RAA230161

24V Input, USB Voltage Supply for Power Delivery

R19DS0091EJ0100
REV.1.00
Dec. 4. 2017

Description

RAA230161 (USB Voltage Supply) is the power supply IC for the power supply application with USB power delivery. This IC provide 5.3V to 20V power supply. Power MOSFETs are included and maximum output power is 60W (20V, 3A). Various protection circuits are included to design safe system easily. The output voltage can be selected by I2C and the IC status can be monitored. The design of the power supply system with USB power delivery become easy by this IC.

Features

- DC/DC

Synchronous rectification type step-down DC/DC
Input voltage range : 21.6V to 26.4V (Typ.24V)
Output voltage : 5.3V, 9.15V, 12.1V, 15.1V, 20V (Set by I2C)
Maximum output current : 3A
Output current setting : 0.5A, 1A, 1.5A, 2A, 2.5A, 3A
Switching frequency : 500kHz (fixed)
Integrated soft start
Integrated Power MOSFET
Integrated discharge circuit
Integrated phase compensator

- Protection circuit

Over voltage protection (Latch type)
Over current protection (Latch type)
Over temperature protection (Latch type)
165°C (typ.)
Short circuit protection (Latch type)
Under voltage lockout circuit
Watch dog timer (Monitoring by I2C)

- Package

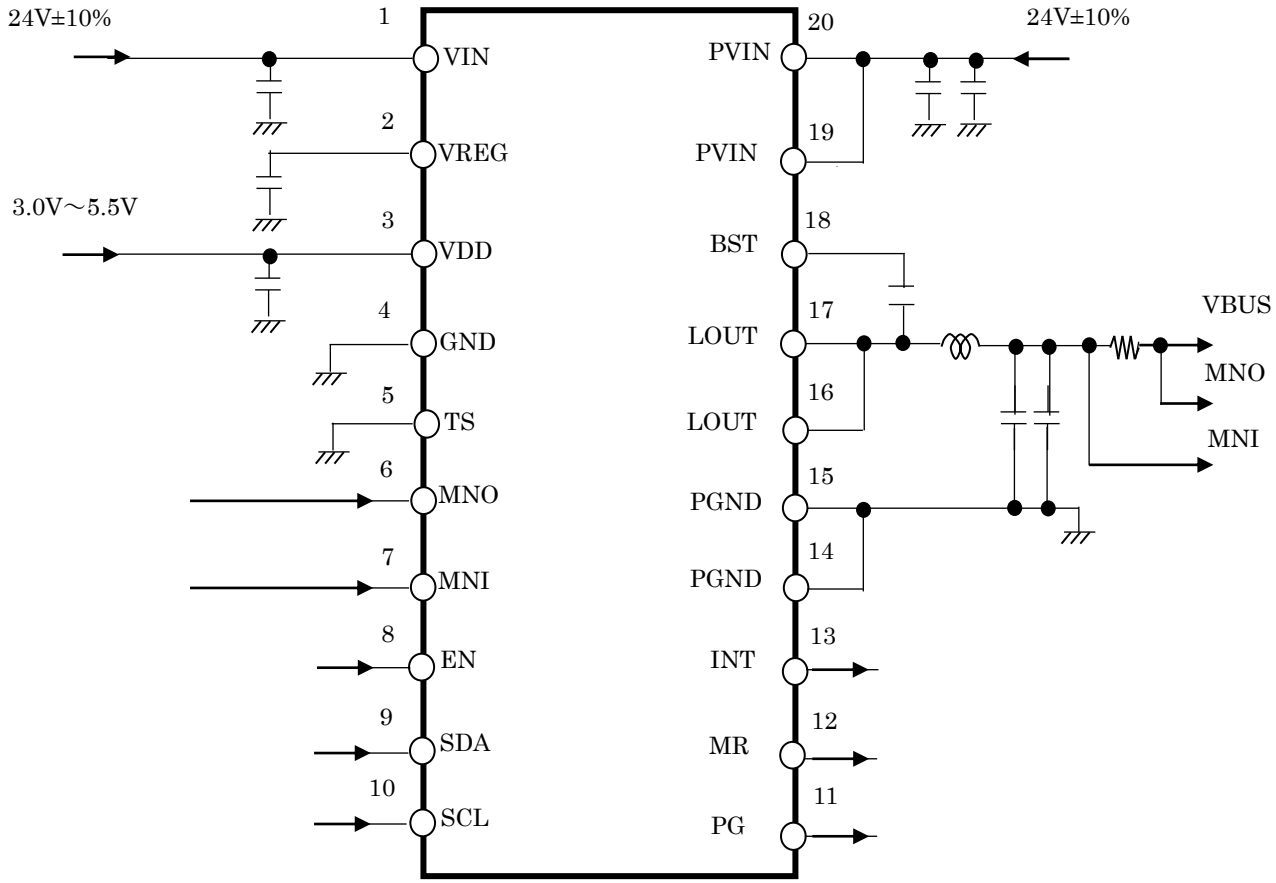
20-pin HTSSOP

Application

Power supply application with USB power delivery: AC adopter, USB Hub, Monitor, STB, etc.

Note: The information in this document is being issued in developing the product, and may change before final product.
Note: A quality grade of the device 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.

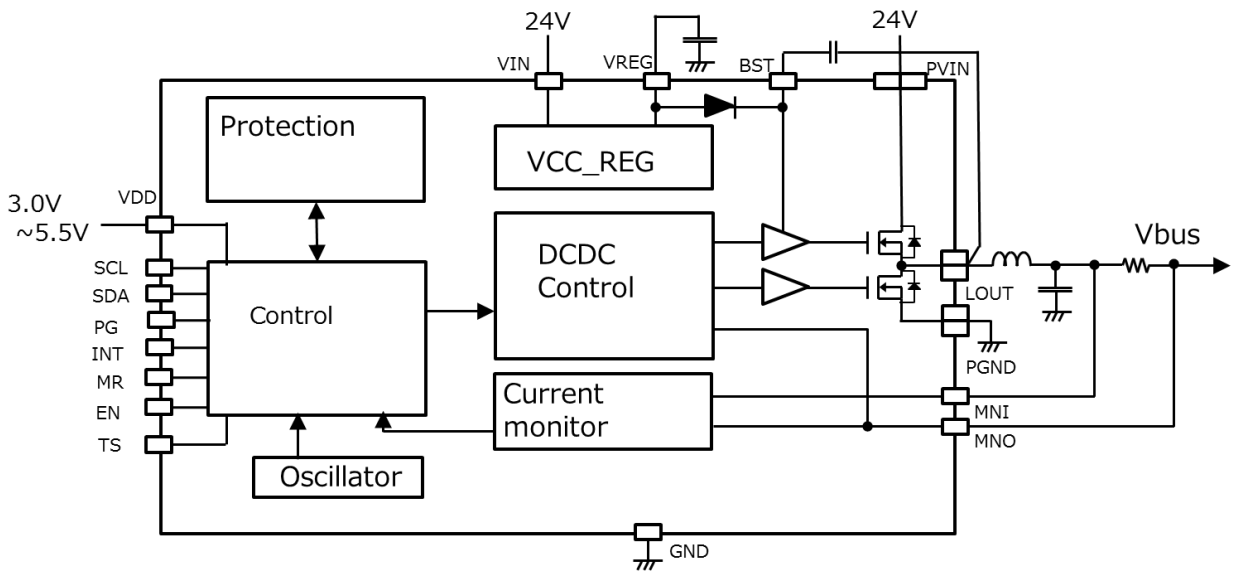
Pin configuration



Pin Description

Pin No.	Symbol	I/O	Function
1	VIN	I	Power supply
2	VREG	I	Internal power supply output (For 1uF capacitor connection)
3	VDD	I	Power supply for I2C
4	GND	I/O	Ground
5	TS	I/O	Test pin
6	MNO	I	Monitor pin for controlling DCDC converter output voltage.
7	MNI	I	Monitor pin for DCDC converter output current.
8	EN	I	Device enable Note : Integrated pull down resister
9	SDA	I/O	I2C Data input and output
10	SCL	I	I2C Clock input
11	PG	O	Power good output Note : Open drain
12	MR	O	Reset signal output for microcontroller (Low active) Note : Open drain
13	INT	O	Status output (Low active) Note : Open drain
14	PGND	I/O	Power ground for DCDC converter
15	PGND	I/O	Power ground for DCDC converter
16	LOUT	O	DCDC converter output
17	LOUT	O	DCDC converter output
18	BST	I/O	Bootstrap pin
19	PVIN	I	Power supply for DCDC converter
20	PVIN	I	Power supply for DCDC converter

Block Diagram



Absolute Maximum Ratings

(Unless otherwise specified, TA = 25°C)

Parameter	Symbol	Ratings	Unit	Condition
VIN applied voltage	VIN, PVIN	-0.3 to +27	V	
MNI,MNO,LOUT applied voltage	MNI,MNO,LOUT	-0.3 to +27	V	
VDD applied voltage	VDD	-0.3 to +6.5V	V	
VIN input current(peak)	IVIN(peak)-	4.2	A	
LOUT output current(peak)	ILOUT(peak)+	4.2	A	
MNO sink current (DC)	IMNO(DC)-	45	mA	When discharge circuit operation
GND voltage	GND	-0.3 to +0.3	V	
Total power dissipation	PT	3400*1	mW	
Operating ambient temperature	TA	-40 to +105	°C	
Operating junction temperature	TJ	-40 to +125	°C	TA≦＋25℃
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 -34.0 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)

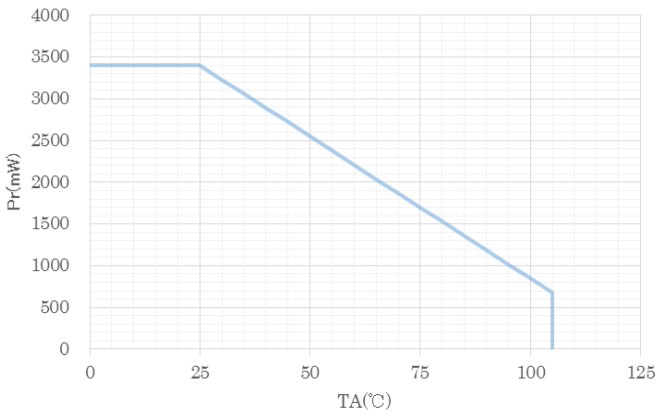
95%, 0.035mm thickness (layers 2 and 3)

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.

Derating curve（Reference）

20-pin HTSSOP



Recommended Operating Condition

(Unless otherwise specified, TA = 25°C)

Parameter	Symbol	MIN.	TYP.	MAX.	Unit	Condition
VIN applied voltage	VIN	21.6	24	26.4	V	
VDD applied voltage	VDD	3.0		5.5	V	
SDA,SDL,EN applied voltage	-	0		5.5	V	
MNI,MNO applied voltage	MNI, MNO	0		22.0	V	

Electrical Characteristics

(Unless otherwise specified, TA = 25°C, VIN = 24V, VDD = 3.3V)

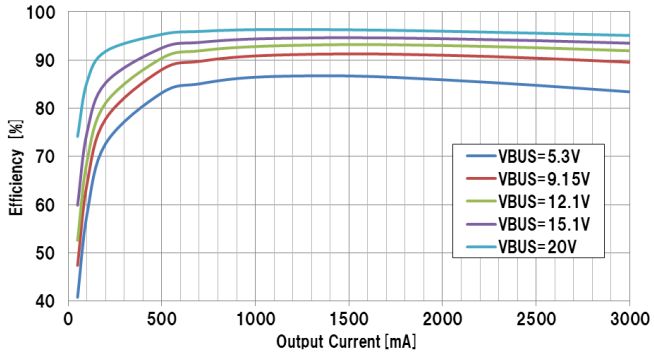
Parameter		Symbol	MIN.	TYP.	MAX.	Unit	Condition
Total	Shutdown current	IDD(SHDN)		90		uA	EN=GND
Under voltage lock out circuit (UVLO_VIN)	Operating start voltage	Vrls(vin)		6.2		V	Detect VIN rising
	Operating stop voltage	Vdet(vin)		5.7		V	Detect VIN falling
Internal power supply (VREG)	Internal power supply voltage	VREG	4.7	5.0	5.3	V	Ireg = 0mA
Output	Output voltage accuracy	Vacc	-5		+5	%	(USB_PD spec.)
	High side FET on-resistance	Ronh		30		mΩ	Io = 100mA
	Low side FET on-resistance	Ronl		70		mΩ	Io = 100mA
Soft start	Soft start slope*1			2.44		V/ms	
Over voltage protection (OVP)	Detecting range (Vout ratio)			110		%	
Over current protection (OCP)	Detecting range (Iocp ratio)			120		%	
Over temperature protection (OTP)	Detecting temperature*2			165		°C	
Logic input	High level threshold voltage	VIH	VDD*0.7		VDD+0.3	V	EN
	Low level threshold voltage	VIL	-0.3		VDD*0.3	V	EN
	Input current	IEN		1		uA	EN = 3.3V
	Pull down resistor	REN		5		MΩ	EN
PG, INT, MR circuit	Output voltage	Vod			0.1	V	At 0.1mA
	Leak current	Iod			1	uA	VDD=3.3V

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

Typical Performance Characteristics

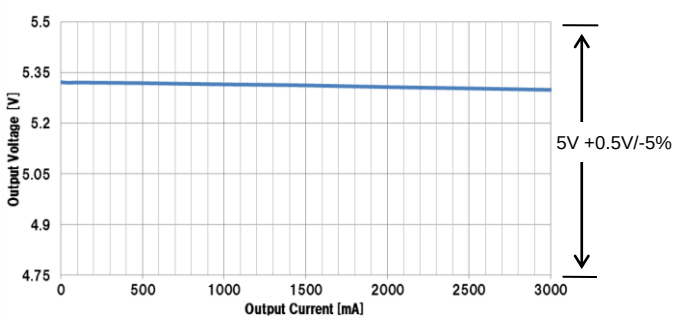
(Unless otherwise specified, TA = 25°C, VIN = PVIN = 24V)

Efficiency vs. Output Current

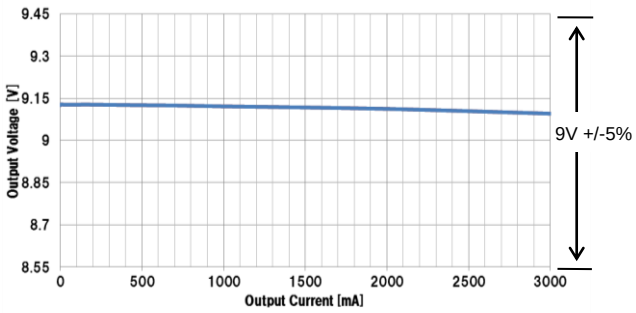


Load Regulation

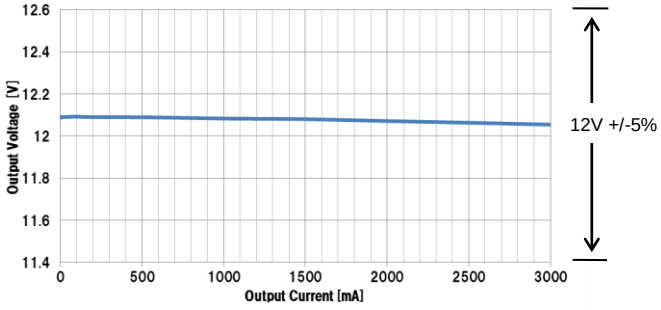
VOUT=5.3V



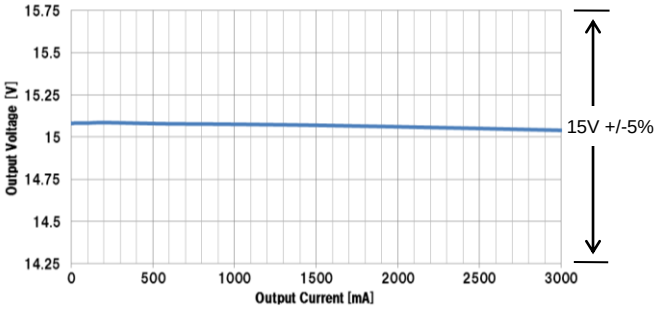
VOUT=9.15V



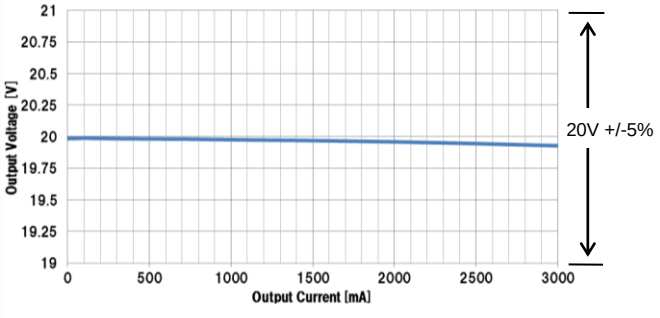
VOUT=12.1V



VOUT=15.1V



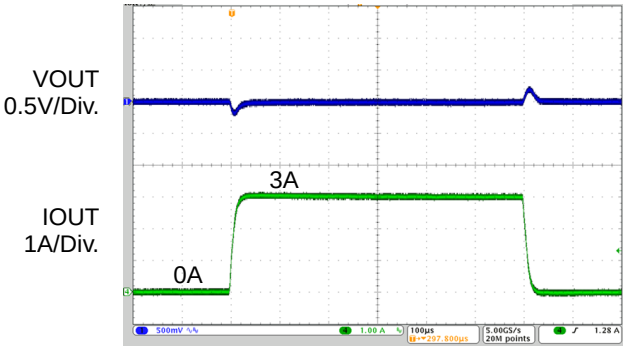
VOUT=20V



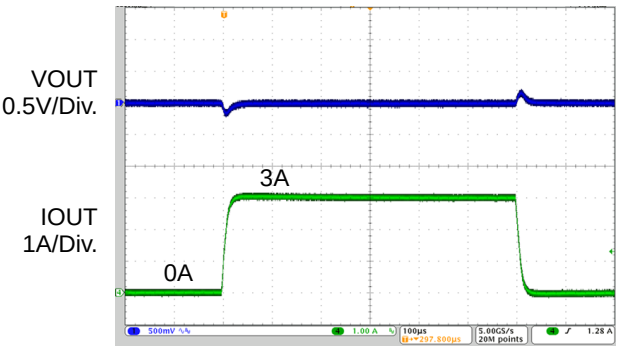
Load Step Transient Waveforms

L = 6.8uH, CIN = 20uF, COUT = 44uF

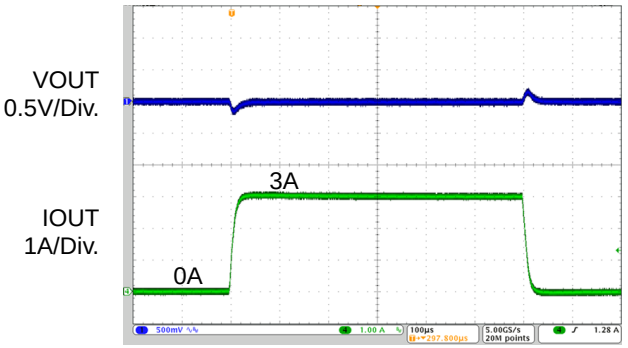
VOUT=5.3V



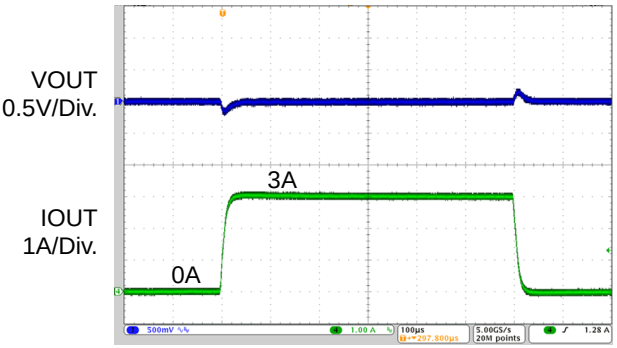
VOUT=9.15V



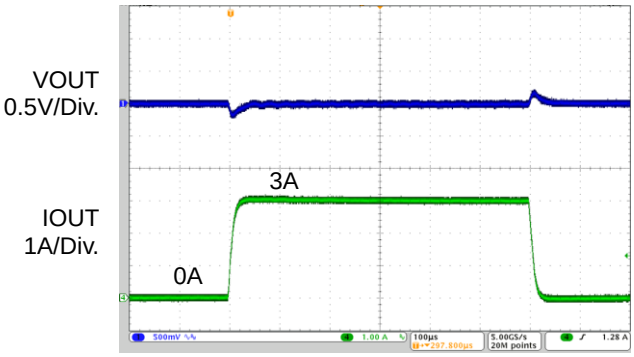
VOUT=12.1V



VOUT=15.1V

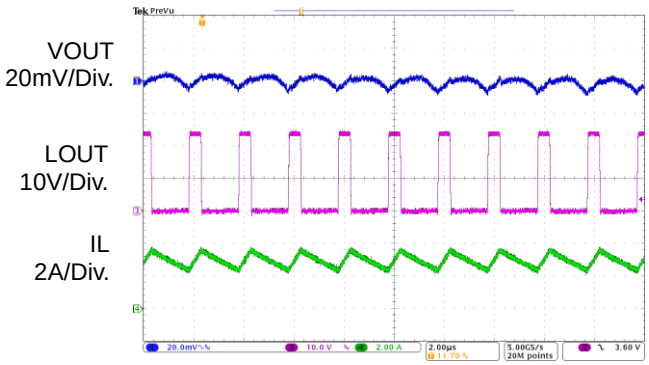


VOUT=20V



Operation Waveforms

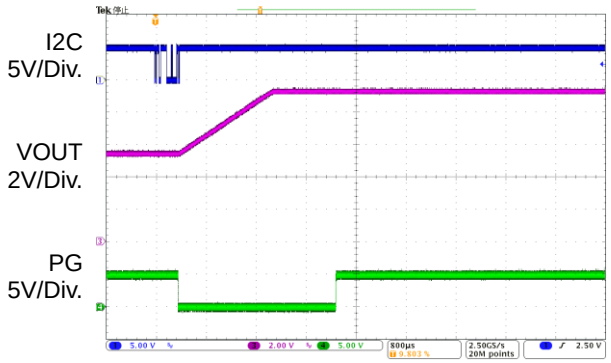
VOUT = 5.3V, IOUT = 3A



2us/Div.

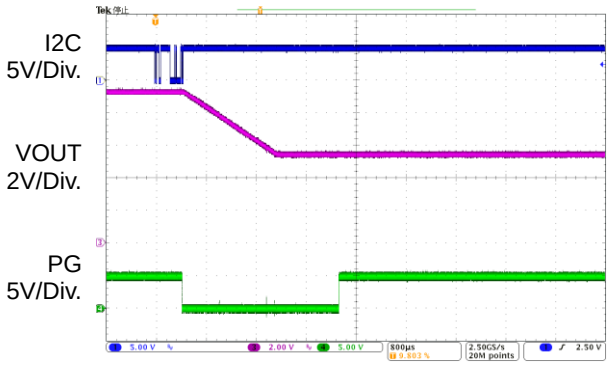
Output Voltage Changing Waveforms

VOUT : 5.3V to 9.15V



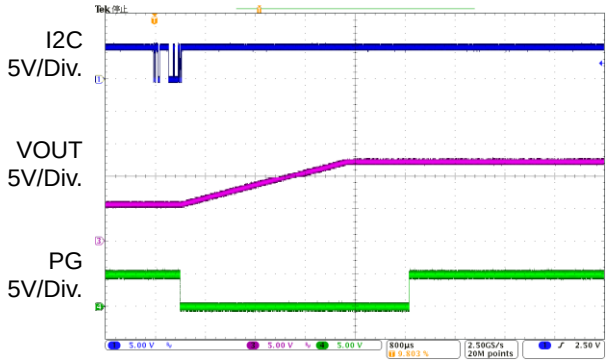
800us/Div.

VOUT : 9.15V to 5.3V



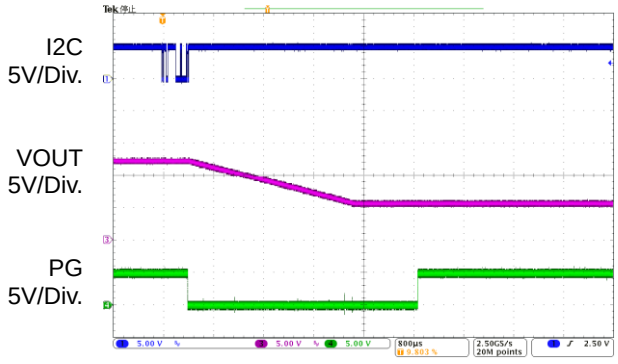
800us/Div.

VOUT : 5.3V to 12.1V



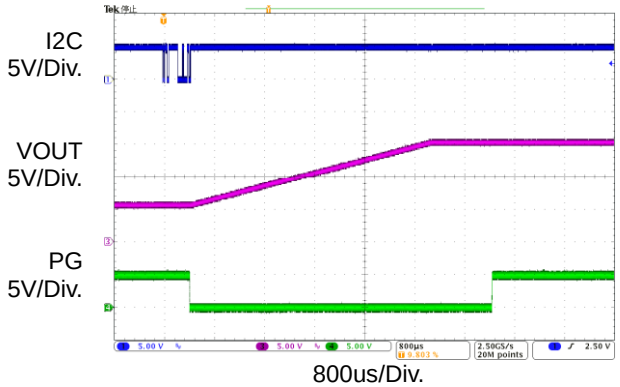
800us/Div.

VOUT : 12.1V to 5.3V



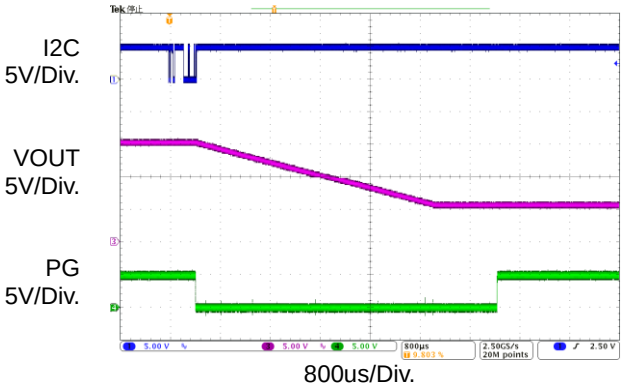
800us/Div.

VOUT : 5.3V to 15.1V



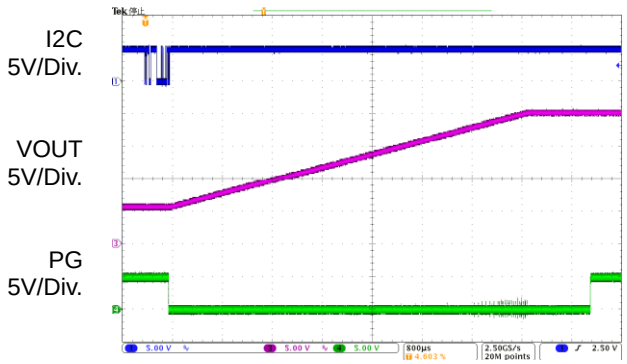
800us/Div.

VOUT : 15.1V to 5.3V



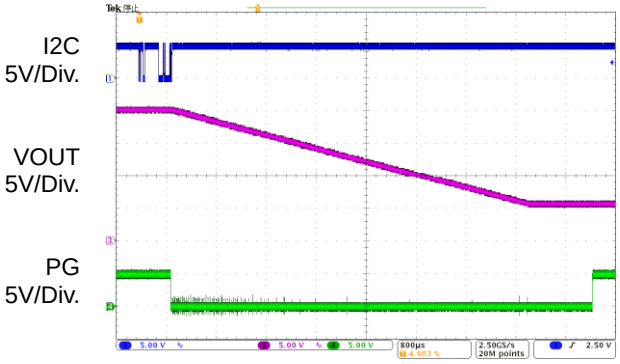
800us/Div.

VOUT : 5.3V to 20V



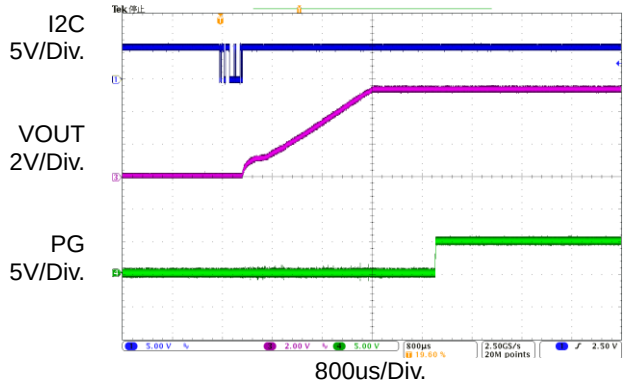
800us/Div.

VOUT : 20V to 5.3V



800us/Div.

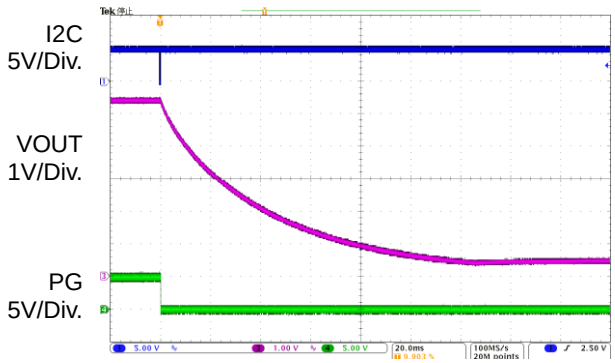
Start-up Waveforms



800us/Div.

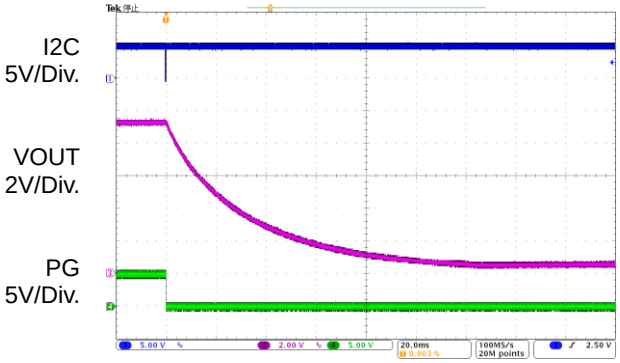
Shutdown Waveforms

VOUT = 5.3V



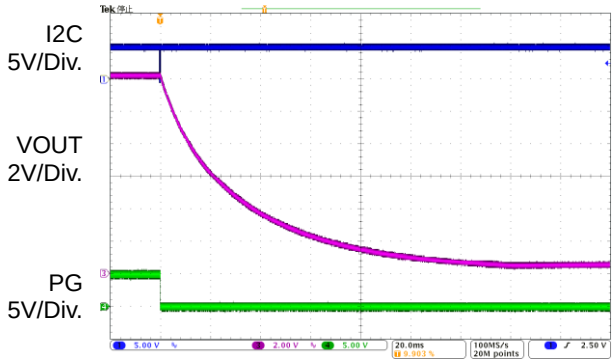
20ms/Div.

VOUT = 9.15V



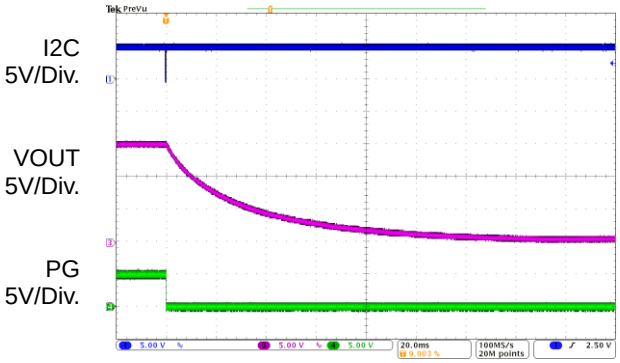
20ms/Div.

VOUT = 12.1V



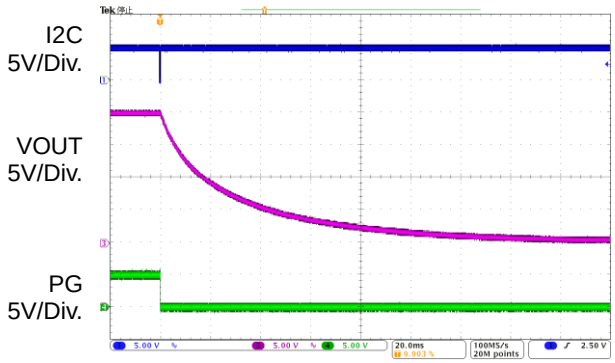
20ms/Div.

VOUT = 15.1V



20ms/Div.

VOUT = 20V



20ms/Div.

Operation mode

Mode	EN pin	I2C	DC/DC
OFF	Low	Not acceptable	Stop
STBY	High	Acceptable	Stop
ON	High	Acceptable	Operation

- OFF Mode

The IC stops the operation when EN pin is Low.

- STBY Mode

The IC starts the operation and become this mode when EN pin become High. The IC can receive I2C signal in this mode. DC/DC doesn't output the voltage yet.

- ON Mode (DC/DC_ON)

The IC status is normal operation.
The DC/DC starts to output the voltage when receiving ON signal through I2C at STBY mode, so VBUS starts to output the voltage.
The DC/DC output voltage (VBUS) is changed to OFF when receiving OFF signal through I2C, then the IC becomes Standby mode.

Explain of Operation

- Output voltage

5.3V, 9.15V, 12.1V, 15.1V, 20V are set by I2C.
The voltages are higher because of the line impedance (about 100mΩ) like a load switch on VBUS.

- Output current setting

0.5A, 1A, 1.5A, 2A, 2.5A, 3A are set by I2C.

- Soft start

This function decreases sudden change of the output voltage at rising and changing output voltage.

- Discharge circuit

When operation mode is changed from ON mode to STBY mode, the discharge switch becomes on and the capacitor connected to the output are discharged. After discharging, LOUT pin become HiZ.

Protection Circuit View

Protection circuit	Function	Operation status on protection			Reset
		Common circuit	DC/DC Output	Signal output pin status	
Over voltage protection （OVP）	Detect over voltage at output	Operation	Stop (Latch)	INT=L	By I2C
Over current protection （OCP）	Detect over current at output Operate when the output current is over “output current setting”	Operation	Stop (Latch)	INT=L	By I2C
Over temperature protection (OTP)	Detect over temperature of IC chip	Operation	Stop (Latch)	INT=L	By I2C
Short circuit protection (SCP)	Detect output voltage drop due to short circuit, etc.	Operation	Stop (Latch)	INT=L	By I2C
Watch Dog Timer （WDT）	Detect abnormal operation of the system. Provide single “L” pulse from MR pin at detecting to reset MCU, etc.	Operation	Stop (Latch)	Provide single “L” pulse from MR pin	By I2C
Under voltage lockout circuit (UVLO_VIN)	Detect drop of VIN	Stop	Stop	-	Recover automatically as Standby mode when EN=”H”

Note OVP : Over Voltage Protection
OCP : Over Current Protection
OTP : Over Temperature Protection
SCP : Short Circuit Protection
UVLO : Under Voltage Lockout Circuit
WDT : Watch Dog Timer

Notes on Use

- Pattern Writing

  Separate the ground of control signals from the ground of power line so that these grounds do not have a common impedance as much as possible.

  Place the VREG capacitor near the VREG pin to reduce the noise into the pin.

  Keep the pattern lines for large current (PVIN, LOUT and PGND) broad and short as much as possible to lower the characteristic impedance and shorten the current loop. Providing sufficient vias is preferable when using vias.

  Do not allow feedback current (switching current) to flow under the IC.

  Place the PVIN capacitor near the PVIN pin to reduce the noise into the pin.

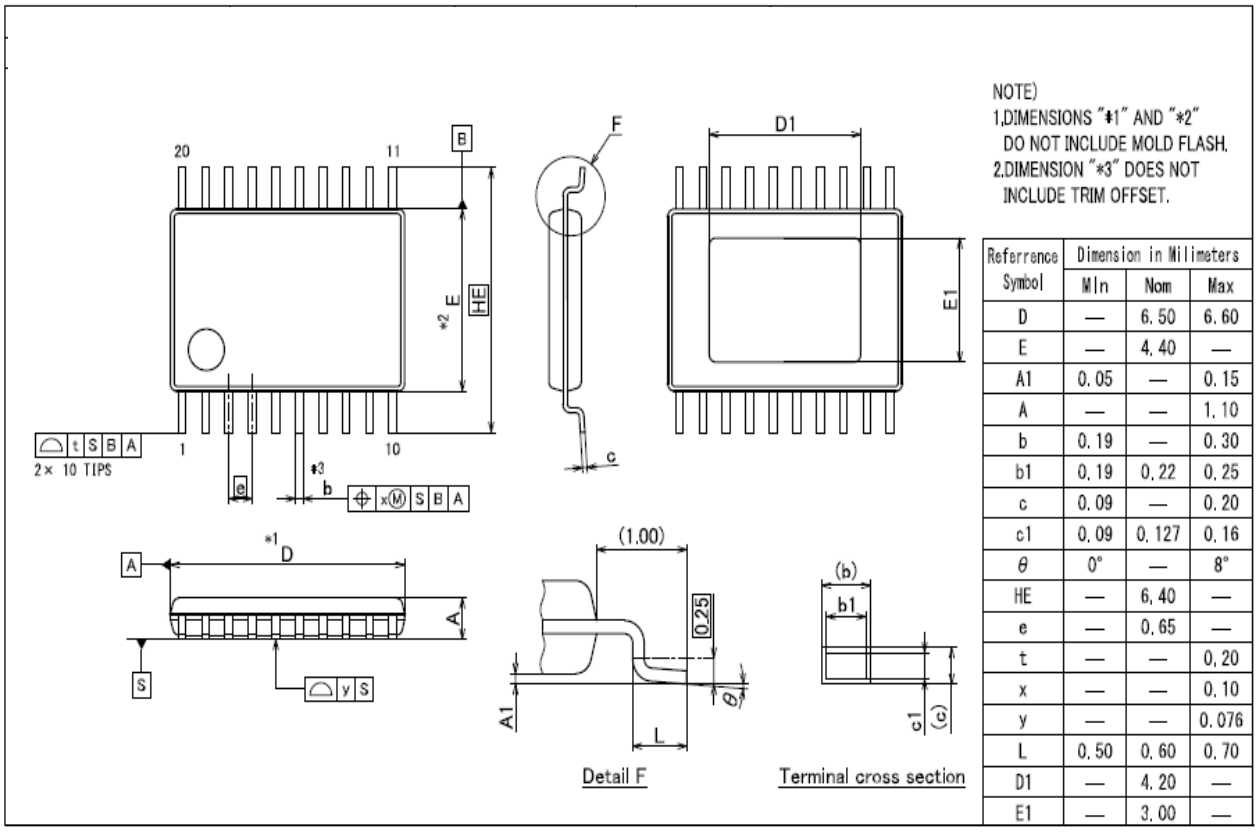
- Connection of Exposed PAD

  HTSSOP package has an Exposed PAD on the bottom to improve radiation performance. At mounting it on the board, connect this Exposed PAD to GND. In addition, providing sufficient vias is preferable at Exposed PAD.

Package Dimensions

20pin HTSSOP

Renesas code : PTSP0020JF-A



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	—

Revision History	RAA230161 Data Sheet

Rev.	Date	Description	
		Page	Summary
1.00	Dec. 4. 2017	-	First Edition issued.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other disputes involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawing, chart, program, algorithm, application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copy or otherwise misappropriation of Renesas Electronics products.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

   "Standard": 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.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Renesas Electronics products are neither intended nor authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems, surgical implantations etc.), or may cause serious property damages (space and undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for which the product is not intended by Renesas Electronics.
6. When using the Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat radiation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions or failure or accident arising out of the use of Renesas Electronics products beyond such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please ensure to implement safety measures to guard them against the possibility of bodily injury, injury or damage caused by fire, and social damage in the event of failure or malfunction of Renesas Electronics products, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures by your own responsibility as warranty for your products/system. Because the evaluation of microcomputer software alone is very difficult and not practical, please evaluate the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please investigate applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive carefully and sufficiently and use Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall not use Renesas Electronics products or technologies for (1) any purpose relating to the development, design, manufacture, use, stockpiling, etc., of weapons of mass destruction, such as nuclear weapons, chemical weapons, or biological weapons, or missiles (including unmanned aerial vehicles (UAVs)) for delivering such weapons, (2) any purpose relating to the development, design, manufacture, or use of conventional weapons, or (3) any other purpose of disturbing international peace and security, and you shall not sell, export, lease, transfer, or release Renesas Electronics products or technologies to any third party whether directly or indirectly with knowledge or reason to know that the third party or any other party will engage in the activities described above. When exporting, selling, transferring, etc., Renesas Electronics products or technologies, you shall comply with any applicable export control laws and regulations promulgated and administered by the governments of the countries asserting jurisdiction over the parties or transactions.
10. Please acknowledge and agree that you shall bear all the losses and damages which are incurred from the misuse or violation of the terms and conditions described in this document, including this notice, and hold Renesas Electronics harmless, if such misuse or violation results from your resale or making Renesas Electronics products available any third party.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.3.0-1 November 2016)

RENESAS

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL II Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

Colophon 6.0