RAA23022x RAA23023x

16V Input, 3A, Dual Step-Down DC/DC Converter
+ Battery Backup

R18DS0017EJ0100
REV.1.00
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Description

The RAA23022x and RAA23023x are dual step-down DC/DC converter, 4.5V to 16V input voltage rage and 3A output current. Auto PFM mode makes devices low power operation at light load, so it makes a system lower power.
The RAA23022x is suitable for battery backup system using lithium primary cell with built-in battery backup circuit.

Features

- DC/DC

Input voltage range	4.5V to 16V
Shutdown current	1uA (typ.)
Auto PFM mode	
Maximum output current	3A
Synchronous rectification type step-down DC/DC	
Integrated power MOSFETs	
Switching frequency	1.1MHz (fixed)
Output voltage range	0.8V to 6V
Internal phase compensator	
Soft start	2ms (fixed)
Discharge circuit	
Power Good	
Battery backup circuit (RAA23022x)	

- Protection circuit

Short circuit protection (latch type)	
Thermal shutdown circuit	165°C (typ.)
Under voltage lockout circuit (recovery type)	

- Package

20-pin HTSSOP

Application

Communication (Router, Home Gate Way, Radio, etc.)
Industrial (Surveillance camera, Various controller, etc.)
Building (Security device, Emergency device, Various controller, etc.)
OA (Printer, Plane paper copier, etc.)
Smart meter
Smart home appliances
And, usable various application

Note: The information contained in this document is being issued in advance of the production cycle for the product. The parameters for the product may change before final production, or Renesas Electronics Corporation, at its own discretion, may withdraw the product prior to its production.

A quality grade of these ICs is “Standard”. Recommended applications are indicated below.
Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment, and industrial robots, etc.

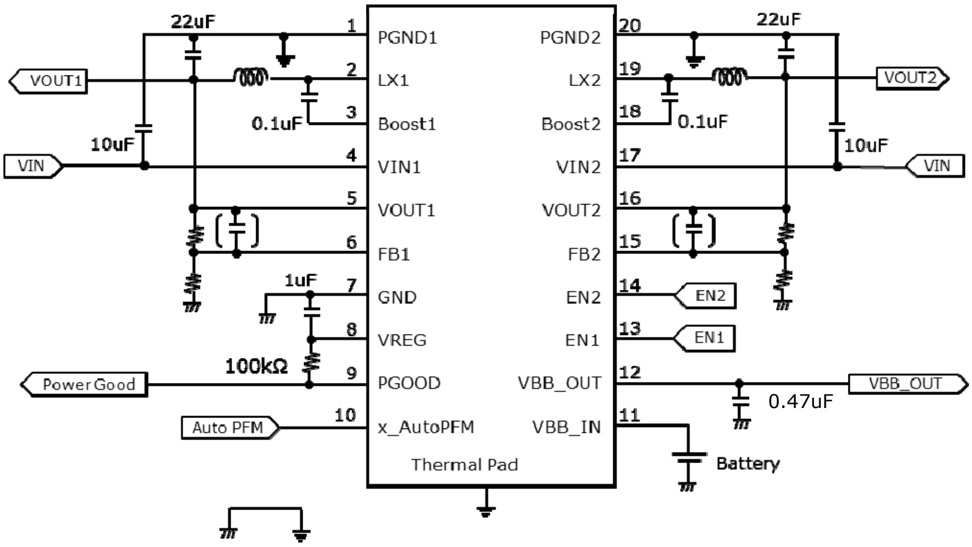
Product Lineup Table

Part number	Output	Type	VIN range	VOUT	IOUT (max.)	Switching frequency
RAA230221	2	Step-down + BB*1	4.5 to 16V	CH1 3.3V (fixed) CH2 0.8V to 6.0V*2	3A	1.1MHz
RAA230222	2	Step-down + BB*1	4.5 to 16V	CH1 3.3V (fixed) CH2 5.0V (fixed)	3A	1.1MHz
RAA230223	2	Step-down + BB*1	4.5 to 16V	CH1 and CH2 0.8V to 6.0V*2	3A	1.1MHz
RAA230231	2	Step-down	4.5 to 16V	CH1 3.3V (fixed) CH2 0.8V to 6.0V*2	3A	1.1MHz
RAA230232	2	Step-down	4.5 to 16V	CH1 3.3V (fixed) CH2 5.0V (fixed)	3A	1.1MHz
RAA230233	2	Step-down	4.5 to 16V	CH1 and CH2 0.8V to 6.0V*2	3A	1.1MHz

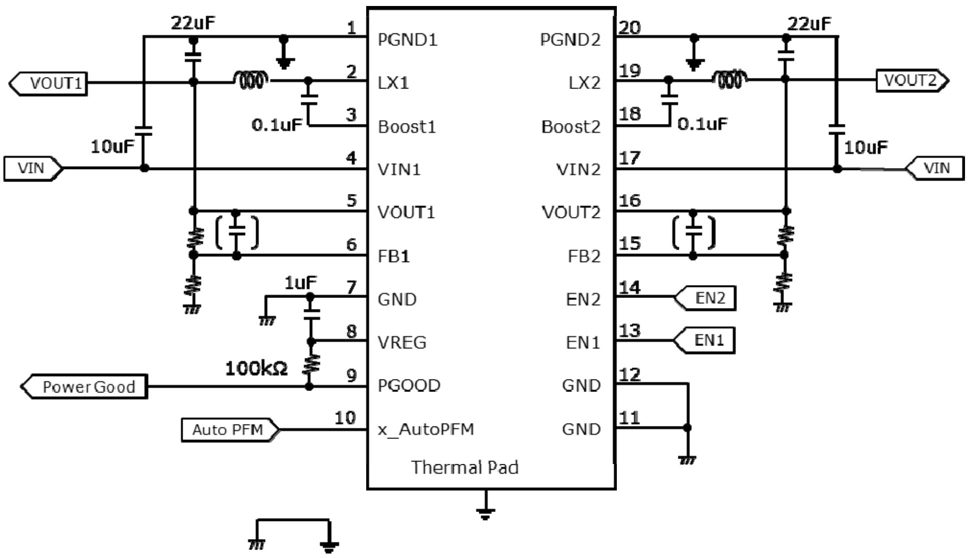
Note *1 BB : Battery Backup
*2 Adjustable by external resistors

Circuit example

RAA23022x (2CH DCDC + Battery Backup, VOUT set by external resistors)

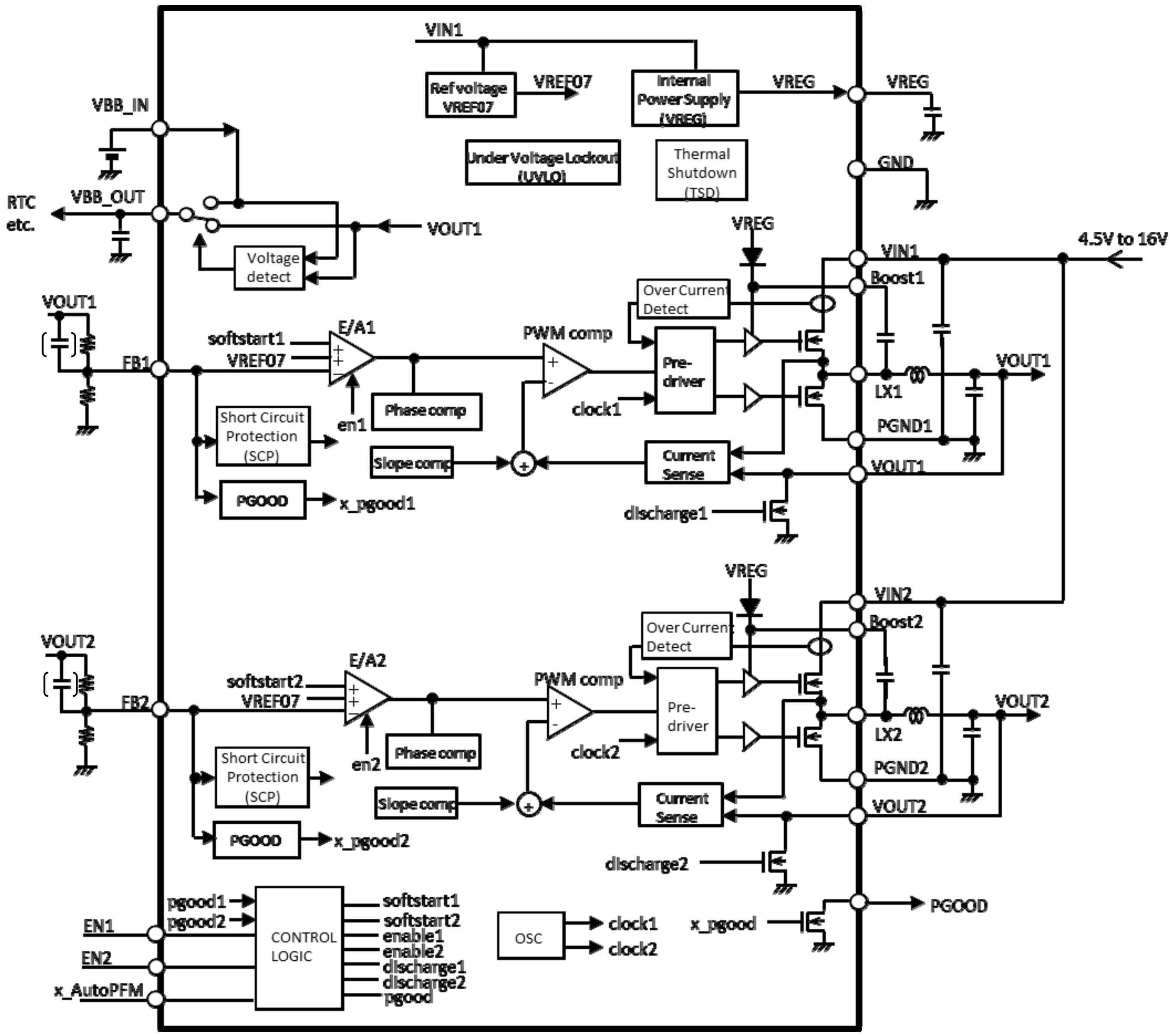


RAA23023x (2CH DCDC, VOUT set by external resistors)

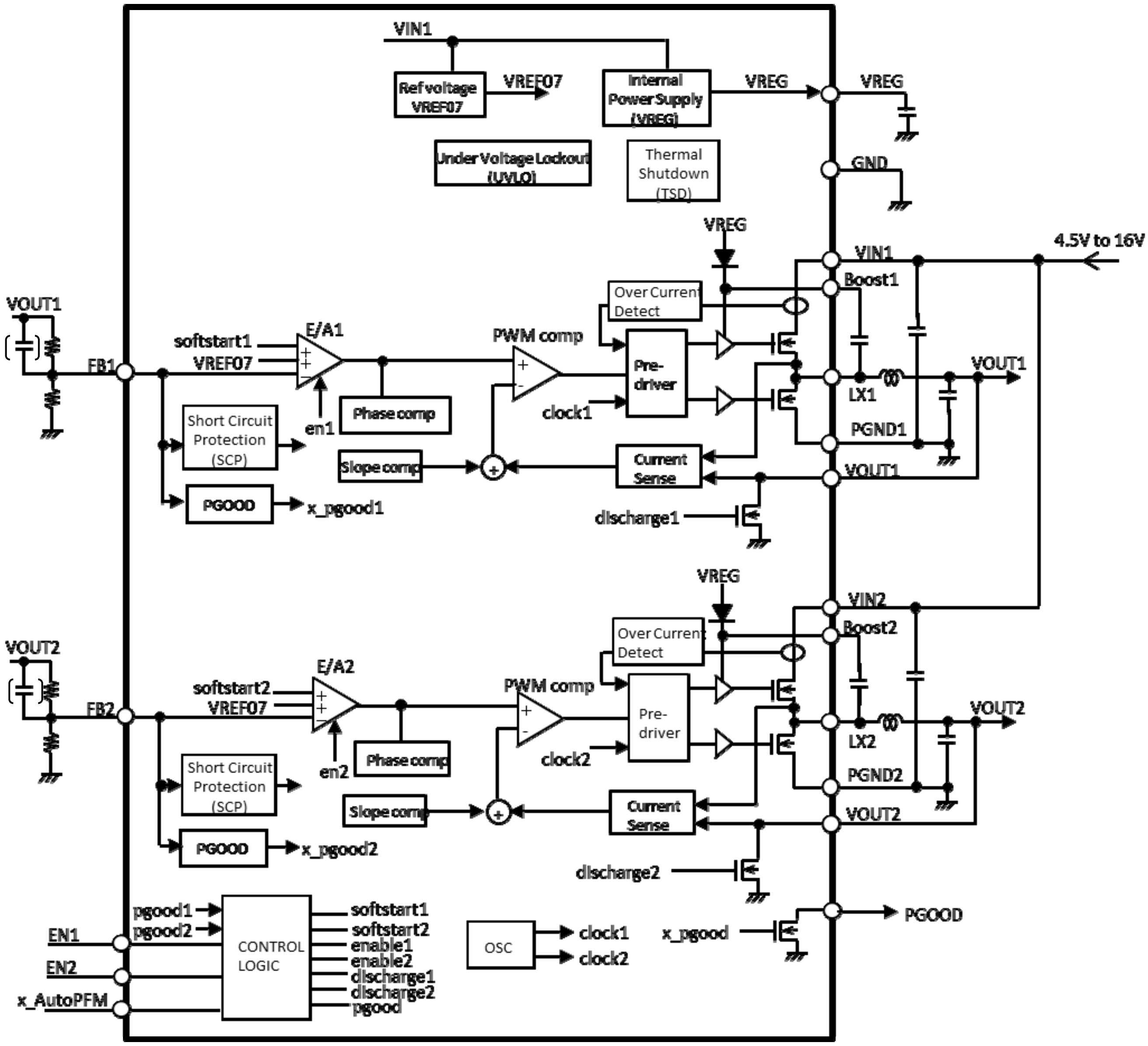


Block Diagram

RAA23022x (2CH DCDC + Battery backup, VOUT set by external resistors)



RAA23023x (2CH DCDC, VOUT set by external resistors)



Pin Function

RAA23022x (2CH DCDC + Battery backup)

Pin No.	Symbol	I/O	Function
1	PGND1	I/O	CH1 Power Ground
2	LX1	O	CH1 Inductor connection
3	Boost1	I	CH1 Boot strap input (Connect 0.1uF capacitor between LX1 and Boost1)
4	VIN1	I	CH1 Power supply
5	VOUT1	I	CH1 VOUT feedback
6	FB1	I	CH1 Feedback resistor connection
7	GND	I/O	Analog Ground
8	VREG	O	Internal power supply output (Connect 1uF capacitor between VREG and AGND)
9	PGOOD	O	Power good output (open drain) CH1 and CH2 stop :L CH1 or CH2 operation : HiZ
10	x_AutoPFM	I	Auto PFM mode ON/OFF x_AutoPFM=”L” : Auto PFM mode (change automatically) PFM mode at light load PWM mode at heavy load x_AutoPFM=“H” : PWM mode (fixed)
11	VBB_IN	I	Battery connection
12	VBB_OUT	O	Backup voltage output
13	EN1	I	CH1 enable EN1=“L” : CH1 Stop EN1=”H” : CH1 Operation
14	EN2	I	CH2 enable EN2=“L” : CH2 Stop EN2=”H” : CH2 Operation
15	FB2	I	CH2 Feedback resistor connection
16	VOUT2	I	CH2 VOUT feedback
17	VIN2	I	CH2 Power supply
18	Boost2	I	CH2 Boot strap input (Connect 0.1uF capacitor between LX2 and Boost2)
19	LX2	O	CH2 Inductor connection
20	PGND2	I/O	CH2 Power Ground

RAA23023x (2CH DCDC)

Pin No.	Symbol	I/O	Function
1	PGND1	I/O	CH1 Power Ground
2	LX1	O	CH1 Inductor connection
3	Boost1	I	CH1 Boot strap input (Connect 0.1uF capacitor between LX1 and Boost1)
4	VIN1	I	CH1 Power supply
5	VOUT1	I	CH1 VOUT feedback
6	FB1	I	CH1 Feedback resistor connection
7	GND	I/O	Analog Ground
8	VREG	O	Internal power supply output (Connect 1uF capacitor between VREG and AGND)
9	PGOOD	O	Power good output (open drain) CH1 and CH2 stop :L CH1 or CH2 operation : HiZ
10	x_AutoPFM	I	Auto PFM mode ON/OFF x_AutoPFM="L" : Auto PFM mode (change automatically) PFM mode at light load PWM mode at heavy load x_AutoPFM="H" : PWM mode (fixed)
11	GND	I/O	Analog Ground
12	GND	I/O	Analog Ground
13	EN1	I	CH1 enable EN1="L" : CH1 Stop EN1="H" : CH1 Operation
14	EN2	I	CH2 enable EN2="L" : CH2 Stop EN2="H" : CH2 Operation
15	FB2	I	CH2 Feedback resistor connection
16	VOUT2	I	CH2 VOUT feedback
17	VIN2	I	CH2 Power supply
18	Boost2	I	CH2 Boot strap input (Connect 0.1uF capacitor between LX2 and Boost2)
19	LX2	O	CH2 Inductor connection
20	PGND2	I/O	CH2 Power Ground

Absolute Maximum Ratings

(Unless otherwise specified, TA = 25°C,)

Parameter	Symbol	Ratings	Unit	Condition
VIN applied voltage	VIN	-0.3 to +17.6	V	VIN1, VIN2
EN applied voltage	EN	-0.3 to +17.6	V	EN1, EN2
x_AutoPFM applied voltage	x_AutoPFM	-0.3 to +17.6	V	x_AutoPFM
PGOOD voltage	PGOOD	-0.3 to +6.5	V	PGOOD
FB applied voltage	FB	-0.3 to +6.5	V	FB1, FB2
VOUT applied voltage	VOUT	-0.3 to +6.5	V	VOUT1, VOUT2
VBB_IN applied voltage (RAA23022x)	VBB_IN	-0.3 to +6.5	V	VBB_IN
VIN input current(peak)	IVIN(peak)-	4.2	A	VIN1, VIN2
LX output current(peak)	ILX(peak)+	4.2	A	LX1, LX2
VOUT sink current (DC)	IVOUT(DC)-	100	mA	VOUT1, VOUT2 When discharge circuit operation
GND voltage	GND	-0.3 to +0.3	V	PGND1, PGND2, GND
Total power dissipation	PT	3400*1	mW	TA≦＋25℃
Operating ambient temperature	TA	-40 to +85	°C	
Operation junction temperature	TJ	-40 to +125	°C	
Storage temperature	Tstg	-55 to +150	°C	

Note: *1 This is the value at T_A < +25°C. At T_A > +25°C, the total power dissipation decrease with −34 mW/°C.

Board specification : 4 layers glass epoxy board, 76.2mm x 114.3mm x 1.664mm.

Copper coverage area: 50%, 0.070mm thickness (top and bottom layers)

95%, 0.035mm thickness (layers 2 and 3)

Connecting exposed pad

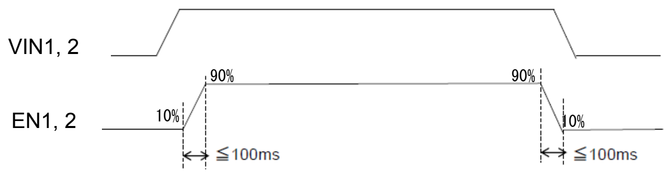
Caution: Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Recommended Operating Condition

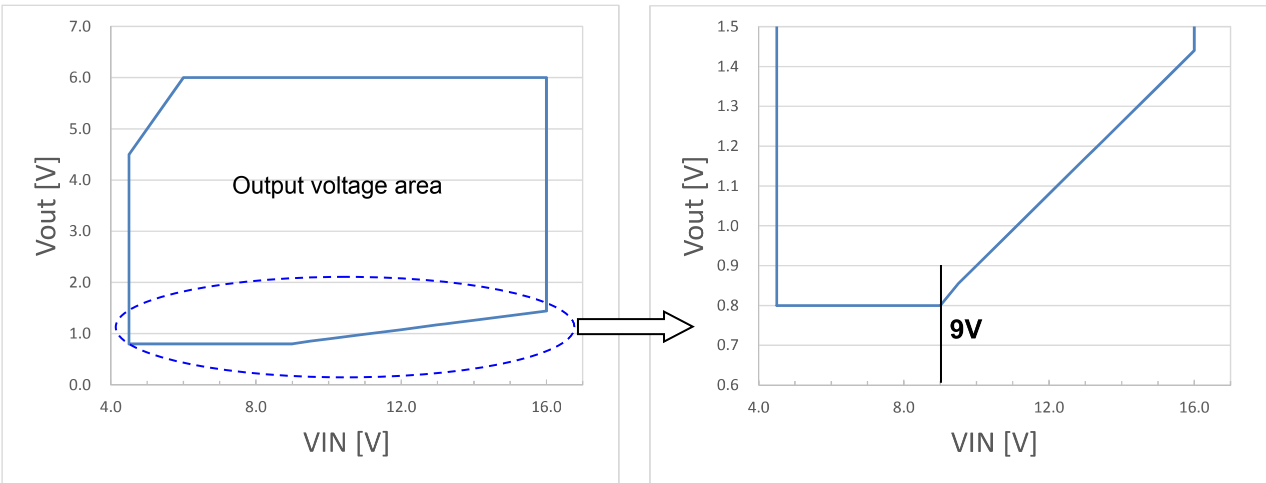
(Unless otherwise specified, TA = 25°C)

Parameter	Symbol	MIN.	TYP.	MAX.	Unit	Condition
VIN applied voltage	VIN	4.5		16.0	V	VIN1, VIN2
EN applied voltage	EN	0		16.0	V	EN1, EN2 *1
x_AutoPFM applied voltage	x_AutoPFM	0		16.0	V	x_AutoPFM
PGOOD voltage	PGOOD	0		6.0	V	PGOOD
FB applied voltage	FB	0		6.0	V	FB1, FB2
VOUT setting range	Vdcdc_ext	*2		6.0	V	At external resistor setting

*1 About rising time (tr) and falling time (tf) of input signal to EN1 and EN2 pin, when EN1 and EN2 pin are not connected to power supply pin (VIN1, VIN2), set tr and tf less than 100ms.
When EN1, EN2 pin are connected to VIN1, VIN2 pin, there are no restriction.



*2 Output voltage (minimum value)



Electrical Characteristics

(Unless otherwise specified, TA = 25°C, VIN1 = VIN2 = 12V)

Parameter		Symbol	MIN.	TYP.	MAX.	Unit	Condition
Total	Shutdown current	IDD(SHDN)		1	10	uA	EN1 = EN2 = GND
Under voltage lock out circuit (UVLO)	Operating start voltage	Vrls(vin)	3.6	3.9	4.2	V	VIN1 and VIN2 rising are detected
	Operating stop voltage	Vdet(vin)	3.4	3.7	4.0	V	VIN1 and VIN2 falling are detected
Internal power supply (VREG)	Internal power supply voltage	VREG	4.7	5.0	5.3	V	Ireg = 0mA, VIN1 = 6V to 16V
Output (PWM mode)	E/A feedback voltage	vref07	0.693	0.700	0.707	V	Include input offset at external resistor setting
	Output voltage accuracy	Vacc	-2.5		+2.5	%	Fixed VOUT products
	High side FET on-resistance	Ronh		180		mΩ	Io=100mA
	Low side FET on-resistance	Ronl		130		mΩ	Io=-100mA
Discharge circuit	On-resistance	Rondc	—	100	200	Ω	CH1, CH2, Io=15mA
Soft start	Soft start time [*1]	tss	1.2	2	3.5	ms	
Thermal shutdown circuit	Detect temperature[*2]			165		°C	
	Hysteresis temperature[*2]			20		°C	
Logic input	High level threshold voltage	VIH	1.3		VIN+0.3	V	EN1, EN2, x_AutoPFM
	Low level threshold voltage	VIL	-0.3		0.4	V	EN1, EN2, x_AutoPFM
	Input current	IEN		1		uA	EN1 = 3.3V, EN2 = 3.3V x_AutoPFM = 3.3V
Battery backup (RAA23022x)	VBB_IN input voltage range	VBB	2.7	3.0	3.7	V	
	On-resistance between VBB_IN and VBB_OUT	Ron_vbat		400		Ω	VBB_OUT = VBB_IN, Io=0.5mA
	On-resistance between VOUT1 and VBB_OUT	Ron_vout1		100		Ω	VBB_OUT = VOUT1, Io=0.5mA
	VBB leak current [*1]	IL_BB		0.5		uA	VBB_OUT = VBB_IN = 3.0V, No load

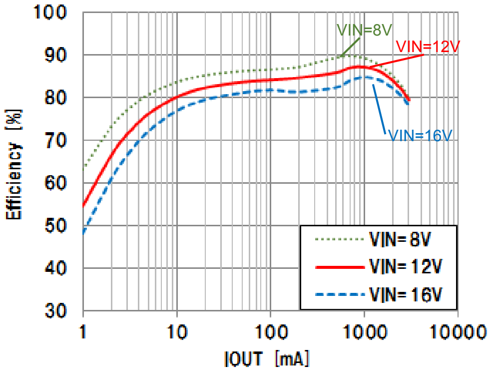
Note: *1 Reference value
*2 Not production tested.

Typical Performance Characteristics

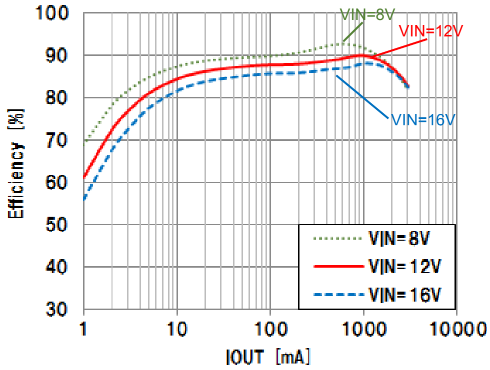
(Unless otherwise specified, T_A = 25°C)

Efficiency vs. Output Current

CH1 Vout=3.3V, Auto PFM mode

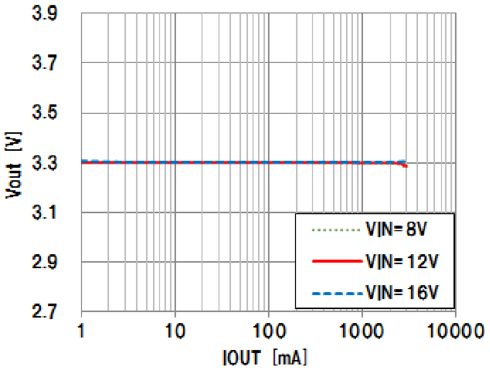


CH2 Vout=5.0V, Auto PFM mode

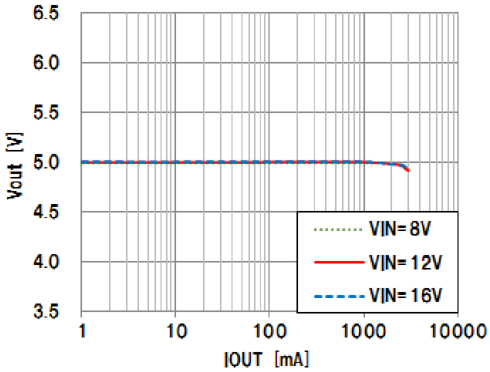


Output voltage vs. Output Current

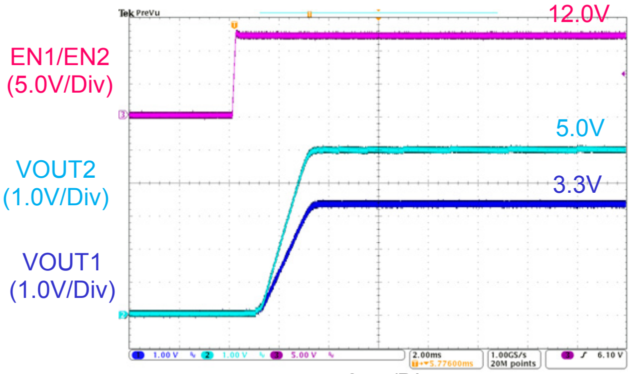
CH1 Vout=3.3V, Auto PFM mode



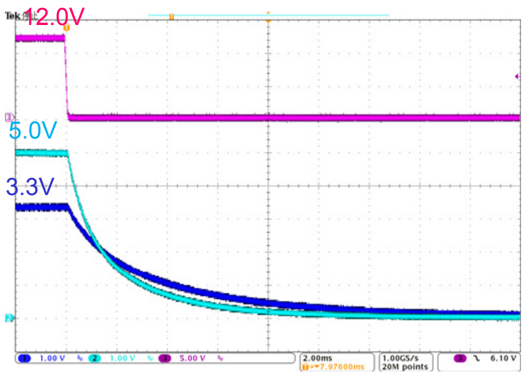
CH2 Vout=5.0V, Auto PFM mode



Start-up and Shutdown Waveforms



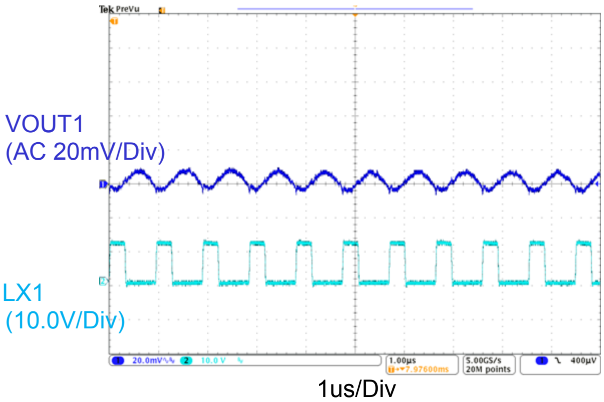
2ms/Div



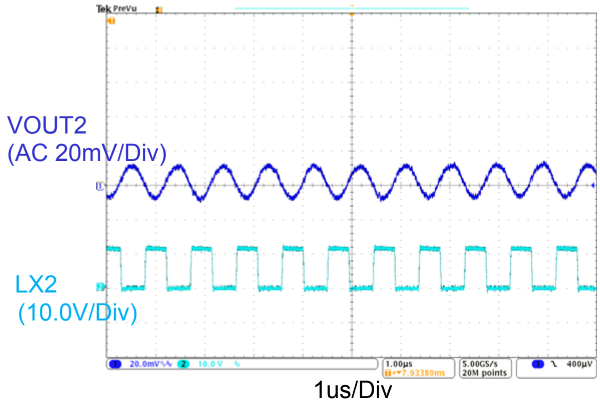
2ms/Div

Operation Waveforms

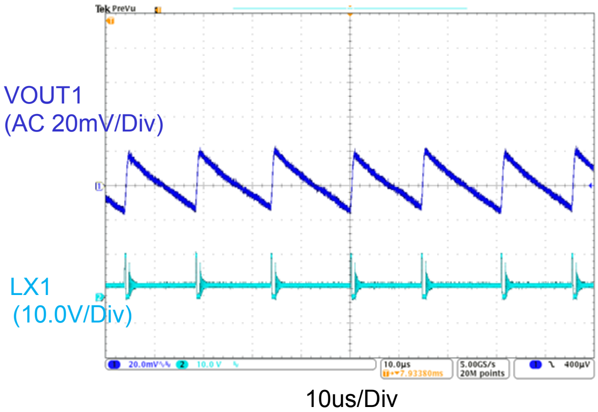
CH1 VIN=12V, Vout=3.3V, Iout=3.0A
Auto_PFM mode



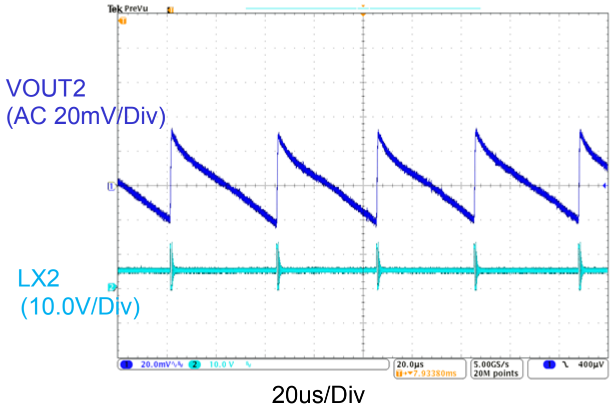
CH2 VIN=12V, Vout=5.0V, Iout=3.0A
Auto PFM mode



CH1 VIN=12V, Vout=3.3V, Iout=0.01A
Auto_PFM mode

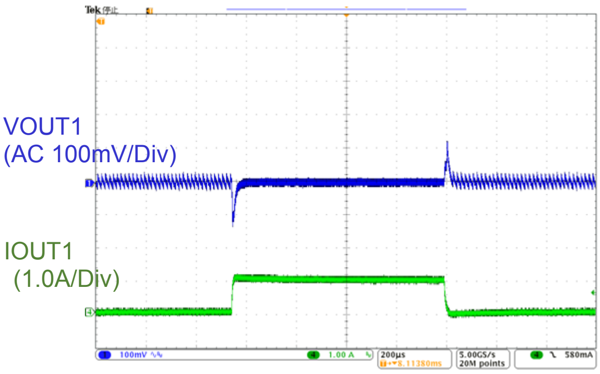


CH2 VIN=12V, Vout=5.0V, Iout=0.01A
Auto PFM mode



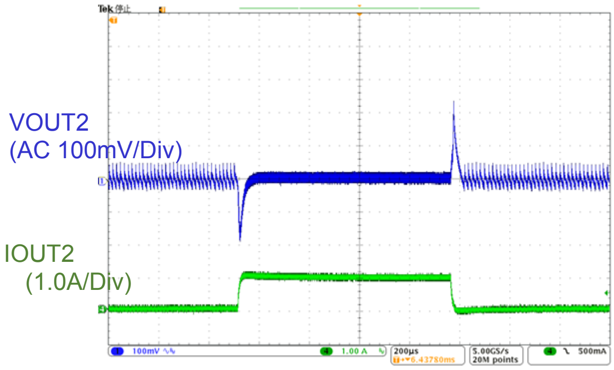
Load Step Transient Waveforms

CH1 VIN=12V, Vout=3.3V, Iout=0.01A-1.0A
Auto_PFM mode



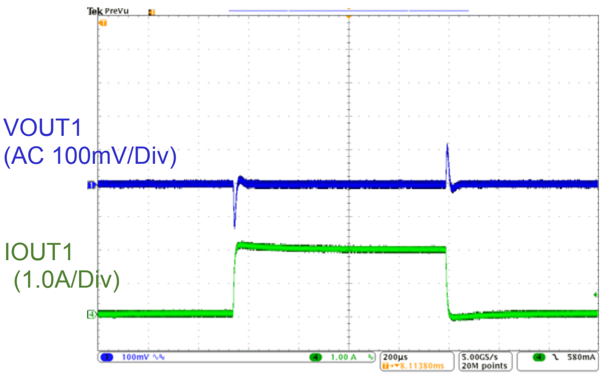
200us/Div

CH2 VIN=12V, Vout=5.0V, Iout=0.01A-1.0A
Auto PFM mode



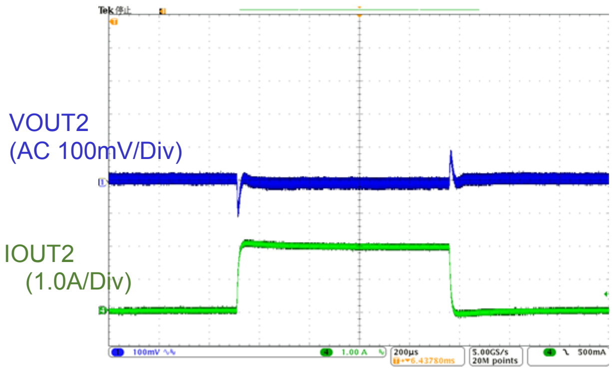
200us/Div

CH1 VIN=12V, Vout=3.3V, Iout=0.01A-2.0A
PWM mode



200us/Div

CH2 VIN=12V, Vout=5.0V, Iout=0.01A-2.0A
PWM mode

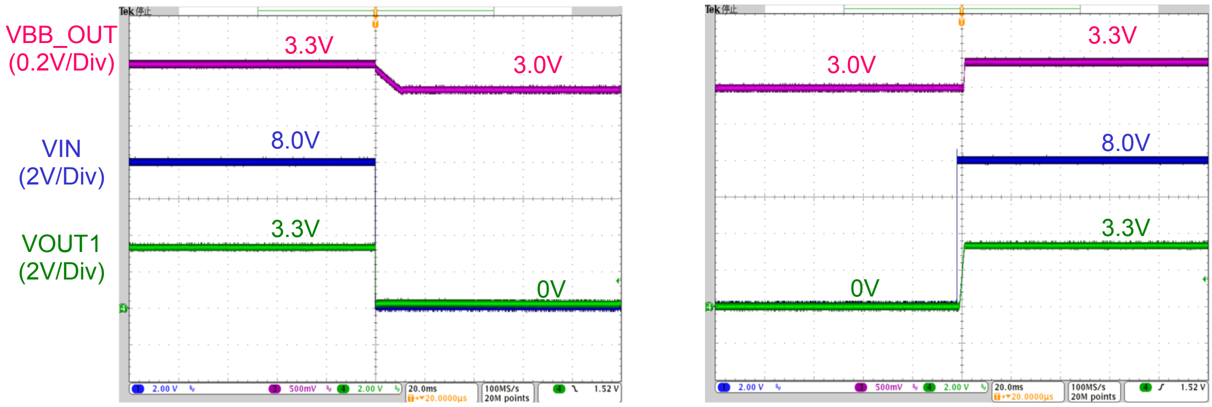


200us/Div

Battery Backup circuit : VBB_OUT changing Waveform (RAA23022x)

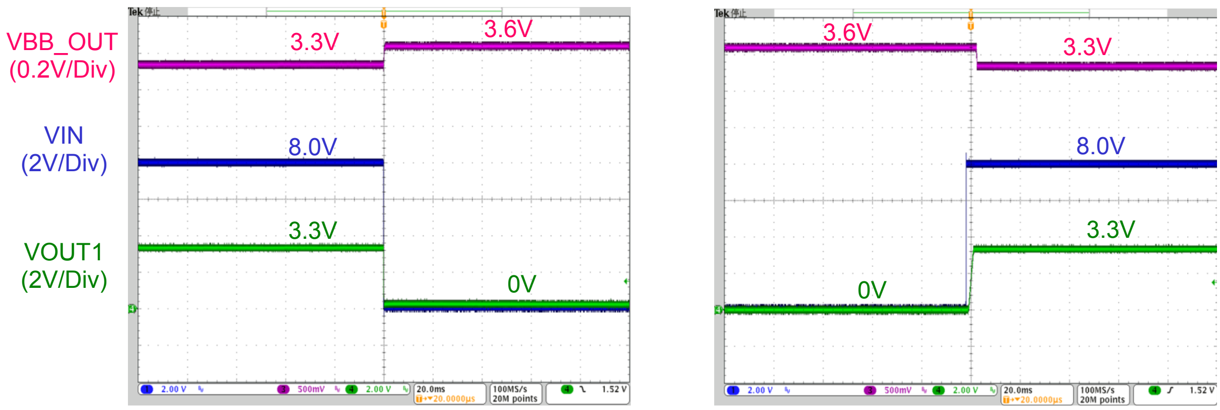
VIN=8.0V, VOUT1=3.3V, VBB_OUT output current =10uA, VBB_OUT capacitor = 0.47uF

(1) Battery Voltage (VBB_IN pin)=3.0V、VOUT1=3.3V



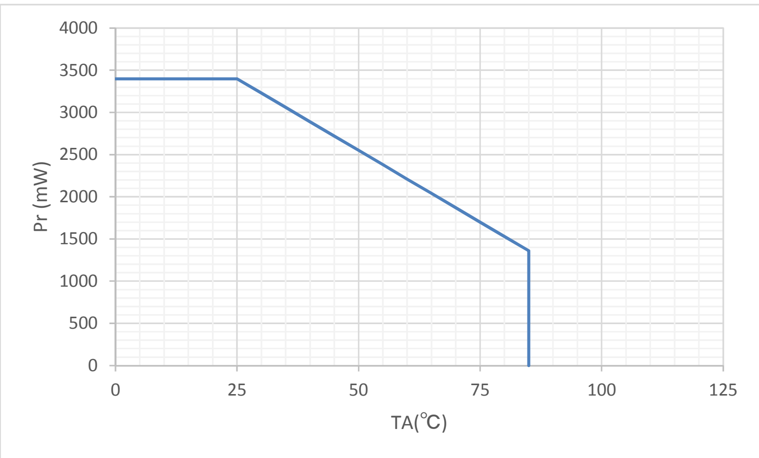
20ms/Div 20ms/Div

(2) Battery Voltage(VBB_IN pin) = 3.6V、VOUT1=3.3V



20ms/Div 20ms/Div

Temperature Derating Curve



Detailed Description

Control Block

EN1, EN2 : ON/OFF setting

EN1	EN2	State	VREG
L	L	Shutdown (CH1 and CH2 stop)	0V
H	L	CH1 Operation CH2 Stop	5.0V
H	H	CH1 and CH2 Operation	5.0V
L	H	Ch1 Stop CH2 Operation	5.0V

Note: L: Low level, H: High level

There is no pull-down resistor within EN1 and EN2 pin because of reducing power consumption at light load.
Fix EN1 and EN2 pin to high level or low.

x_autoPFM : AutoPFM mode/ PWM mode setting

x_autoPFM	Operation
L	Auto PFM mode (change automatically) PFM mode at light load PWM mode at heavy load
H	PWM mode (fixed)

Note: L: Low level, H: High level

There is no pull-down resistor within x_autoPFM pin because of reducing power consumption at light load.
Fix x_autoPFM pin to high level or low.

PGOOD : Power Good output

State	PGOOD
CH1 and CH2 stop	L
CH1 or CH2 operation	HiZ

Note: L: Low level, H: High level

When using this function, connect PGOOD pin to VREG, VOUT1, VOUT2, etc.
When VREG voltage falls under 3.7V, PGOOD pin becomes high impedance though CH1 and CH2 stop.

Auto PFM mode

RAA23022x and RAA23023x have Auto PFM mode to achieve high efficiency over a wide load current range. The devices operate with PFM (Pulse Frequency Modulation) mode at light load current, and PWM (Pulse Width Modulation) mode at heavy load current. An operation mode is automatically switched depending on load current.

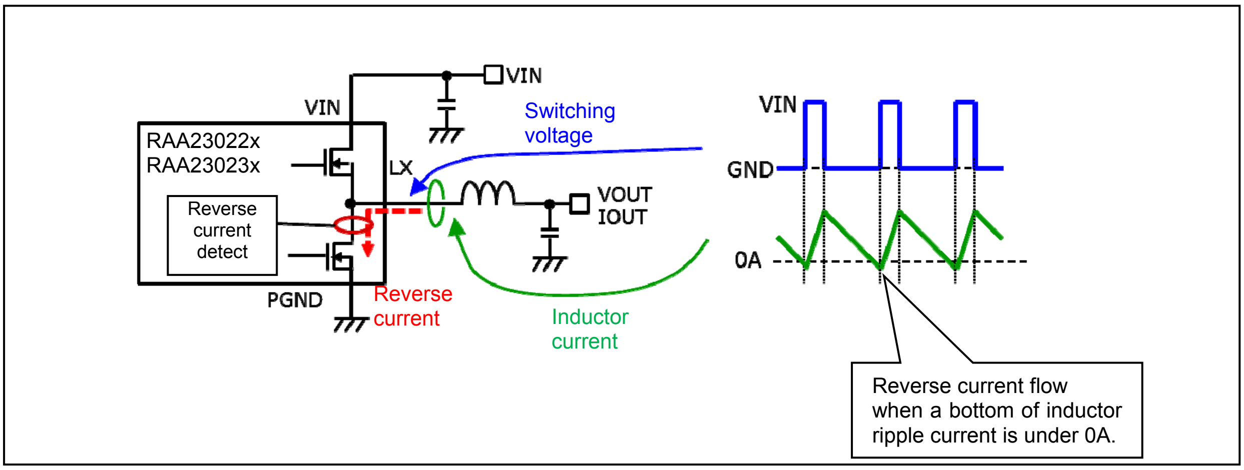
When a bottom of inductor ripple current is under 0A, reverse current flow at low-side N-channel MOSFET of output block. The devices operate with PFM mode during detecting this current.

A current of switching PFM / PWM mode (I_{change}) is calculated by an equation below.

$$I_{change} = \frac{\Delta IL}{2}$$

$$\Delta IL = \frac{(V_{IN} - V_{OUT})}{L} \times \frac{V_{OUT}}{V_{IN}} \times \frac{1}{f_{SW}}$$

L : inductance, f_{SW} : 1.1MHz



RAA23022x and RAA23023x have x_autoPFM pin. When Low level, the devices operate Auto PFM mode (PFM mode / PWM mode changed automatically). When High level, the devices operate PWM mode, then not change into Auto PFM mode.

Soft Start

To limit the startup inrush current and output voltage overshoot, a soft start circuit is used to ramp up the reference voltage from 0 V to its final value linearly. When EN pin is set from low level to high level, the device starts operation and output voltage rises with soft start. Both CH1 and CH2 soft start time are fixed at 2ms(Typ.) and no additional components are needed. Soft start feature gradually increases the error amplifier (E/A) input threshold voltage by using the voltage that is generated by the digital soft start (DSS) circuit.

Discharge Circuit

The device has discharge circuit in both CH1 and CH2. This enables a rapid discharge without an external MOSFET. When an EN pin is changed from high level to low, each discharge switch in VOUT pin is turned on and all capacitors which are connected to each output are rapidly discharged through VOUT pin.

When VIN pin voltage becomes low level, discharge switches become off because there are no voltage to keep them on. The control voltage of discharge switches is VREG, and the discharge time of VREG capacitor is over 100ms when VIN voltage falls down, so even if EN pin is connected to VIN pin, an output voltage can be discharged because VREG voltage level can keep the discharge switches on.

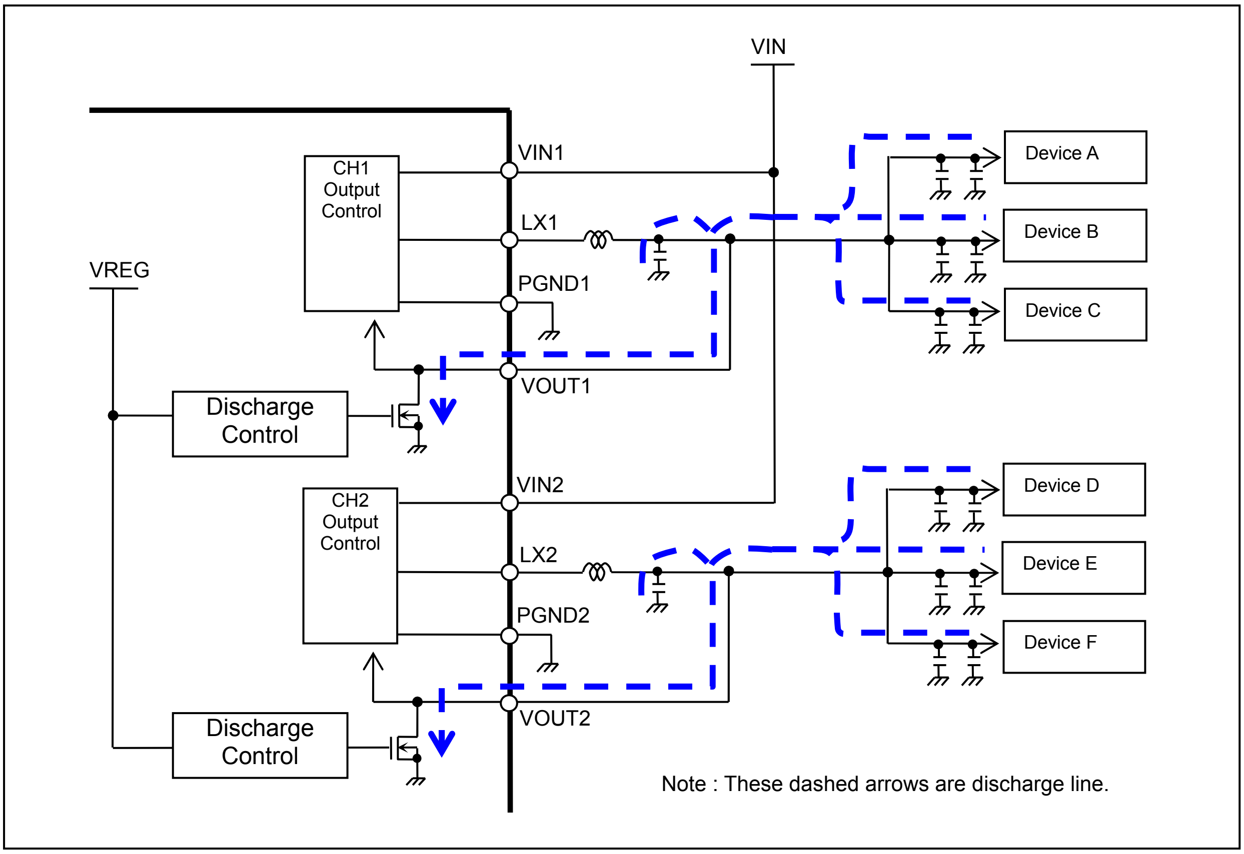
Discharge time can be calculated by an equation below.

$$V_{dc} = V_{OUT} \times e^{-\frac{t_{dc}}{C_{ALL} \times R_{ondc}}}$$

V_{dc} is a voltage after t_{dc}(s).

C_{ALL} is sum of all capacitance which are connected to CH1 or CH2 output (output capacitor, bypass capacitor around MCU, etc.).

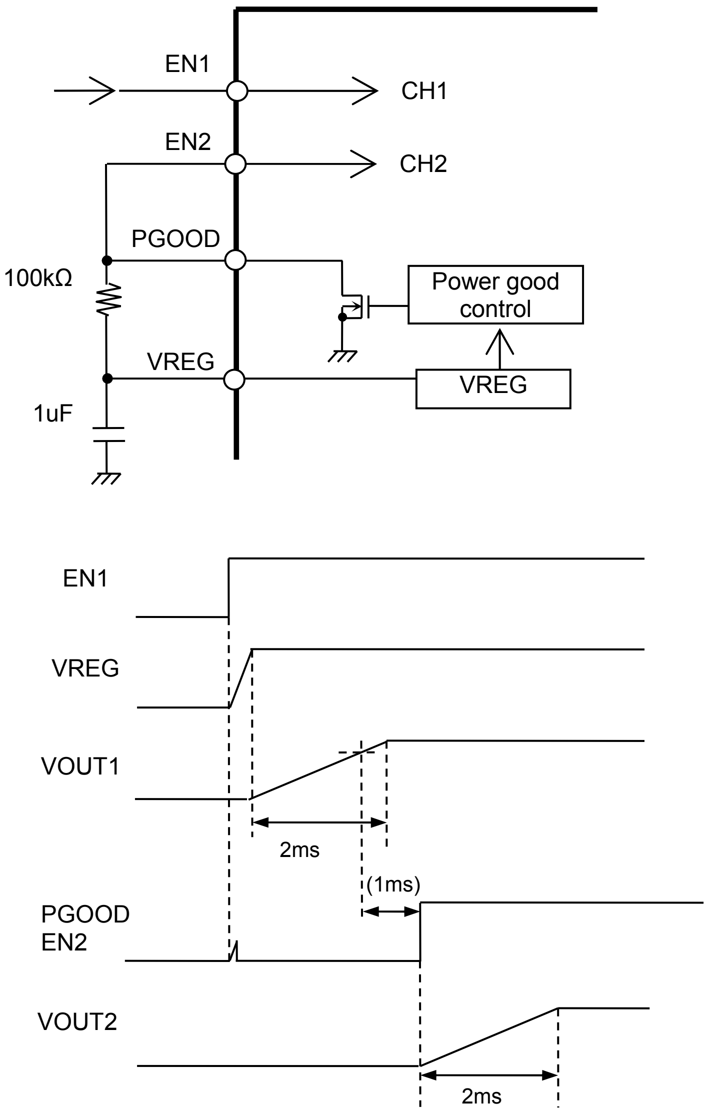
R_{ondc} is on resistance of discharge circuit.



Power Good

Power Good is an open-drain output that requires a pull – up resistor (Recommended value = 100kΩ). PGOOD pin becomes high impedance (HiZ) when either CH1 or CH2 FB pin voltage and thus its output voltage rises above 80% of nominal regulation point. If it is pulled-up, PGOOD output high level. PGOOD pin goes low when both CH1 or CH2 output voltage falls below 80% of the regulation point. When both EN1 and EN2 pin goes low level, PGOOD pin becomes HiZ because VREG is used for power good control and it fall down at this time. So, if PGOOD pin is connected to VIN, its status becomes high level even if CH1 and CH2 stop. PGOOD pin must be pulled up to CH1 output, CH2 output or VREG when using this function.
CH1 and CH2 can be started in order by connecting PGOOD pin to EN1 or EN2. This function can be also used for sequence signal for other devices.

Circuit example when CH2 is started after CH1



Battery Backup (RAA23022x)

RAA23022x has a battery backup circuit which is used to operate some devices at system power-off. The circuit can be easily designed by RAA23022x without two diodes.
When CH1 operates, VBB_OUT = VOUT1. When CH1 stops and VOUT1 pin voltage is higher than VBB_IN pin, VBB_OUT = VOUT1 pin. When CH1 stops and VOUT1 pin voltage is lower than VBB_IN pin, VBB_OUT = VBB_IN pin.
VBB_OUT voltage value is dependent on on-resistance between VBB_IN and VBB_OUT, On-resistance between VOUT1 and VBB_OUT and VBB_OUT output current. VBB_OUT can be calculated by equations below.

1. Normal operation mode (VBB_OUT = VOUT1)

$$V_{BB\_OUT} = V_{OUT1} - I_{BB\_OUT} \times R_{on\_vout1}$$

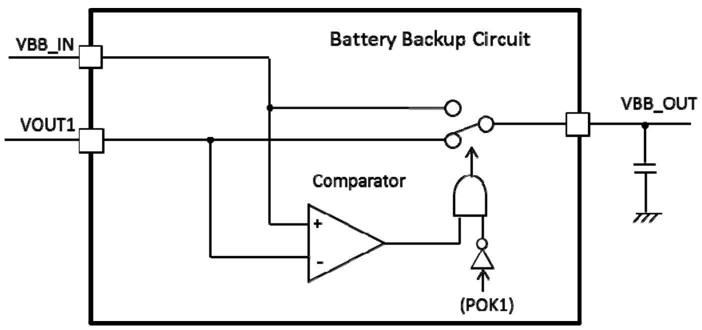
2. Battery backup mode (VBB_OUT = VBB_IN)

$$V_{BB\_OUT} = V_{BB\_IN} - I_{BB\_OUT} \times R_{on\_vbat}$$

V_{BB_OUT} : VBB_OUT voltage (V)
V_{OUT1} : VOUT1 voltage = CH1 output voltage (V)
V_{BB_IN} : VBB_IN voltage = Battery voltage (V)
I_{BB_OUT} : VBB_OUT output current (A)
R_{on_vout1} : On resistance between VOUT1 and VBB_OUT 100Ω (Typ.)
R_{on_vbat} : On resistance between VBB_IN and VBB_OUT 400Ω (Typ.)

Note : $2.7V \leq V_{BB\_OUT} \leq 3.7V$

Connect over 0.47uF capacitor to VBB_OUT pin.



Note : POK1 is an IC internal signal which identifies CH1 operating status.
It cannot be seen from IC outside.

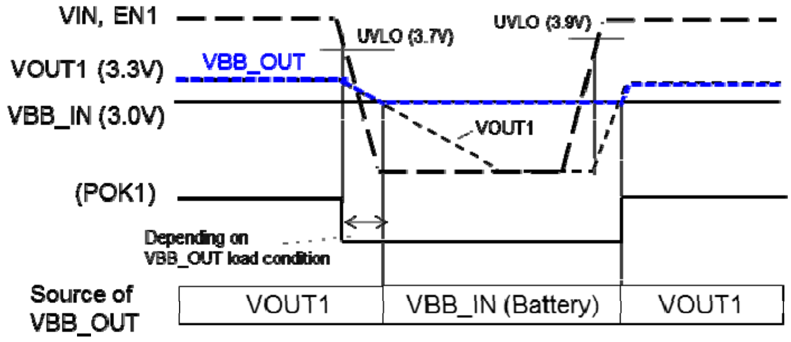
VBB_OUT pin output status

CH1	VOUT1, VBB_IN	VBB_OUT
Operation (POK1 = H)	VOUT1 ≥ VBB_IN or VOUT1 < VBB_IN	VOUT1
Stop (POK1 = L)	VOUT1 ≥ VBB_IN	VOUT1
	VOUT1 < VBB_IN	VBB_IN

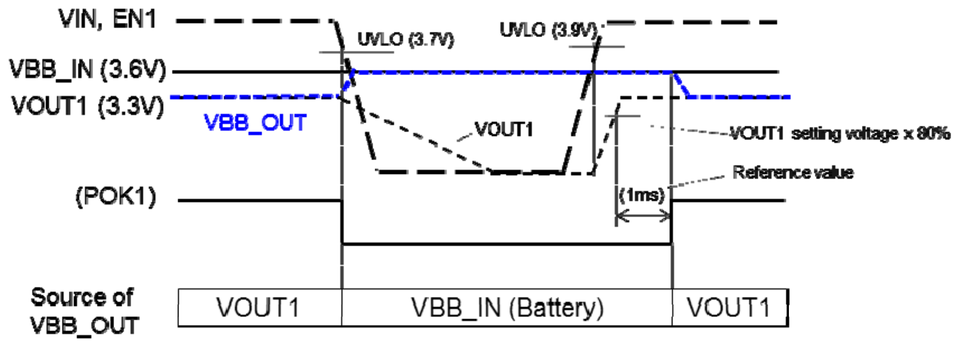
Note : L: Low level, H: High level

Timing chart of battery backup

1. With 3.0V battery



2. With 3.6V battery



Protection Circuit View

Protection circuit	Function	Operation status		Reset
		Common circuit (VREG, etc.)	CH1, CH2 Output	
Short circuit protection (SCP)	Detect output voltage dropping because of short circuit, etc. (Latch type)	Operation	Latched to off	Turn EN1 and EN2 pin from high level to low level or Drop VIN1 and VIN2 pin voltage under operation stop voltage of UVLO
Thermal shutdown circuit (TSD)	Detect rise up of IC internal temperature (Over 165˚C) (Auto recovery type)	Operation	Stop	The temperature falls
Under voltage lockout circuit (UVLO)	Detect dropping of VIN (Auto recovery type)	Operation	Stop	Up VIN1 and VIN2 over operating start voltage (3.9V)

Note SCP : Short Circuit Protection
TSD : Thermal Shutdown Circuit
UVLO : Under Voltage Lockout Circuit

Short Circuit Protection (Latch type)

When CH1 or CH2 output voltage drops, each FB pin input voltage also drops. If this voltage falls below the input detection voltage (0.35V(typ.)) of the short circuit protection, the outputs both CH1 and CH2 are stopped (latched to OFF). At this time, common circuits (such as VREG, etc.) continue operating.
When the protection is operating, to reset the latch, either turn the EN1 pin and EN2 pin from high to low or drop the VIN1 pin and VIN2 voltage under operation stop voltage of UVLO.

Thermal Shutdown Circuit (Auto Recovery Type)

When overheating has been detected (detect temperature: 165°C), the outputs both CH1 and CH2 is stopped. Then, power MOSFET of output both high side and low side are turned off. Common circuits (such as VREG, etc.) continue operating.
If the device temperature falls and becomes under detect temperature, the protection is canceled and output automatically resumes.

Under Voltage Lockout Circuit (Auto Recovery Type)

(1) Under voltage lockout operation
When the power supply voltage (VIN1 and VIN2) falls to the operation stop voltage (3.7V), output from all channels stops. Common circuits (such as VREG, etc.) continue operating.
(2) Restoring output
Once VIN1 and VIN2 is restored to the Operating start voltage (3.9V), the under voltage lockout operation is canceled and output automatically resumes. The output voltage cannot be restored while the under voltage lockout circuit is operating, not even by manipulating the EN pin.

Current Limiting

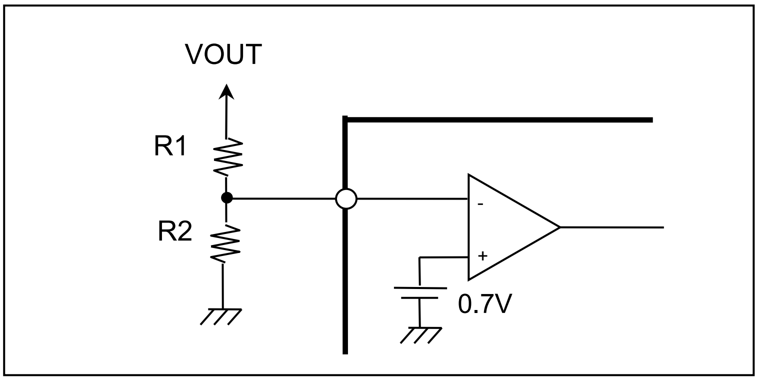
If an overcurrent occurs, an output current is limited on a pulse-by-pulse basis. If the current sensor detects an overcurrent, the current is limited and the switching operation of the Power MOSFET in the output stage stops until the next cycle.
When an output current is limited, the output voltage drops. If a FB pin voltage falls below the input detection voltage, the short-circuit protection circuit starts operating.

Guide for Circuit Design

Setting Output Voltage (When the output voltage is set by external resistor)

The output voltage can be calculated by an equation below.

VOUT = 0.7 x (1 + R1 / R2)



Examples of R1 and R2 selection

Vout	0.9V	1.0V	1.05V	1.1V	1.18V	1.2V	1.5V	1.8V	2.5V	3.3V	5.0V
R1	110k	100k	100k	91k	110k	130k	150k	130k	100k	100k	110k
R2	390k	240k	200k	160k	160k	180k	130k	82k	39k	27k	18k

Output voltage accuracy (When the output voltage is set by external resistor)

Output voltage accuracy can be calculated by an equation below.

$$V_{OUTACC} = V_{ITHACC} + \frac{(Vout - V_{ITH})}{Vout} \times 2 \times R_{ACC}$$

V_{OUTACC} is the output voltage accuracy (%).
V_{ITHACC} is the E/A input threshold voltage accuracy (%).
V_{OUT} is the output voltage (V).
R_{ACC} is the external resistor accuracy (%).

So, an output voltage accuracy of the device is below.

$$V_{OUTACC} = 1 + \frac{(Vout - 0.7)}{Vout} \times 2 \times R_{ACC}$$

Note : These equation don't include Vout fluctuation by load step transient.

Inductor selection

An inductor target is that ripple current (ΔIL) of inductor becomes 10 to 40 % of Iout(max).

When ΔIL increases, inductor current peak raises, so ripple of Vout gets larger and power loss increases. But, large size inductor is required to lower ΔIL.

ΔIL can be calculated by an equation below.

$$\Delta \mathrm{IL} = \frac{(Vin - Vout)}{L} \times \frac{Vout}{Vin} \times \frac{1}{f_{SW}}$$

fsw is 1.1MHz.

Peak current of inductor (ILpeak) can be calculated by an equation below.

$$IL_{Peak} = I_{OUT}(MAX) + \frac{\Delta IL}{2}$$

Choose a inductor which saturation current is higher than ILpeak .

Inductor Example

Inductance (uH)	Inductor	Manufacturer	I_{TEMP} (A)	I_{SAT} (A)	Size (LxWxT, mm)
2.2	NRS5024T2R2NMGJ	TAIYO YUDEN	3.1	4.1	4.9x4.9x2.4
2.2	744778002	WURTH	4.0	4.8	7.3x7.3x3.2
3.3	NRS5030T3R3MMGJ	TAIYO YUDEN	3.0	3.6	4.9x4.9x3.1
3.3	7447789003	WURTH	3.4	4.2	7.3x7.3x3.2
4.7	NRS5040T4R7NMGK	TAIYO YUDEN	3.1	3.3	4.9x4.9x4.1
4.7	744777004	WURTH	4.0	4.0	7.3x7.3x4.3

Note I_{TEMP} : Rated current by temperature rising
I_{SAT} : Rated current by inductance loss
These inductors are examples. About inductor detail, contact each manufacturer

Output capacitor selection

RAA23022x and RAA23023x have a phase compensation circuit which is optimized to DC/DC operation. In order to operate stably with the phase compensation, connect the output capacitor which is over 22 uF. Ceramic capacitor can be used for output capacitor. It has low ESR, so VOUT ripple is decreased.

VOUT ripple (ΔVrpl) can be calculated by an equation below.

$$\Delta V_{rpl} = \Delta IL \times \left(ESR + \frac{1}{(8 \times C_{OUT} \times f_{SW})} \right)$$

ESR : Equivalent Series Resistance

Input capacitor selection

Connect an input capacitor which is over 10 uF between each VIN pin and power ground. It should be placed close to the device as possible.

VREG capacitor

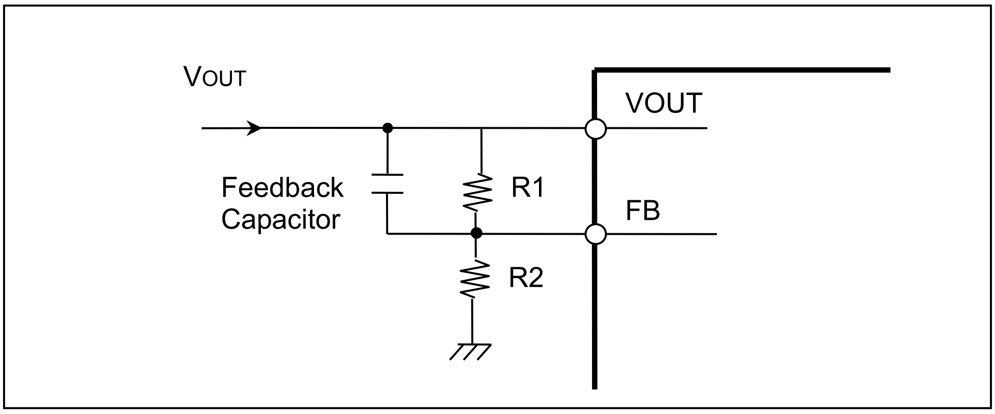
Connect 1uF ceramic capacitor to VREG pin.

Bootstrap capacitor

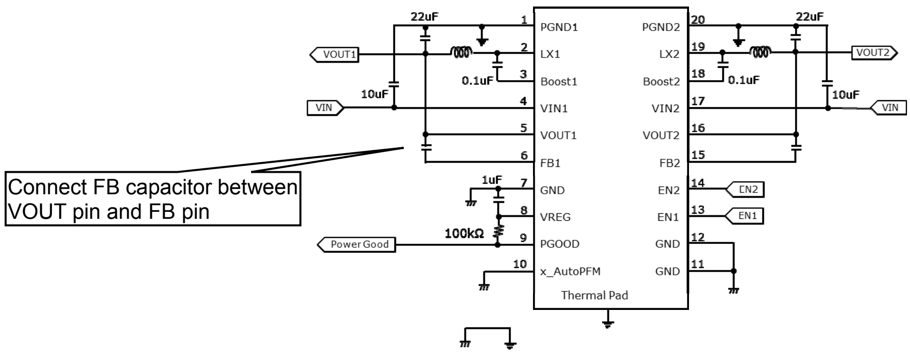
Connect 0.1uF ceramic capacitor between LX pin and Boost pin.

Feedback capacitor

When PFM operation at Auto PFM mode, feedback capacitor can be connected in parallel to high side output voltage setting resistor to adjust phase characteristic. If connected, there are possibility that operation in large current (at PWM operation) is not stable. Confirm the operation with system status.

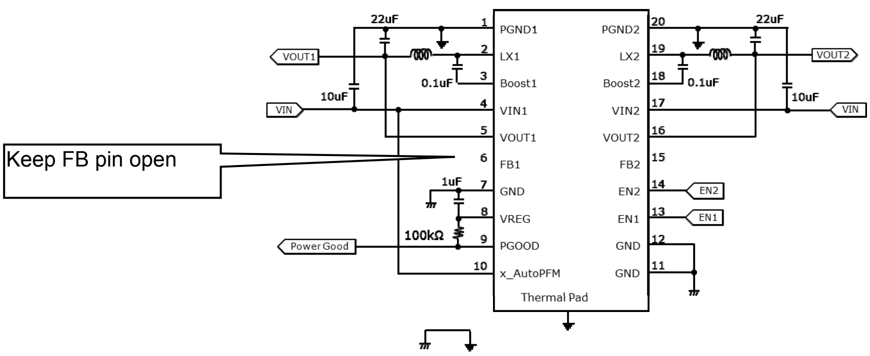


When using feedback capacitor with an output voltage fixed product, connect feedback capacitor between VOUT pin and FB pin.



Example of RAA230232

When not using feedback capacitor with an output voltage fixed product, keep FB pin open.



Example of RAA230232

Components example

VIN (V)	VOUT (V)	L (uH)	Cout (uF)	C_{FB} (pF)	
				Auto PFM mode	PWM mode
12	5V	3.3	22 to 44	0 to 100	No need
	3.3V	3.3	22 to 44	0 to 100	No need
	1.2V	3.3	22 to 44	0 to 100	No need
5	3.3	2.2	22	0 to 100	No need
	1.2	2.2	22	0 to 100	No need

Notes on Use

VIN Applied Voltage

Be sure to apply the same voltage toVIN1 pin and VIN2 pin.

Pattern Wiring

To actually perform pattern wiring, separate a ground of control signal from a ground of a power line, so that these grounds do not have a common impedance as much as possible.

Connection of Exposed PAD

HTSSOP package has an Exposed PAD on the bottom to improve radiation performance. On the mounting board, connect this Exposed PAD to PGND or GND.

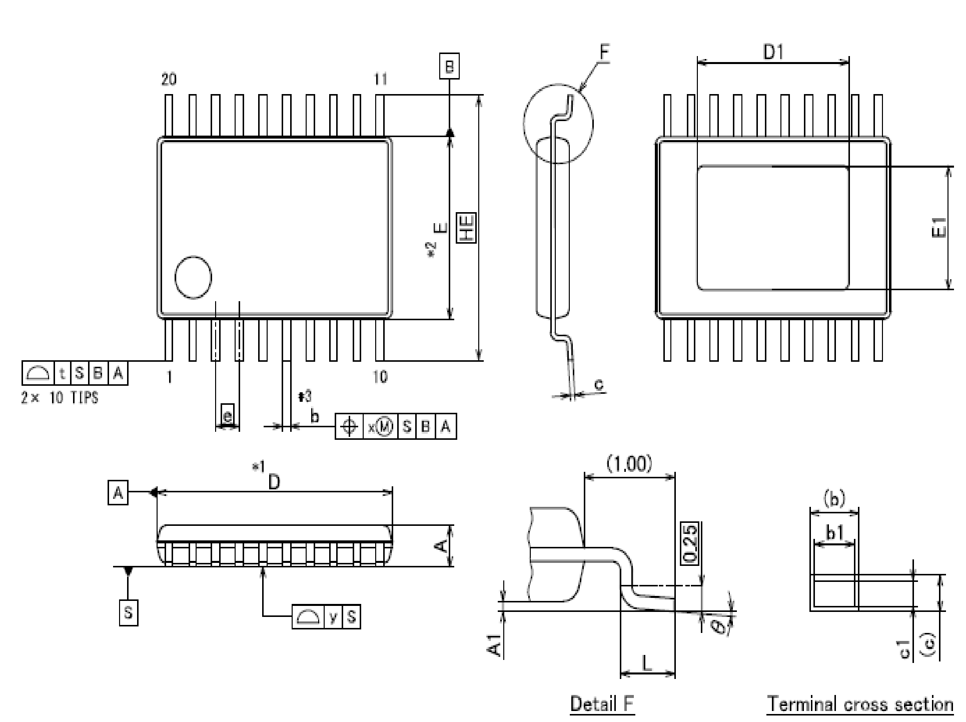
Fixed Usage of Control Input Pin

When EN pin and x_AutoPFM pin are fixed, connect to a pin listed below.

Input Pin	Connect Pin	
	Fixed to Low Level	Fixed to High Level
EN1	GND	VIN
EN2	GND	VIN
x_AutoPFM	GND	VIN

Package Dimensions

20pin HTSSOP
Renesas code : PTSP0020JF-A



NOTE)
1.DIMENSIONS "*1" AND "*2" DO NOT INCLUDE MOLD FLASH.
2.DIMENSION "*3" DOES NOT INCLUDE TRIM OFFSET.

Referrence Symbol	Dimension in Milimeters		
	Min	Nom	Max
D	—	6. 50	6. 60
E	—	4. 40	—
A1	0. 05	—	0. 15
A	—	—	1. 10
b	0. 19	—	0. 30
b1	0. 19	0. 22	0. 25
c	0. 09	—	0. 20
c1	0. 09	0. 127	0. 16
θ	0°	—	8°
HE	—	6. 40	—
e	—	0. 65	—
t	—	—	0. 20
x	—	—	0. 10
y	—	—	0. 076
L	0. 50	0. 60	0. 70
D1	—	4. 20	—
E1	—	3. 00	—

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