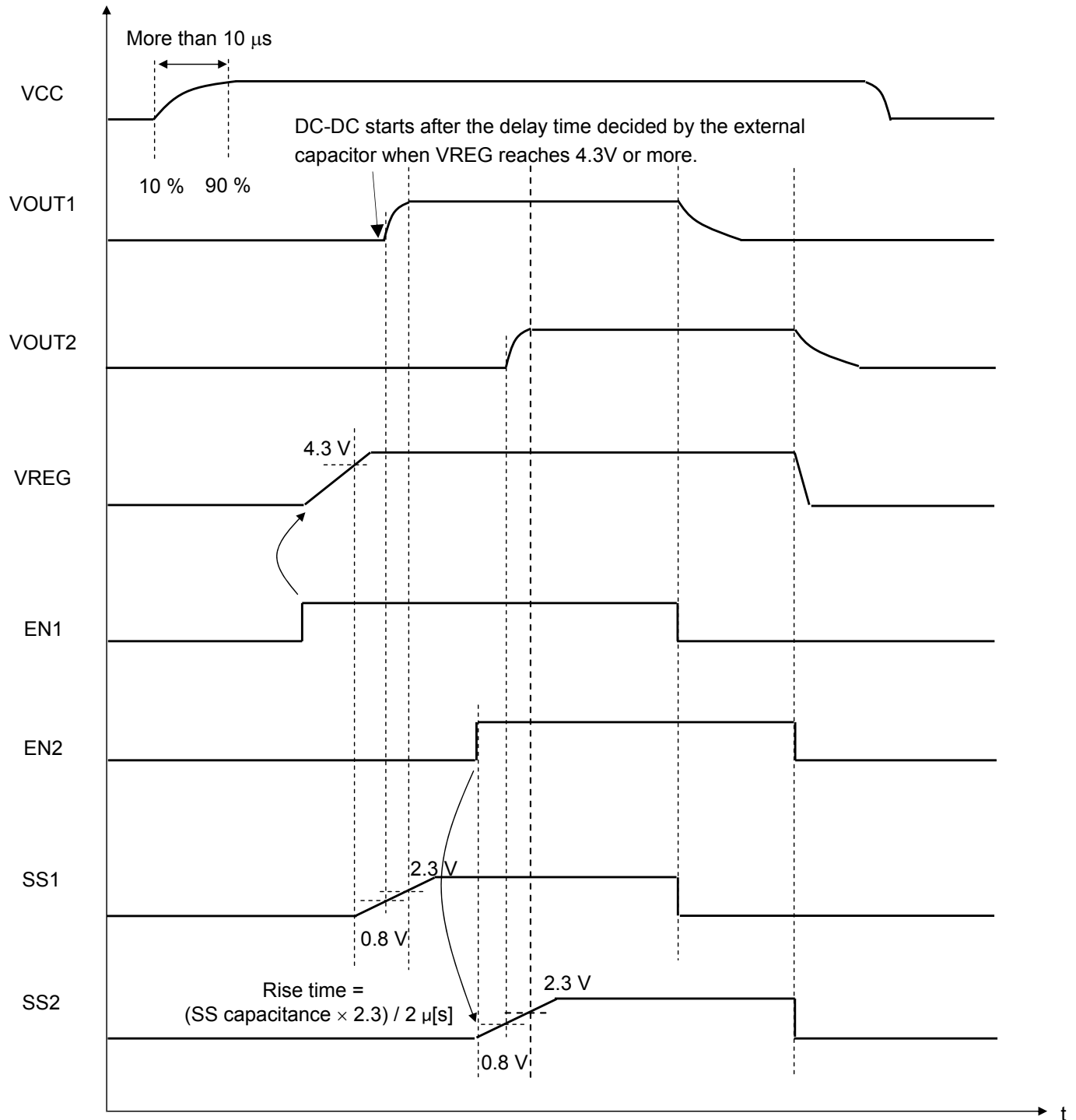


Figure : Power ON/OFF sequence by EN1/EN2

Note) All values given in the above figure are typical values.

OPERATION (Continued)

2. Start / Stop Control Timing Chart

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

- ON/OFF operation sequence by VCC pin control (EN1 pin and EN2 pin are connected to VCC).

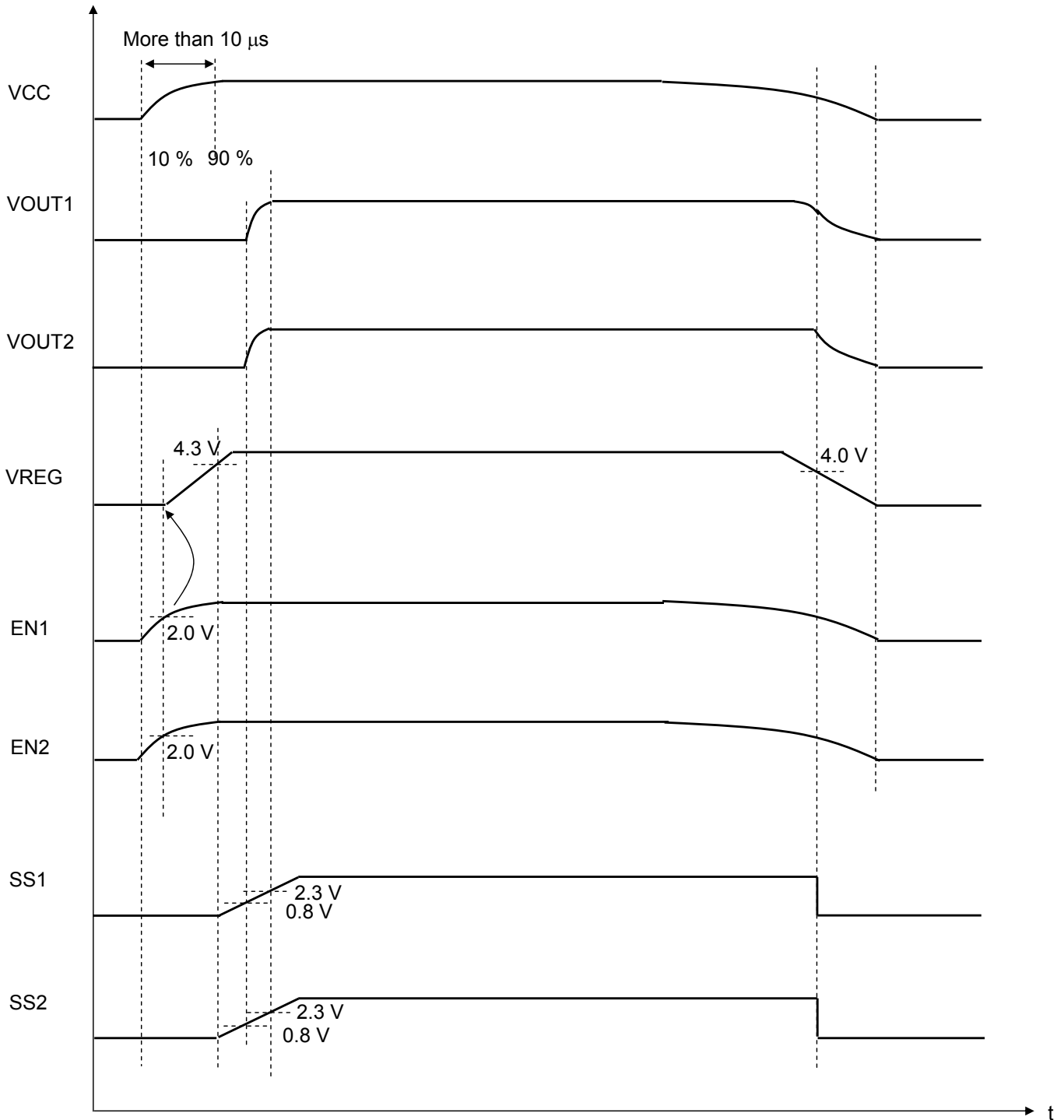


Figure : Power ON/OFF sequence by VCC/EN1/EN2

Note) All values given in the above figure are typical values.

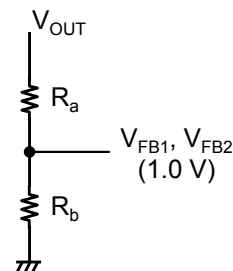
OPERATION (Continued)

3. Output voltage setting

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

The output voltage of AN33012UA is set with the external feedback resistance divider arranged between the terminal FB1, FB2 and GND between the DC-DC output and the terminal FB. The output voltage is decided depending on the following equation.

$$V_{out} = 1.0 \times \left[1 + \frac{R_a}{R_b} \right]$$



4. Min/Max Duty Operation

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

MinDuty is decided by the minimum ON time. The minimum ON time, $T_{on}(\min)$, is the time that this IC can turn on the high side switch. This is decided by the gate capacitance of the high side switch and the internal timing delay. The following attention is necessary because in applications where the Input/Output voltage difference is great, and the switching frequency is high, there is a possibility to reach the limiting value of the minimum ON time. The minimum ON time, $T_{on}(\min)$, is about 200ns (max).

This IC has the function of MaxDuty, which will not exceed a certain definite value for safety reasons in case of abnormal circumstances. The following attention is necessary because in applications where the Input/Output voltage difference is close, and the switching frequency is high, there is a possibility to reach the limiting value of the minimum OFF time. The minimum OFF time, $T_{off}(\min)$, is about 200ns (max).

$$T_{on}(\min) < \frac{V_{out}}{V_{in}} \times \frac{1}{F}$$

$$T_{off}(\min) < \left(1 - \frac{V_{out}}{V_{in}} \right) \times \frac{1}{F}$$

$$V_{OUT}(\max) = V_{IN} \times (1 - 200ns \times F)$$

*) F : Switching frequency

When operating near the Min/Max limited duty, the ripple voltage and the inductor current ripple increases even if the output voltage is stabilized. It is recommended to use on the condition when the turn on switching time and turn off switching time are 200ns or more.

*) Please take note of the output voltage setting when the switching frequency is high.

OPERATION (Continued)

5. Oscillation Frequency

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

The switching frequency of the built-in oscillator circuit can be set from 200kHz to 2000kHz, determined by the resistance of the terminal RT, set by external resistance. The setting accuracy of the frequency is approximately $\pm 10\%$. The equation and the corresponding table are described as follows.

RT [k Ω]	OSC Frequency (kHz)	RT [k Ω]	OSC Frequency (kHz)
22	2022	91	674
24	1910	100	620
27	1764	110	569
30	1640	120	527
33	1530	130	490
36	1434	150	430
39	1352	160	406
43	1254	180	364
47	1169	200	330
51	1096	220	302
56	1015	240	278
62	934	270	249
68	864	300	225
75	796	330	206
82	738	360	190

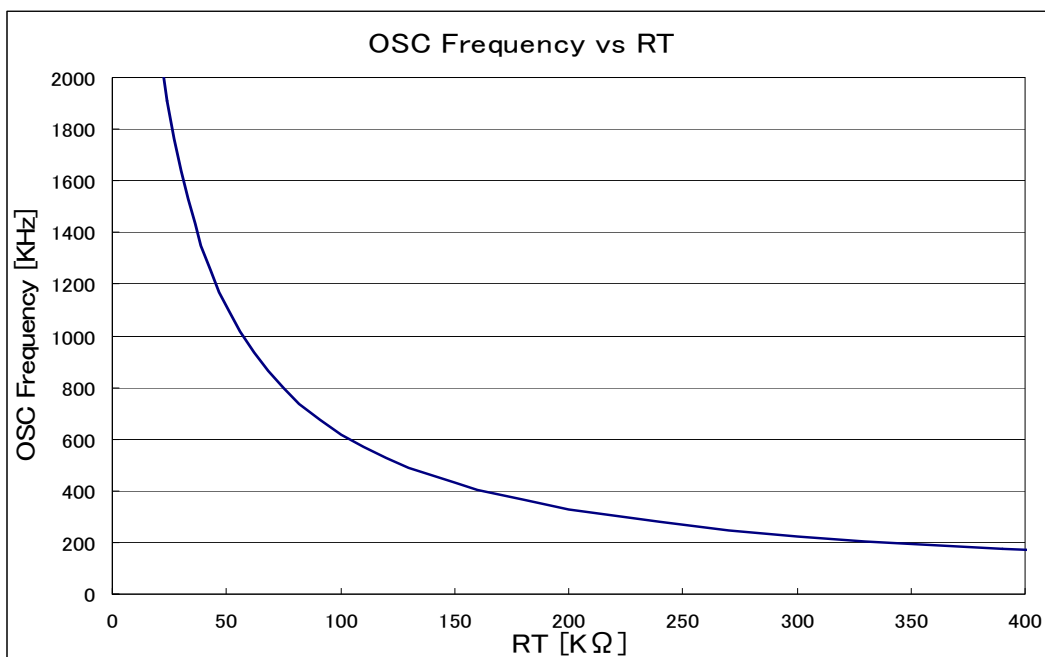


Figure : switching frequency vs external resistance

OPERATION (Continued)

6. Over-Current Protection

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Over-current protection function (OCP) turns off the Power MOS in IC when the voltage difference of the external resistance R_{SENSE} exceeds 50mV(Typ.) to stop the supply of current from VCC to VOUT. Detection current I_{SENSE} can be calculated as:

$$I_{SENSE} = 50mV / R_{SENSE}$$

The over-current protection function operates via pulse-by-pulse control, and Duty is limited during the over-current protection period. Moreover, because the over-current detects the peak current that flows through R_{SENSE} , it is necessary to convert it from desired output current I_{OUT} value (Refer to Figure). Equation is shown below.

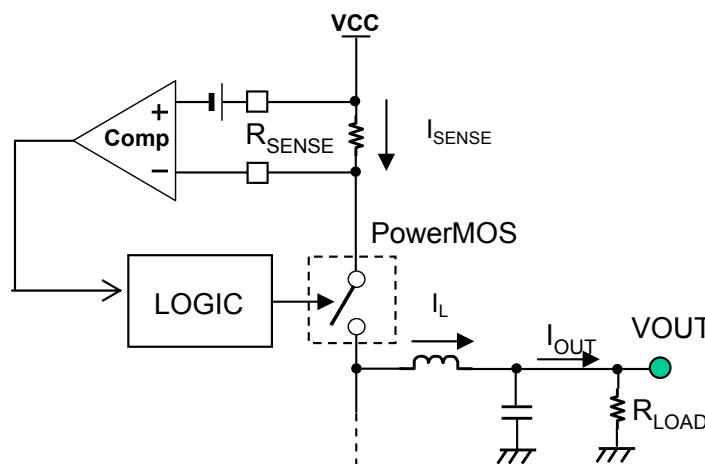


Figure : Over-Current Protection circuit block diagram

$$R_{sense} \approx \frac{0.05}{I_{out} + \frac{V_{OUT} \cdot (V_{CC} - V_{OUT})}{2 \cdot F \cdot L \cdot V_{CC}}}$$

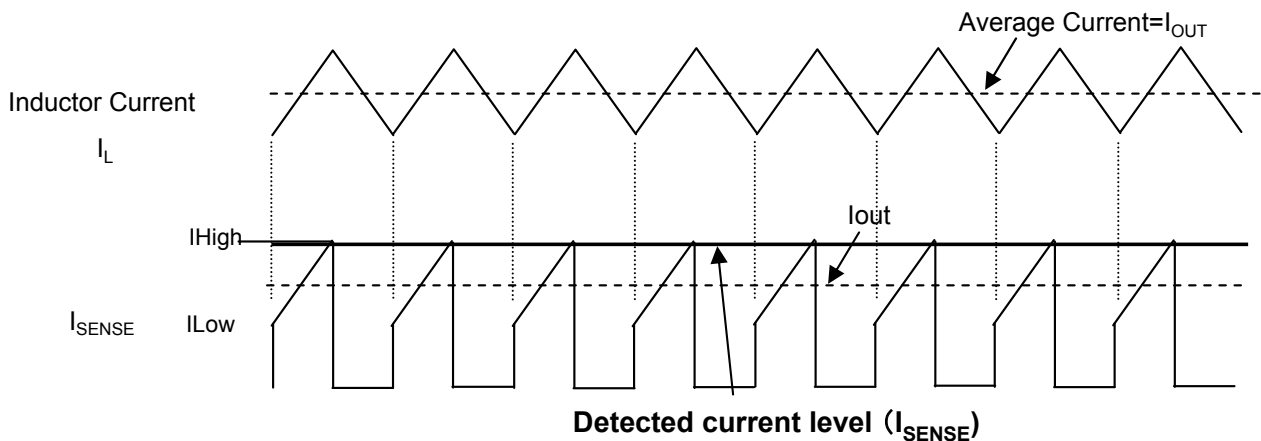


Figure : Method of detection of Over-Current Protection function

OPERATION (Continued)

7. FLAG function after Over current / Short current detection

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed. When FB is equal or lower than 0.3 V, short current detection is triggered, FLAG pin will be pull to Low state. The response timing is determined by TL pin capacitor value CTL (The response timing = $CTL / 2\mu A \times 1.2V$). Note that the pull down current drivability of FLAG pin is 1.2 mA.

Adjusting of FLAG response time in event of "over current" or "short current" condition is make possible by changing the capacitance of TL pin.

In the event of over current detection, FLAG pin will be pull to Low state. Once FLAG is pull to Low state, it will remained at Low state until IC is reset through EN pin.

8. Over Voltage detection

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

When FB is equal or higher than 1.22 V overvoltage detection is triggered, Power MOS will be off and LX will stop switching.

9. Thermal Shut Down (TSD)

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

When the LSI internal temperature becomes more than about 165°C, TSD operates and DC-DC turns off.

10. Input Over Voltage protection

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

When VCC is equal or higher than 34V overvoltage detection is triggered, Power MOS will be off and LX will stop switching.

Conclusion of protection functions

Function name	Over-Current Protection	Over current / Short current detection	Over Voltage detection	Thermal Shut Down	Input Over Voltage protection
explanation	pulse-by-pulse is operated independently	Output FLAG pin after delay time when detected in one side. (Reference below)	Stop switching CH that abnormal is detected.	Stop IC when detected	Stop IC when detected

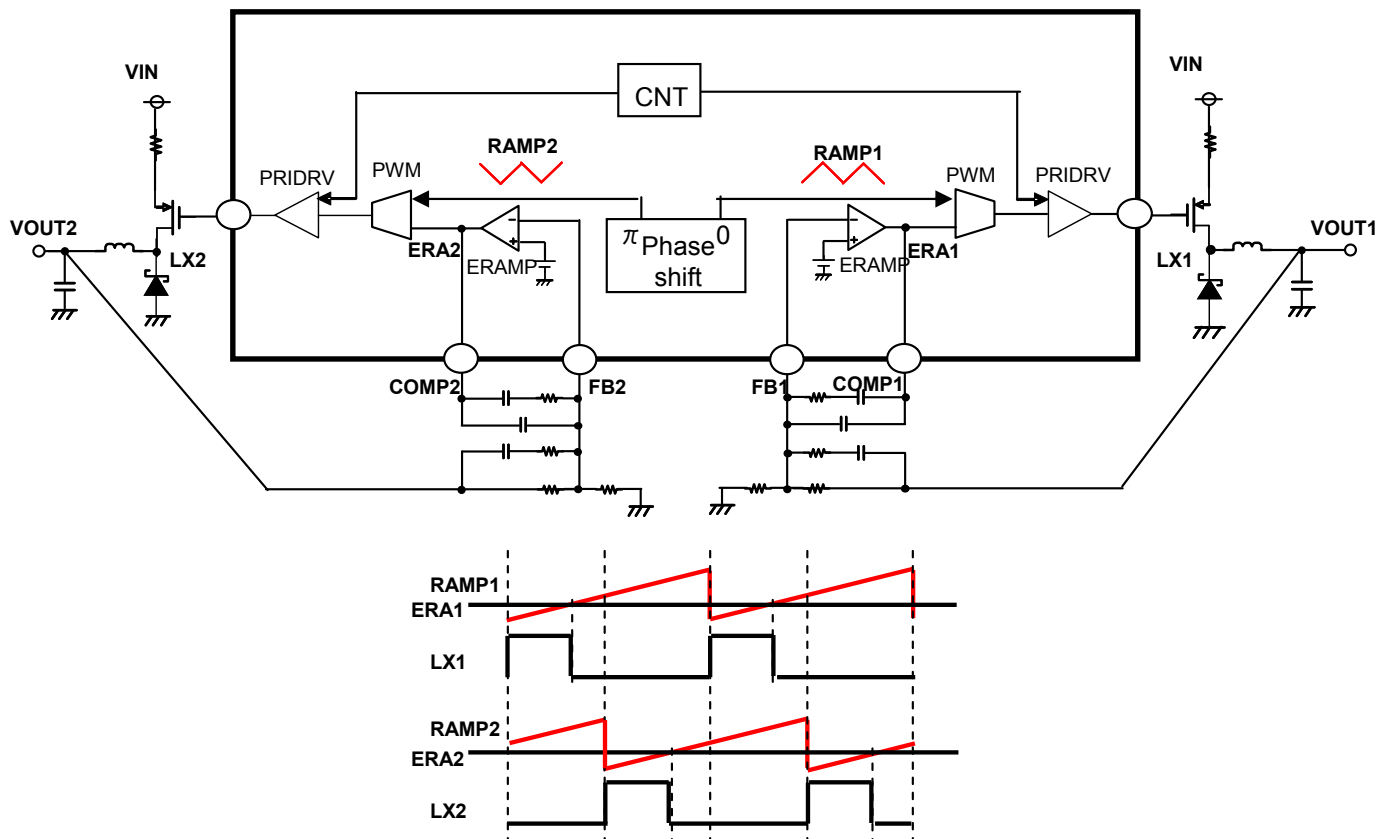
FLAG pin when over current / short current detection

CH1	CH2	FLAG
abnormal	normal	pull-down
normal	abnormal	pull-down
abnormal	abnormal	pull-down
normal	normal	Hi-Z

11. Channel- to-channel phase reversal

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Sawtooth wave is superimposed to the reference input signal of each channel PWM, and it inverts timing of switching to making phases shift 180 deg.



☒ : Channel-to-channel phase reversal function Block diagram and timing chart

OPERATION (Continued)

12. Soft Start Timing and Setting

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

This IC includes a soft start function whereby start-up time can be set to desired timing by adjusting the SS terminal capacitor (C_{SS}). By adjusting the soft-start time, rush current from the Power supply terminal can be limited and the start-up timing of the output voltage can be changed. The timing chart and the method of selecting the external capacitor value is shown in below.

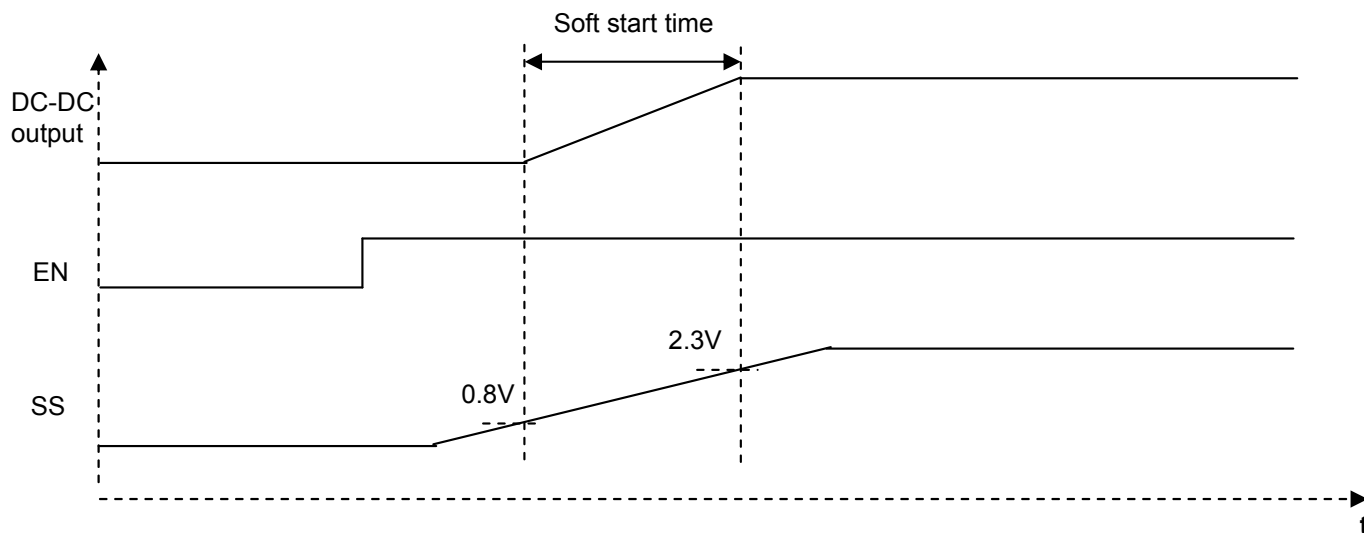


Figure : Soft start operation timing chart

Equation to set soft start time by C_{SS} : $\text{Soft - Start Time (s)} \approx \frac{1.5}{2.2 \mu} \cdot C_{SS}$

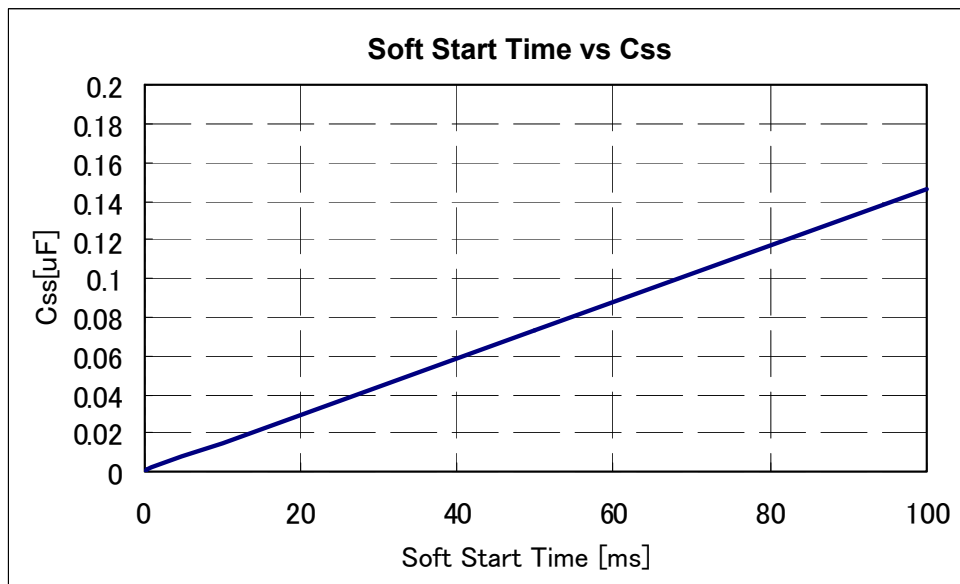


Figure : Soft Start Time vs C_{SS} Value (External Capacitor)

When this IC is used for power supply of communication with external equipment, the communication may not possible during the soft-start period. Depending on the type of external equipment connected, in some cases, when the DC-DC is turned on, even though the soft start maybe halfway through, the voltage level is high enough to enable the communication to start. In such cases, the micro-controller may not recognize the equipment normally and therefore it is required to set the micro-controller to access all possible equipment after the above soft-start setting time.

APPLICATIONS INFORMATION

Condition : Vout = 5.0 V, Frequency = 490 KHz

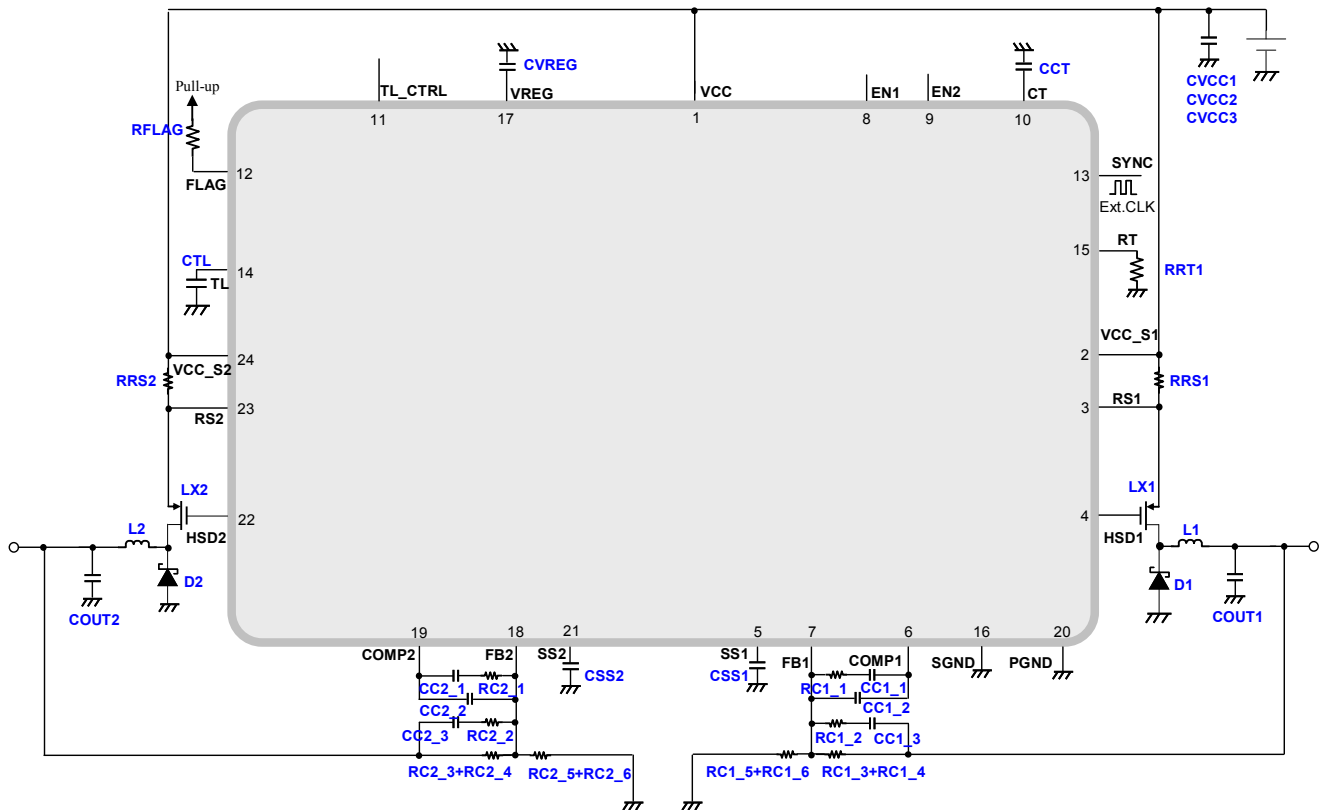


Figure : Application circuit

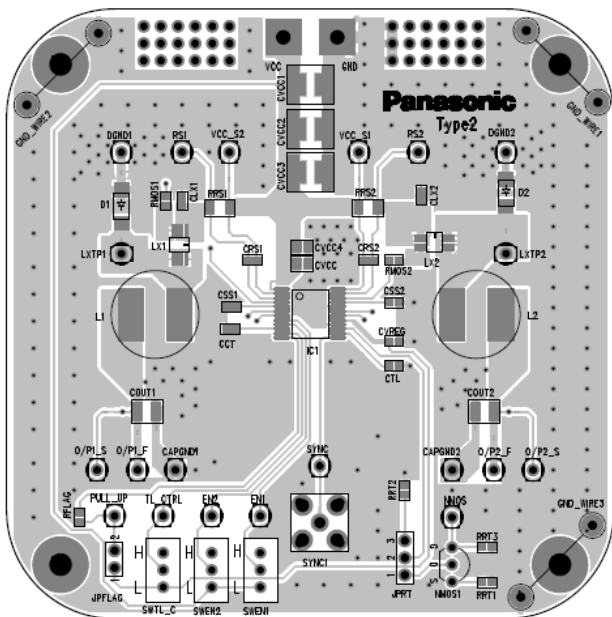


Figure : Top Layer with silk screen
 (Top View) with Evaluation board

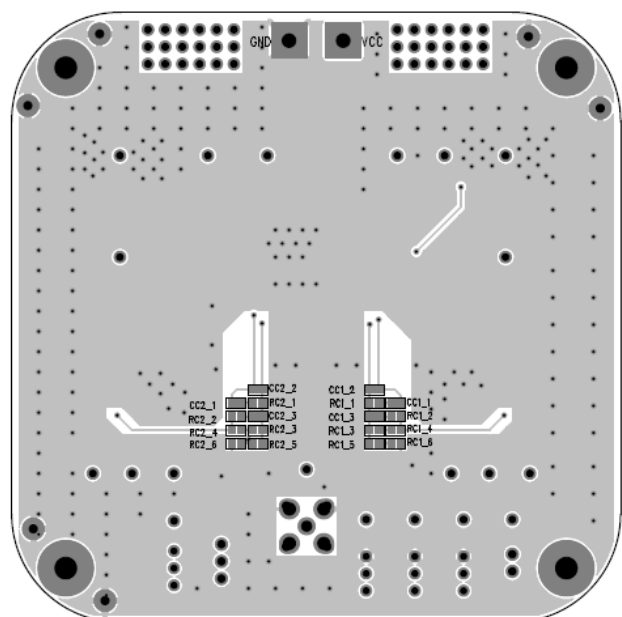


Figure : Bottom Layer with silk screen
 (Bottom View) with Evaluation board

Notes) This application circuit and layout is an example. The operation of mass production set is not guaranteed. You should perform enough evaluation and verification on the design of mass production set. You are fully responsible for the incorporation of the above application circuit and information in the design of your equipment.

APPLICATIONS INFORMATION (Continued)

Reference	Part Name	Value	Maker	Description
CC1_1,CC2_1	GCM1882C1H222JA01J	2.2nF	Murata	Compensation Capacitor
CC1_2,CC2_2	GCM1882C1H270JA01J	27pF	Murata	Compensation Capacitor
CC1_3,CC2_3	GCM1882C1H471JA01J	470pF	Murata	Compensation Capacitor
CCT,CSS1,CSS2,CTL	GCM188R11C104KA01J	0.1uF	Murata	Setting Capacitor
CVREG	GCM188R71C105KA49J	1uF	Murata	VREG Capacitor
CVCC1,CVCC2,CVCC3	CKG57NX7R1H226MT	22μF	TDK	Input Capacitor
COU1,COU2	TMK325C7226MM-T	22μF	TAIYO YUDEN	Output Capacitor
LX1,LX2	ECH8305	—	SANYO	PMOSFET
L1,L2	CDRH8D43-100NC	10μH	SUMIDA	Inductor
IC1	AN33012UA	—	Panasonic	2ch DC-DC Controller
D1,D2	DB24416	—	Panasonic	Schottky Diode
RC1_1,RC2_1, RC1_5,RC2_5	ERA3AEB752V	R=7.5k	Panasonic	Compensation & Feedback Resistor
RC1_3,RC2_3, RC1_6,RC2_6	ERJ3GEY0R00V	R=0	Panasonic	Compensation & Feedback Resistor
RC1_2,RC2_2	ERA3AEB152V	R=1.5k	Panasonic	Compensation & Feedback Resistor
RFLAG	ERA3AEB204V	R=200k	Panasonic	Pull-up Resistor
RMOS1-2	ERJ3GEY0R00V	R=0	Panasonic	
RRT1	ERA3AEB134V	R=130k	Panasonic	OSC Setting Resistor
RRS1,RRS2	ERJ8BWFR011V	R=11m	Panasonic	OCP Sense Resistor

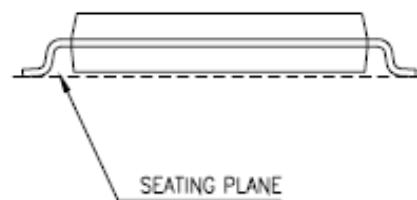
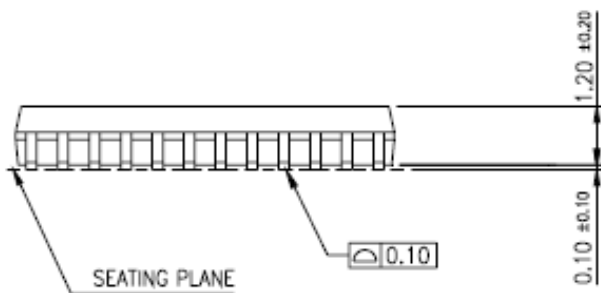
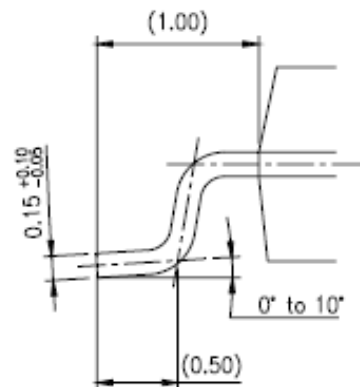
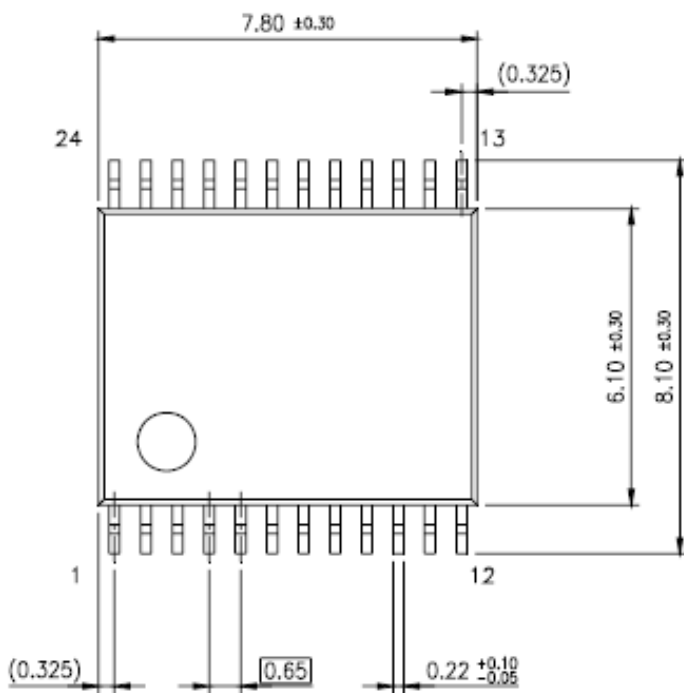
Figure : Recommended component

PACKAGE INFORMATION (Reference Data)

Outline Drawing

Package Code : SSOP024-P-0300F

Unit : mm



Body Material : Br/Sb Free Epoxy resin

Lead Material : Cu Alloy

Lead Finish Method : SnBi Plating

IMPORTANT NOTICE

1. When using the LSI for new models, verify the safety including the long-term reliability for each product.
2. When the application system is designed by using this LSI, please confirm the notes in this book.
Please read the notes to descriptions and the usage notes in the book.
3. This LSI 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 LSI 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 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 requiredOur company shall not be held responsible for any damage incurred as a result of or in connection with the LSI being used for any special application, unless our company agrees to the use of such special application.
4. Please use this product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Our company shall not be held responsible for any damage incurred as a result of our LSI being used by our customers, not complying with the applicable laws and regulations.
5. Pay attention to the direction of LSI. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might emit smoke or ignite.
6. 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.
7. 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.
8. Take notice in the use of this product that it might be damaged or occasionally emit smoke when an abnormal state occurs such as output pin-VCC short (Power supply fault), output pin-GND short (Ground fault), or output-to-output-pin short (load short). 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..
9. The protection circuit is for maintaining safety against abnormal operation. Therefore, the protection circuit should not work during normal operation.
Especially for the thermal protection circuit, if the area of safe operation or the absolute maximum rating is momentarily exceeded due to output pin to VCC short (Power supply fault), or output pin to GND short (Ground fault), the LSI might be damaged before the thermal protection circuit could operate.
10. Unless specified in the product specifications, make sure that negative voltage or excessive voltage are not applied to the pins because the device might be damaged, which could happen due to negative voltage or excessive voltage generated during the ON and OFF timing when the inductive load of a motor coil or actuator coils of optical pick-up is being driven.
11. Product which has specified ASO (Area of Safe Operation) should be operated in ASO
12. Verify the risks which might be caused by the malfunctions of external components.

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.
- (7) This book may be not reprinted or reproduced whether wholly or partially, without the prior written permission of our company.