For Automotive 45 V Input 500 mA Fixed Output LDO Regulators

BD4xxS5-C Series

General Description

The BD4xxS5-C series are low quiescent regulators featuring 45 V absolute maximum voltage, and output voltage accuracy of ±2 % (3.3 V or 5 V: Typ), 500 mA output current and 38 µA (Typ) current consumption. These regulators are therefore ideal for applications requiring a direct connection to the battery and a low current consumption.
A logical “HIGH” at the CTL enables the device and “LOW” at the CTL disables the device.
(Only W: Includes Enable Input).
Ceramic capacitors can be used for compensation of the output capacitor phase. Furthermore, these ICs also feature overcurrent protection to protect the device from damage caused by short-circuiting and an integrated thermal shutdown to protect the device from overheating at overload conditions.

Features

- Qualified for Automotive Applications
- Wide Temperature Range (Tj): -40 °C to +150 °C
- Wide Operating Input Range: 3.0 V to 42 V
- Low Quiescent Current: 38 µA (Typ)
- Output Current: 500 mA
- High Output Voltage Accuracy: ±2 %
- Output Voltage: 3.3 V or 5.0 V (Typ)
- Enable Input (Only W: Includes Enable Input)
- Overload Current Protection (OCP)
- Thermal Shutdown Protection (TSD)
- AEC-Q100 Qualified(Note 1)

(Note 1): Grade 1

Application

- Body
- Audio System
- Navigation System, etc.

Package

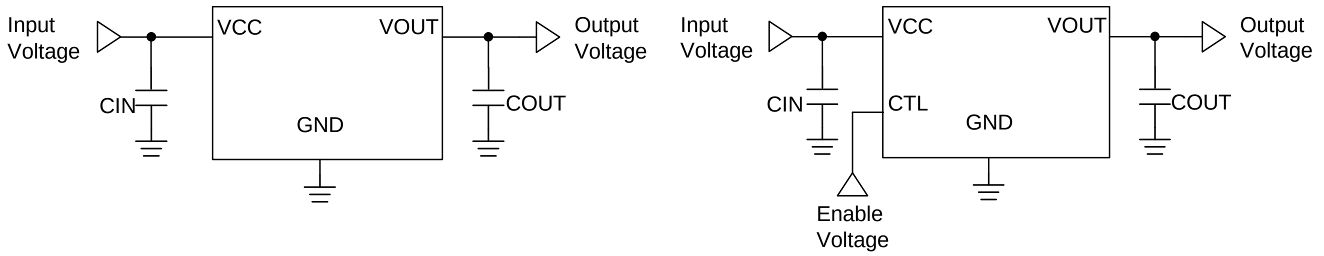
W (Typ) x D (Typ) x H (Max)

- EFJ: HTSOP-J8 4.9 mm × 6.0 mm × 1.0 mm

Figure 1. Package Outlook

Typical Application Circuits

■Components Externally Connected: 0.1 µF ≤ CIN, 10 µF ≤ COUT (Typ)
* Electrolytic, tantalum and ceramic capacitors can be used.



For product without Enable input

For product with Enable input

Figure 2. Typical Application Circuits

○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays.

Ordering Information

B D 4 x x S 5 W E F J - C E 2

Part Number	Output Voltage	Output Current	Enable Input	Package	Product Rank
Part Number	33: 3.3 V 50: 5.0 V	5: 500 mA	W: Includes Enable Input None: Without Enable Input	EFJ: HTSOP-J8	C: for Automotive Packaging and Forming Specification E2: Embossed Tape and Reel

Lineup

Output Current Ability	Output Voltage (Typ)	Enable Input *(Note 1)*	Orderable Part Number
500 mA	3.3 V	○	BD433S5WEFJ-CE2
		–	BD433S5EFJ-CE2
	5.0 V	○	BD450S5WEFJ-CE2
		–	BD450S5EFJ-CE2

(Note 1) ○: Includes Enable Input
–: Not includes Enable Input

Pin Configuration

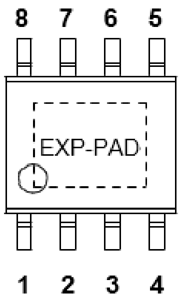


Figure 3. Pin Configuration

Pin Descriptions

■BD433S5EFJ-C / BD450S5EFJ-C

Pin No.	Pin Name	Pin Function
1	VOUT	Output pin
2	N.C.	Not connected
3	N.C.	Not connected
4	N.C.	Not connected
5	GND	Ground pin
6	N.C.	Not connected
7	N.C.	Not connected
8	VCC	Supply voltage input pin
-	EXP-PAD	Heat dissipation

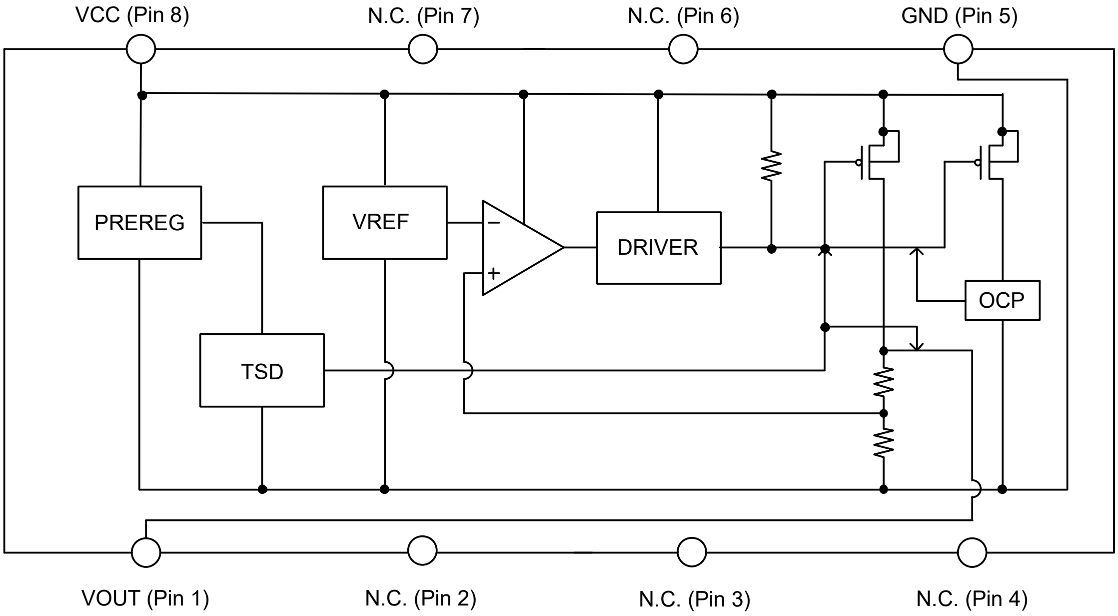
■BD433S5WEFJ-C / BD450S5WEFJ-C

Pin No.	Pin Name	Pin Function
1	VOUT	Output pin
2	N.C.	Not connected
3	N.C.	Not connected
4	N.C.	Not connected
5	GND	Ground pin
6	N.C.	Not connected
7	CTL	Output control pin
8	VCC	Supply voltage input pin
-	EXP-PAD	Heat dissipation

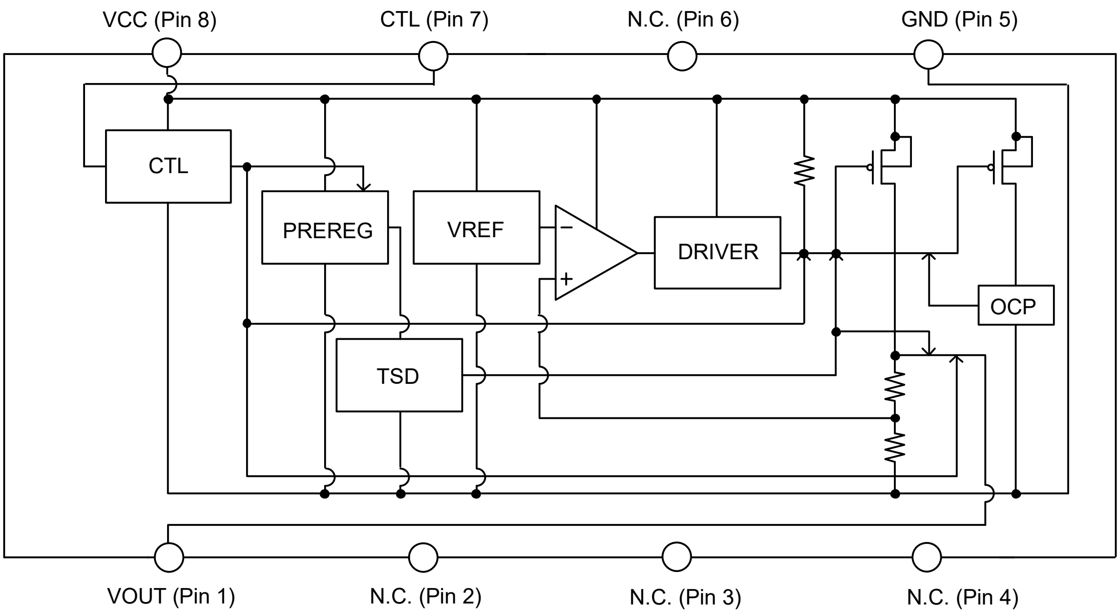
* N.C. Pin is recommended to short with GND.
* N.C. Pin can be open because it isn’t connected it inside of IC.
* EXP-PAD on the back side is connected to the IC substrate, so it should connect to external ground node.

Block Diagrams

■ BD4xxS5EFJ-C



■ BD4xxS5WEFJ-C



Description of Blocks

Block Name	Function	Description of Blocks
CTL(Note 1)	Control Output Voltage ON/OFF	A logical "HIGH" (≥ 2.8 V) at the CTL enables the device and "LOW" (≤ 0.8 V) at the CTL disable the device.
PREREG	Internal Power Supply	Power Supply for Internal Circuit
TSD	Thermal Shutdown Protection	To protect the device from overheating. If the chip temperature (Tj) reaches ca. 175 °C (Typ), the output is turned off.
VREF	Reference Voltage	Generate the Reference Voltage
DRIVER	Output MOS FET Driver	Drive the Output MOS FET
OCP	Over Current Protection	To protect the device from damage caused by over current. If the output current reaches ca. 900 mA (Typ), the output is turned off.

(Note 1) Applicable for product with Enable Input.

Absolute Maximum Ratings

Parameter	Symbol	Ratings	Unit
Supply Voltage(Note 1)	VCC	-0.3 to +45.0	V
Output Control Voltage(Note 2)	CTL	-0.3 to +45.0	V
Output Voltage	VOUT	-0.3 to +8.0	V
Junction Temperature Range	Tj	-40 to +150	°C
Storage Temperature Range	Tstg	-55 to +150	°C
Maximum Junction Temperature	Tjmax	+150	°C
ESD withstand Voltage (HBM)(Note 3)	$V_{ESD, HBM}$	±2000	V

Caution 1: *Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.*

Caution 2: *Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance and power dissipation taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

(Note 1) Do not exceed Pd.

(Note 2) Applicable for product with Enable Input.
The start-up orders of power supply (VCC) and the CTL pin do not influence if the voltage is within the operation power supply voltage range.

(Note 3) ESD susceptibility Human Body Model “HBM”.

Operating Conditions (-40 °C ≤ Tj ≤ +150 °C)

Parameter	Symbol	Min	Max	Unit
Supply Voltage (IOUT ≤ 500 mA) (Note 1)	VCC	5.9	42.0	V
Supply Voltage (IOUT ≤ 250 mA) (Note 1)	VCC	5.5	42.0	V
Supply Voltage (IOUT ≤ 500 mA) (Note 2)	VCC	4.6	42.0	V
Supply Voltage (IOUT ≤ 250 mA) (Note 2)	VCC	4.0	42.0	V
Output Control Voltage(Note 3)	CTL	0	42.0	V
Start-Up Voltage(Note 4)	VCC	3.0	–	V
Output Current	IOUT	0	500	mA
Junction Temperature Range	Tj	-40	+150	°C

(Note 1) For 5.0 V Output products (BD450S5EFJ-C, BD450S5WEFJ-C)

(Note 2) For 3.3 V Output products (BD433S5EFJ-C, BD433S5WEFJ-C)

(Note 3) Applicable for product with Enable Input.

(Note 4) When IOUT = 0 mA

Notice: Please consider that the output voltage would be dropped (Dropout voltage) according to the output current.

Thermal Impedance (Note 1)

Parameter	Symbol	Typ	Unit	Conditions
HTSOP-J8				
Junction to Ambient	θ_{JA}	126	°C/W	1s (Note 2)
		27	°C/W	2s2p (Note 3)
Junction to Top Center of Case(Note 4)	Ψ_{JT}	9	°C/W	1s (Note 2)
		2	°C/W	2s2p (Note 3)

(Note 1) The thermal impedance is based on JESD51 - 2A (Still-Air) standard.

(Note 2) JESD51 - 3 standard FR4 114.3 mm × 76.2 mm × 1.57 mm 1-layer (1s)
(Top copper foil: ROHM recommended footprint + wiring to measure, 2 oz. copper.)

(Note 3) JESD51 -5 / -7 standard FR4 114.3 mm × 76.2 mm × 1.60 mm 4-layer（2s2p）
(Top copper foil: ROHM recommended footprint + wiring to measure / 2 inner layers copper foil area of PCB: 74.2 mm × 74.2 mm, copper (top & reverse side / inner layers) 2oz. / 1oz.)

(Note 4) T_T : Top center of case's (mold) temperature

Electrical Characteristics

Unless otherwise specified, -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, CTL = 5 V (Note 1), IOUT = 0 mA
The typical value is defined at Tj = 25 °C.

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
Shutdown Current	Ishut (Note 1)	–	2.0	5.0	μA	CTL = 0 V Tj ≤ 125 °C
Circuit Current	Icc	–	38	95	μA	IOUT = 0 mA Tj ≤ 125 °C
		–	38	175	μA	IOUT ≤ 500 mA Tj ≤ 150 °C
Output Voltage	VOUT (Note 2)	4.90	5.00	5.10	V	6 V ≤ VCC ≤ 42 V, 0 mA ≤ IOUT ≤ 400 mA
		4.80	5.00	5.10	V	6 V ≤ VCC ≤ 42V 0 mA ≤ IOUT ≤ 500 mA
	VOUT (Note 3)	3.23	3.30	3.37	V	6 V ≤ VCC ≤ 42 V 0 mA ≤ IOUT ≤ 400 mA
		3.20	3.30	3.37	V	6 V ≤ VCC ≤ 42 V 0 mA ≤ IOUT ≤ 500 mA
Dropout Voltage	ΔVd (Note 2)	–	0.20	0.50	V	VCC = VOUT × 0.95 (Typ 4.75 V) IOUT = 300 mA
	ΔVd (Note 3)	–	0.25	0.75	V	VCC = VOUT × 0.95 (Typ 3.135 V) IOUT = 300 mA
Ripple Rejection	R.R.	55	60	–	dB	f = 120 Hz, ein = 1 Vrms IOUT = 100 mA
Line Regulation	Reg.I	–	10	30	mV	8 V ≤ VCC ≤ 16 V
Load Regulation	Reg.L	–	10	30	mV	10 mA ≤ IOUT ≤ 400 mA
Thermal Shutdown	TSD	–	175	–	°C	Tj at TSD ON

(Note 1) Applicable for product with Enable Input.

(Note 2) For 5.0 V Output products (BD450S5EFJ-C, BD450S5WEFJ-C)

(Note 3) For 3.3 V Output products (BD433S5EFJ-C, BD433S5WEFJ-C)

Electrical Characteristics (Enable function * Applicable for product with Enable Input.)

Unless otherwise specified, -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, IOUT = 0 mA. The typical value is defined at Tj = 25 °C.

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
CTL ON Mode Voltage	VthH	2.8	–	–	V	Active Mode
CTL OFF Mode Voltage	VthL	–	–	0.8	V	Off Mode
CTL Bias Current	ICTL	–	15	30	μA	CTL = 5 V

Typical Performance Curves (Reference Data)

■For 3.3 V Output products
■Applicable Models:BD433S5EFJ-C, BD433S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, CTL = 5 V*(Note 1)*, IOUT = 0 mA.
(Note 1) Applicable for product with Enable Input.

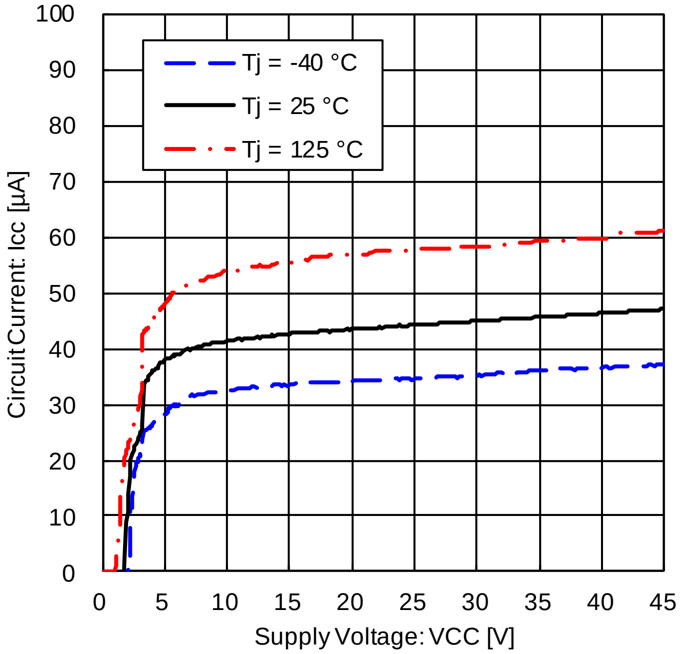


Figure 4. Circuit Current vs Power Supply Voltage

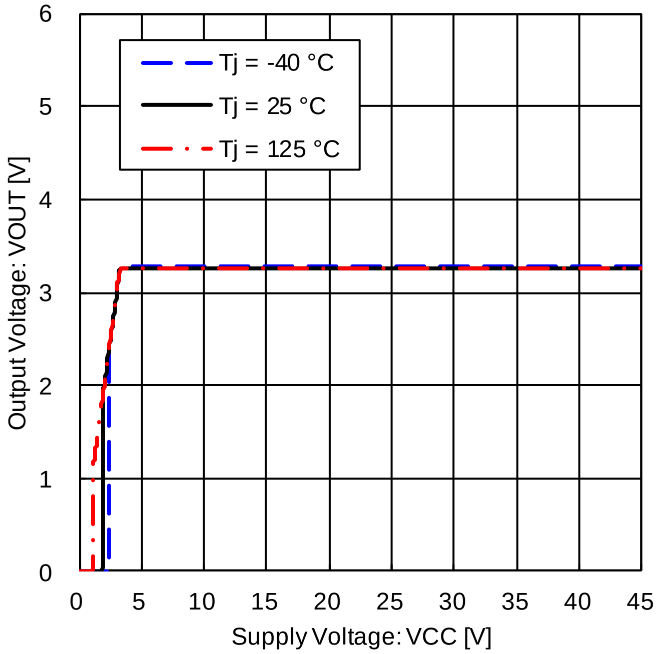


Figure 5. Output Voltage vs Power Supply Voltage
(IOUT = 0 mA)

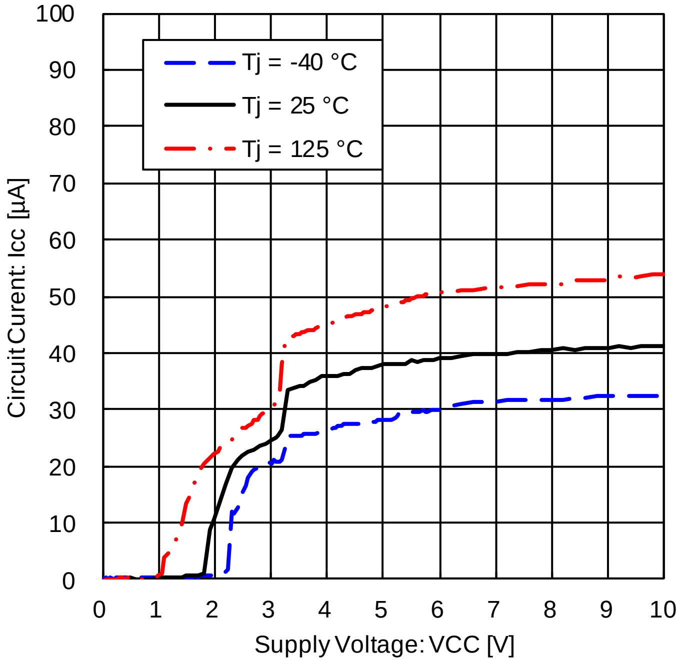


Figure 6. Circuit Current vs Power Supply Voltage
- Magnified Figure 4.

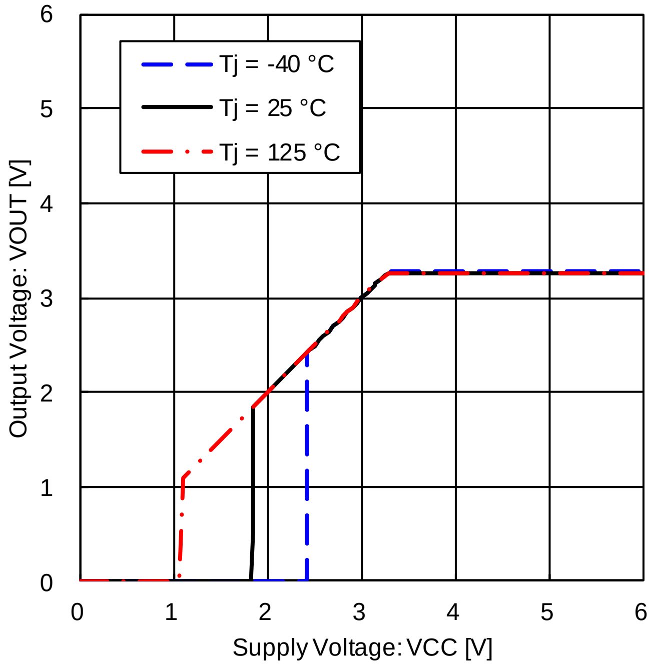


Figure 7. Output voltage vs Power Supply Voltage
(IOUT = 0 mA) - Magnified Figure 5.

Typical Performance Curves (Reference Data) – continued

▪For 3.3 V Output products
▪Applicable Models:BD433S5EFJ-C, BD433S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, CTL = 5 V*(Note 1)*, IOUT = 0 mA.
(Note 1) Applicable for product with Enable Input.

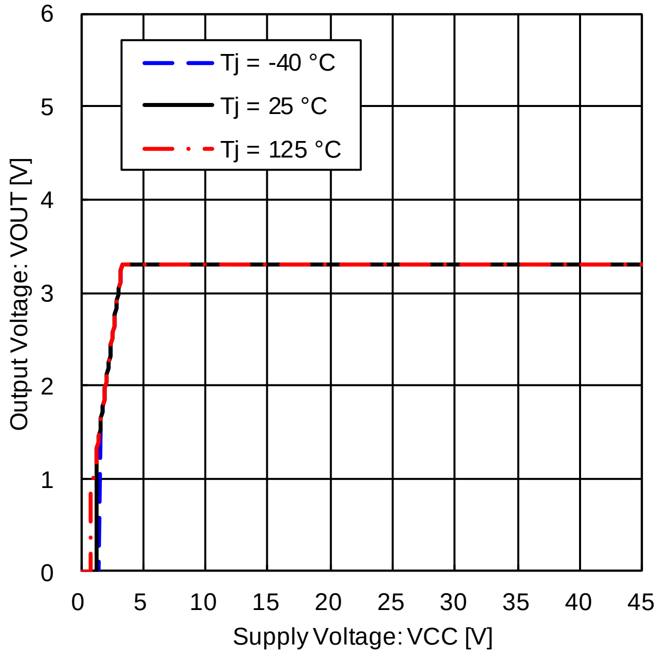


Figure 8. Output Voltage vs Power Supply Voltage
(IOUT = 10 mA)

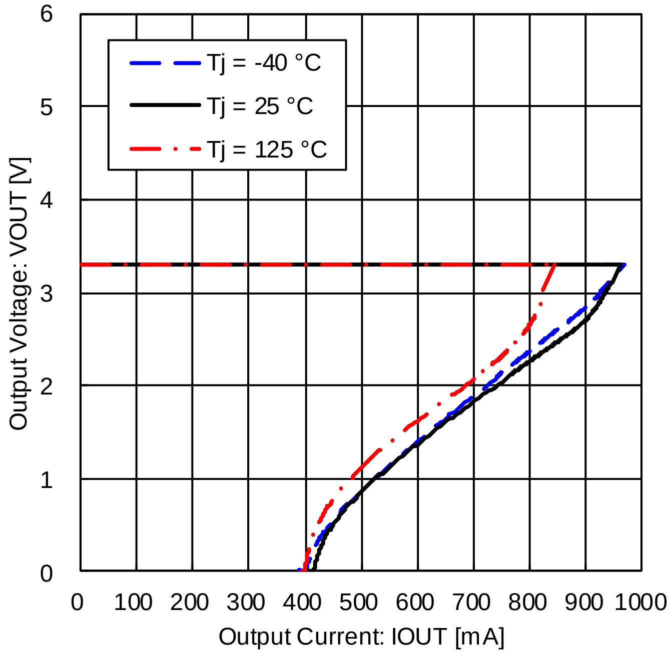


Figure 9. Output Voltage vs Output Current
(Over Current Protection)

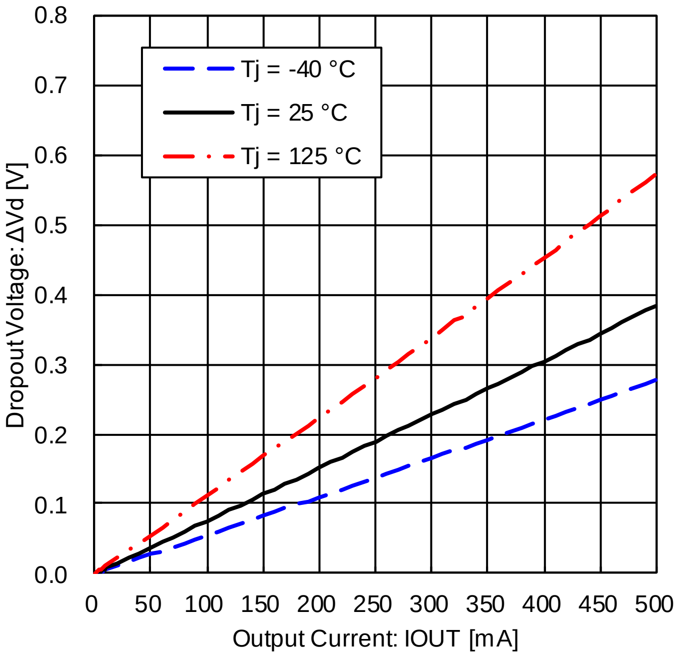


Figure 10. Dropout Voltage
(VCC = 3.135 V)

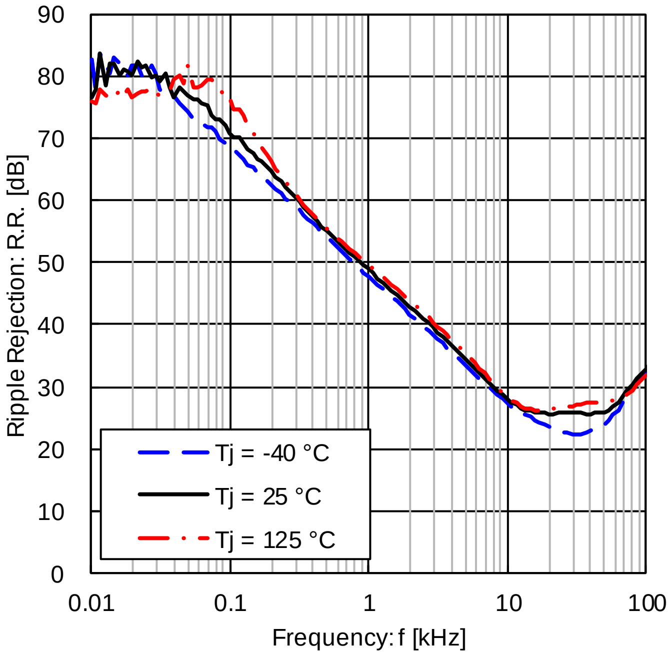


Figure 11. Ripple Rejection
(ein = 1 Vrms, IOUT = 100 mA)

Typical Performance Curves (Reference Data) – continued

■For 3.3 V Output products

■Applicable Models:BD433S5EFJ-C, BD433S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, CTL = 5 V*(Note 1)*, IOUT = 0 mA.

(Note 1) Applicable for product with Enable Input.

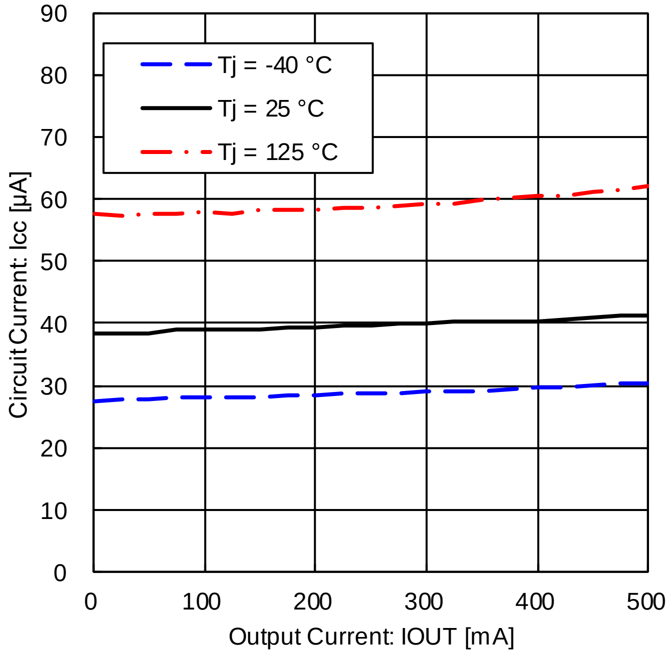


Figure 12. Circuit Current vs Output Current

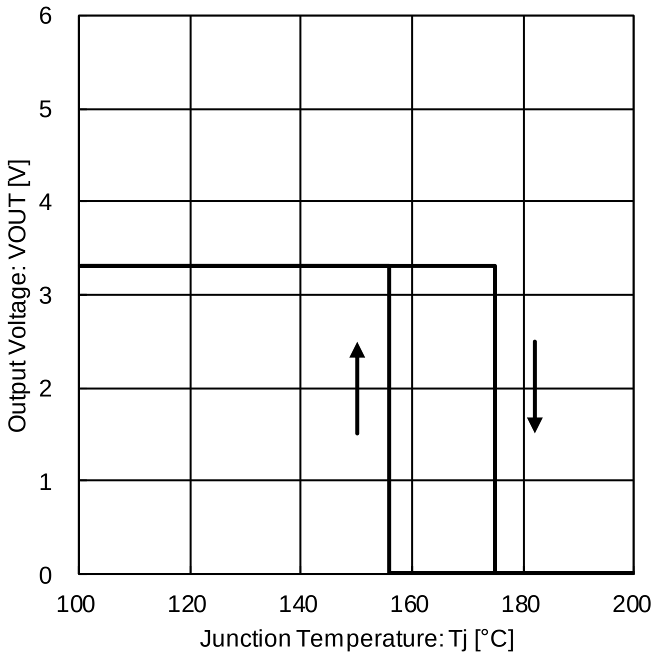


Figure 13. Output Voltage vs Temperature (Thermal Shutdown)

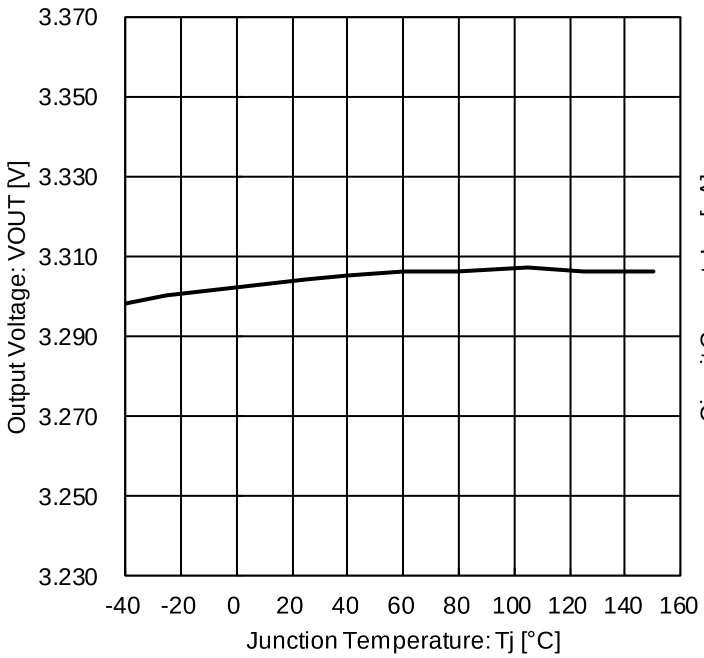


Figure 14. Output Voltage vs Temperature

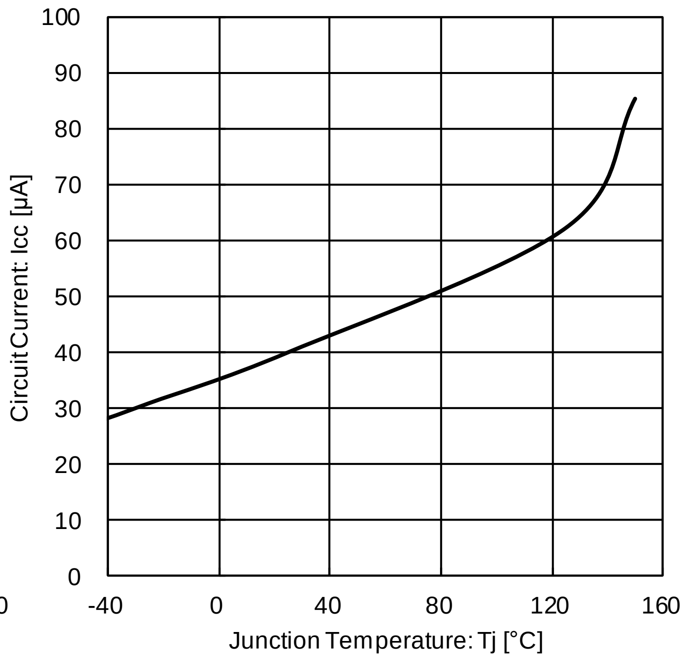


Figure 15. Circuit Current vs Temperature

Typical Performance Curves (Reference Data) – continued

■For 3.3 V Output with Enable input products

■Applicable Model:BD433S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, IOUT = 0 mA

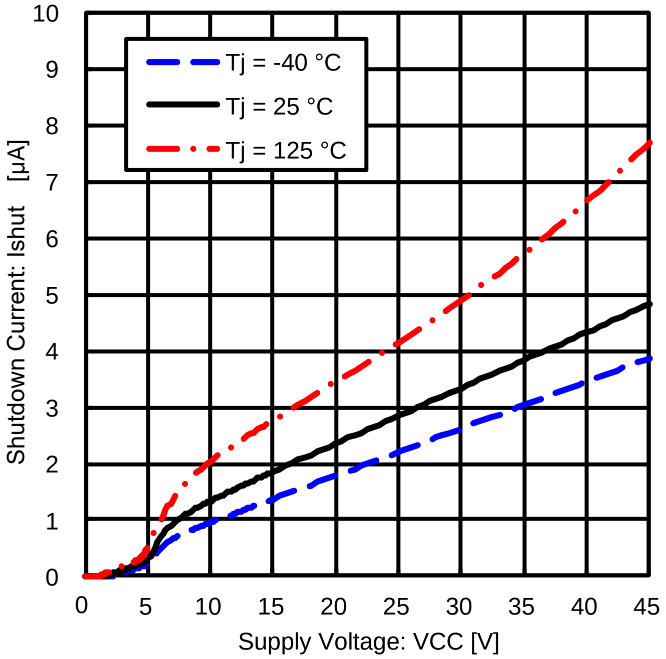


Figure 16. Shutdown Current vs Power Supply Voltage (CTL = 0 V)

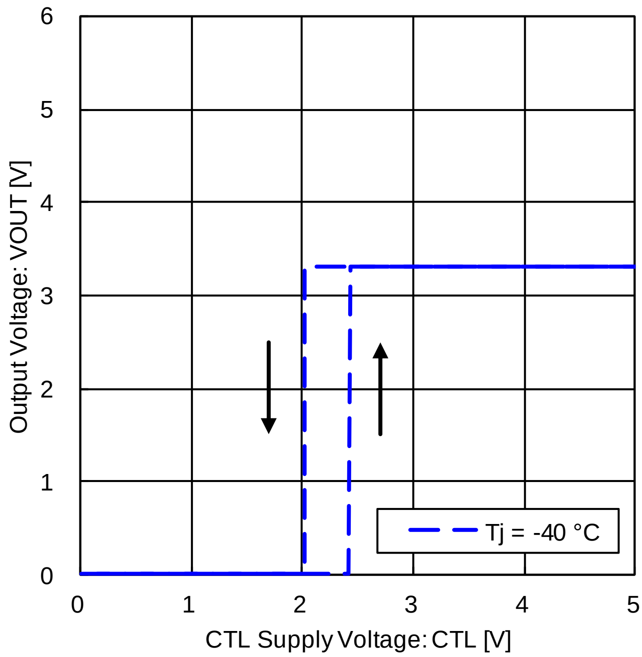


Figure 17. CTL ON / OFF Mode Voltage (Tj = -40 °C)

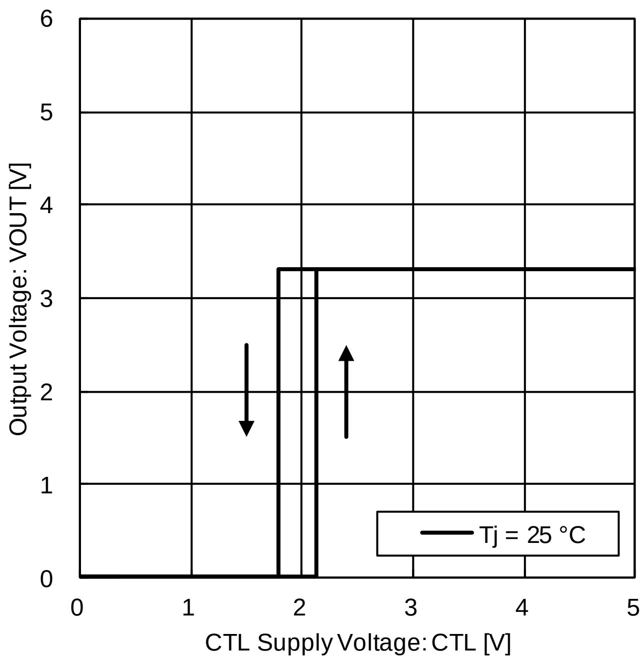


Figure 18. CTL ON / OFF Mode Voltage (Tj = 25 °C)

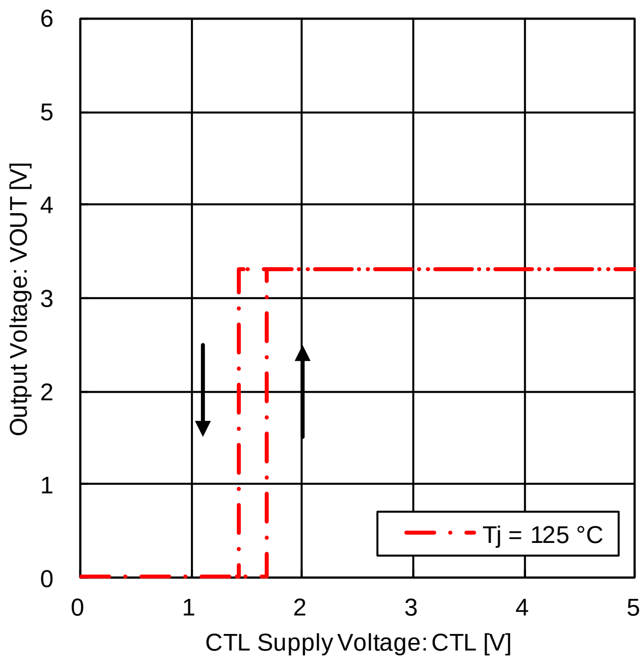


Figure 19. CTL ON / OFF Mode Voltage (Tj = 125 °C)

Typical Performance Curves (Reference Data) – continued

■For 3.3 V Output with Enable input products

■Applicable Model:BD433S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, IOUT = 0 mA

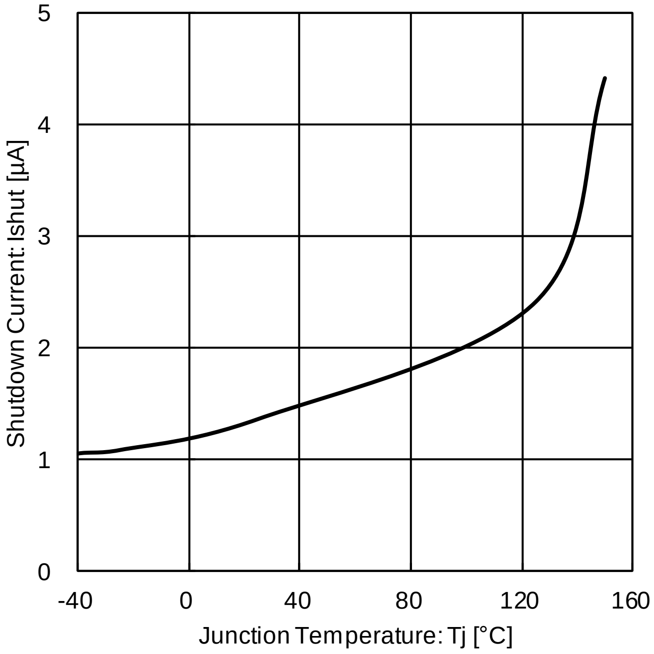


Figure 20. Shutdown Current
(CTL = 0 V)

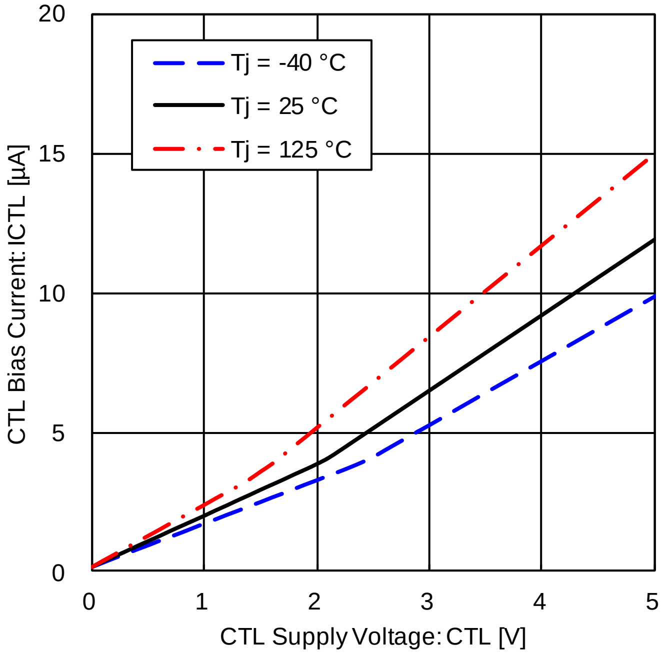


Figure 21. CTL Bias Current vs CTL Supply Voltage

Typical Performance Curves (Reference Data) – continued

■For 5.0 V Output products

■Applicable Models:BD450S5EFJ-C, BD450S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, CTL = 5 V*(Note 1)*, IOUT = 0 mA.

(Note 1) Applicable for product with Enable Input

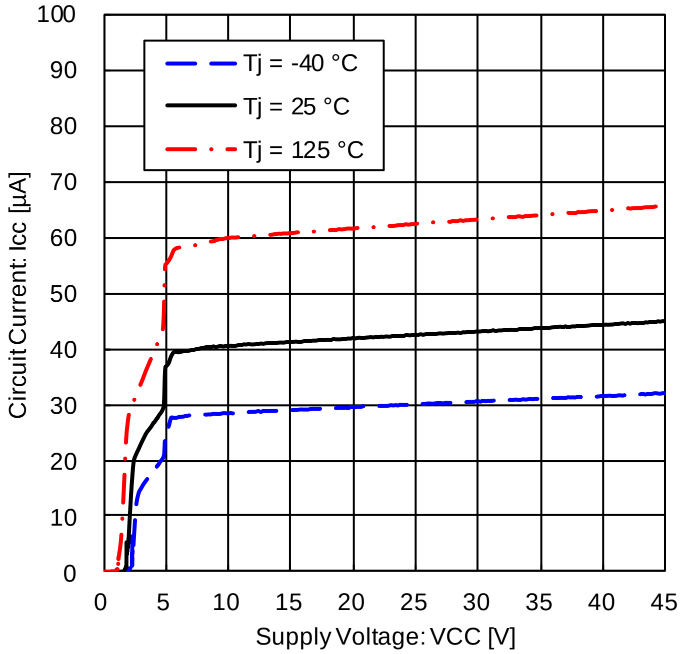


Figure 22. Circuit Current vs Power Supply Voltage

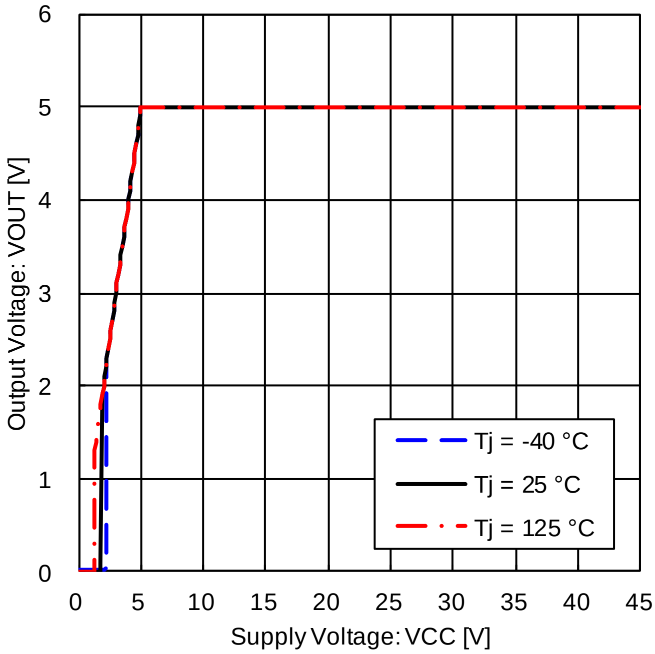


Figure 23. Output Voltage vs Power Supply Voltage (IOUT = 0 mA)

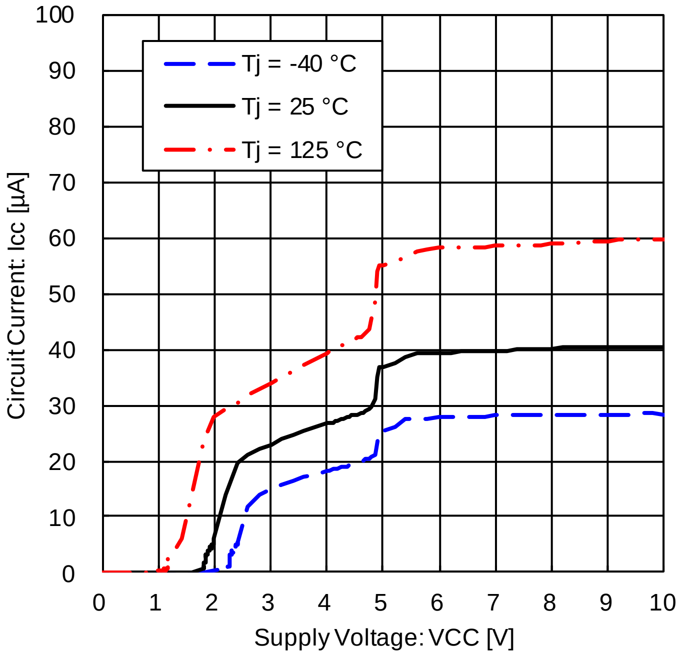


Figure 24. Circuit Current vs Power Supply Voltage - Magnified Figure 22.

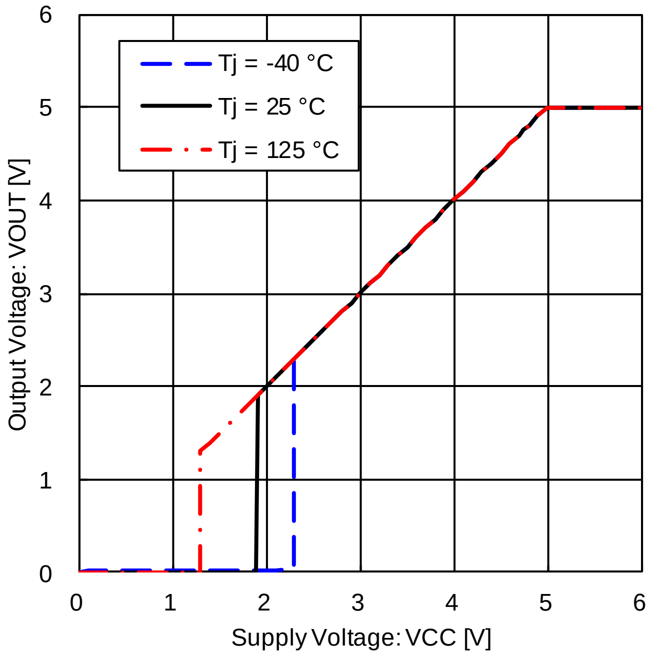


Figure 25. Output Voltage vs Power Supply Voltage (IOUT = 0 mA) - Magnified Figure 23.

Typical Performance Curves (Reference Data) – continued

■For 5.0 V Output products
■Applicable Models:BD450S5EFJ-C, BD450S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, CTL = 5 V*(Note 1)*, IOUT = 0 mA.
(Note 1) Applicable for product with Enable Input

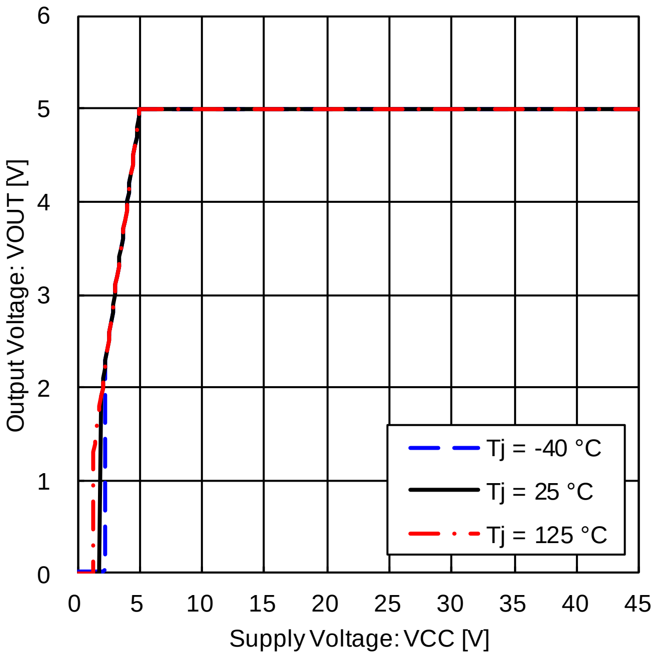


Figure 26. Output Voltage vs Power Supply Voltage
(IOUT = 10 mA)

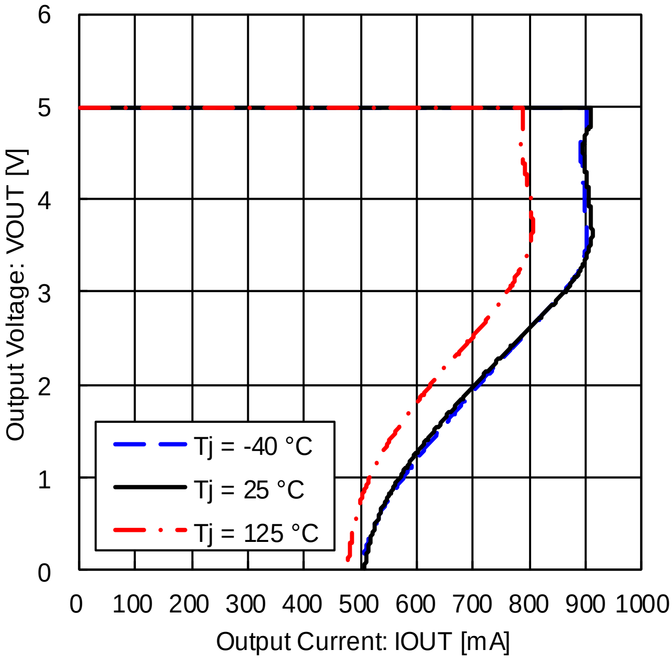


Figure 27. Output Voltage vs Output Current
(Over Current Protection)

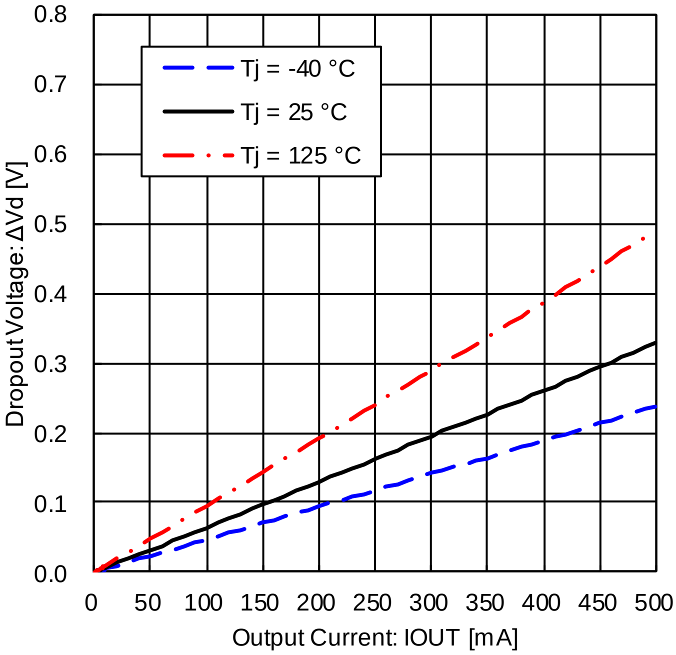


Figure 28. Dropout Voltage
(VCC = 4.75 V)

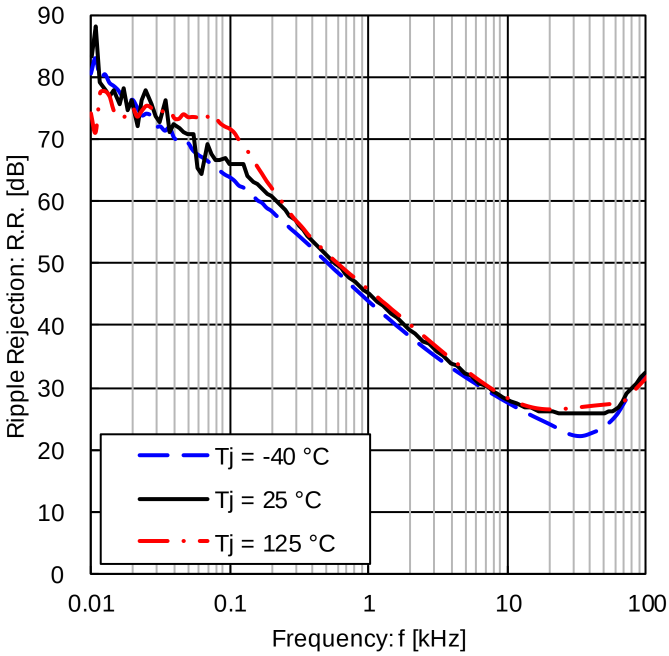


Figure 29. Ripple Rejection
(ein = 1 Vrms, IOUT = 100 mA)

Typical Performance Curves (Reference Data) – continued

■For 5.0 V Output products
■Applicable Models:BD450S5EFJ-C, BD450S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, CTL = 5 V*(Note 1)*, IOUT = 0 mA.
(Note 1) Applicable for product with Enable Input

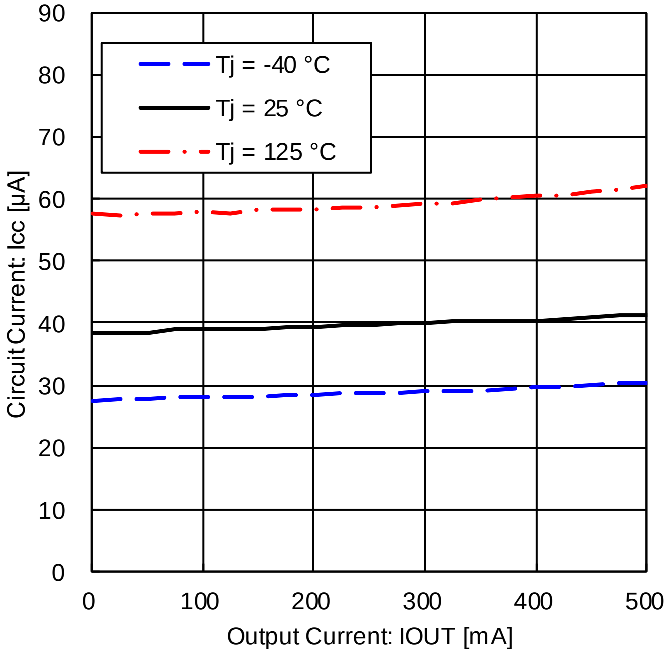


Figure 30. Circuit Current vs Output Current

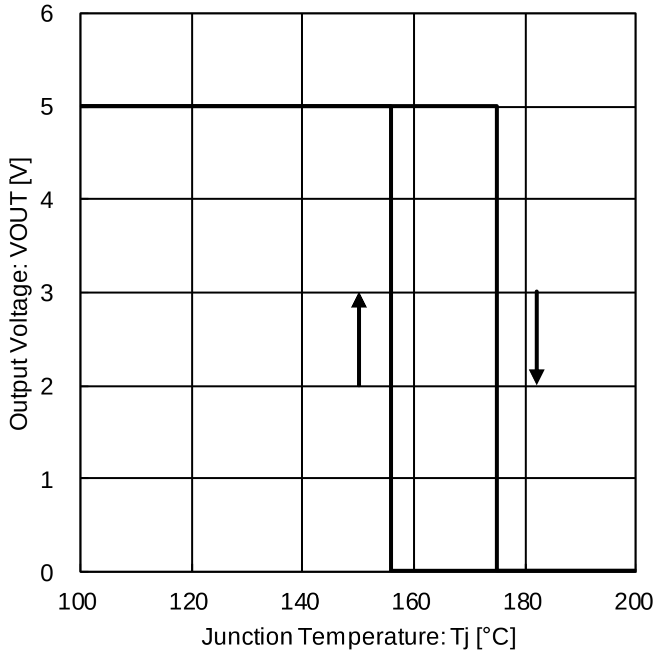


Figure 31. Output Voltage vs Temperature (Thermal Shutdown)

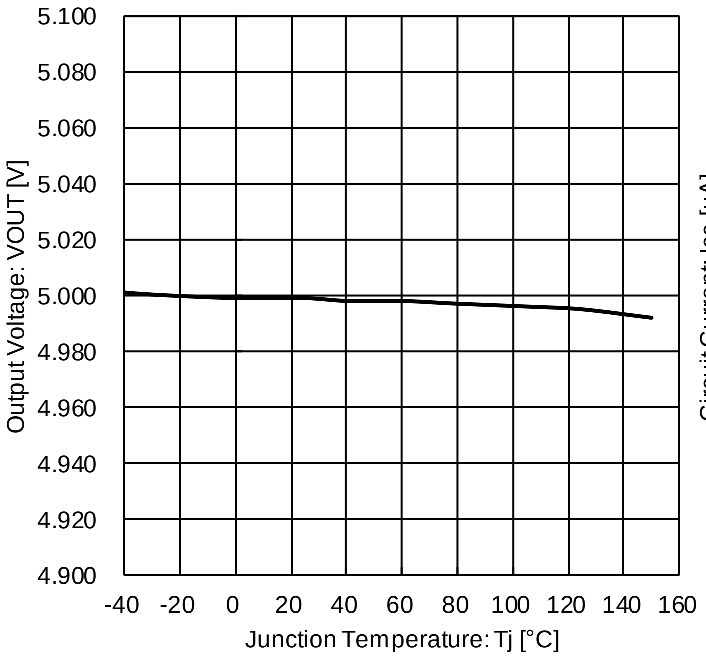


Figure 32. Output Voltage vs Temperature

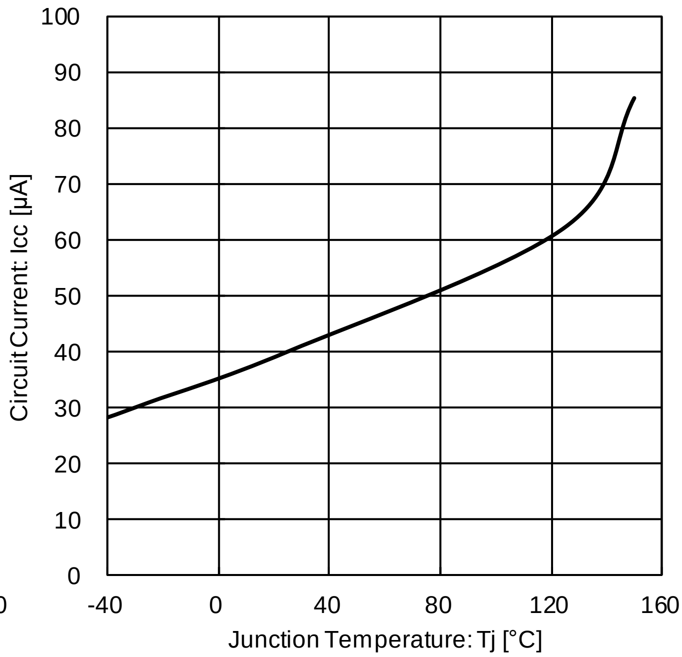


Figure 33. Circuit Current vs Temperature

Typical Performance Curves (Reference Data) – continued

■For 5.0 V Output with Enable input products
■Applicable Model:BD450S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, IOUT = 0 mA

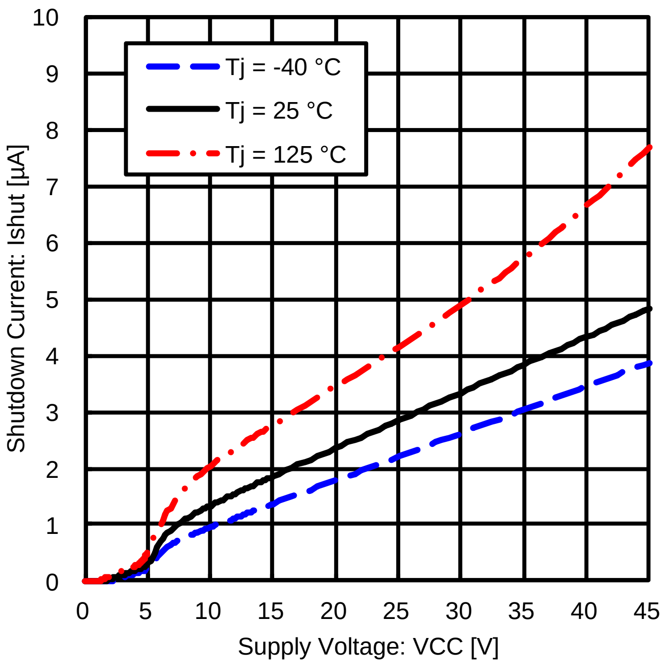


Figure 34. Shutdown Current vs Power Supply Voltage
(CTL = 0 V)

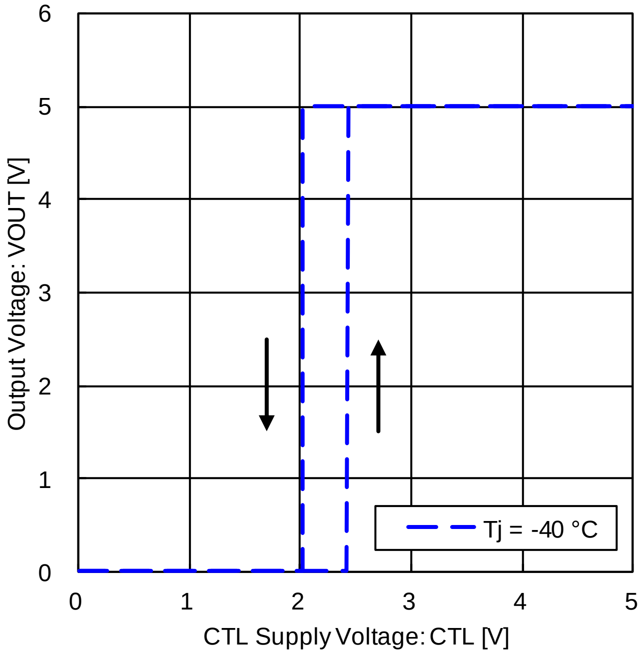


Figure 35. CTL ON / OFF Mode Voltage
(Tj = -40 °C)

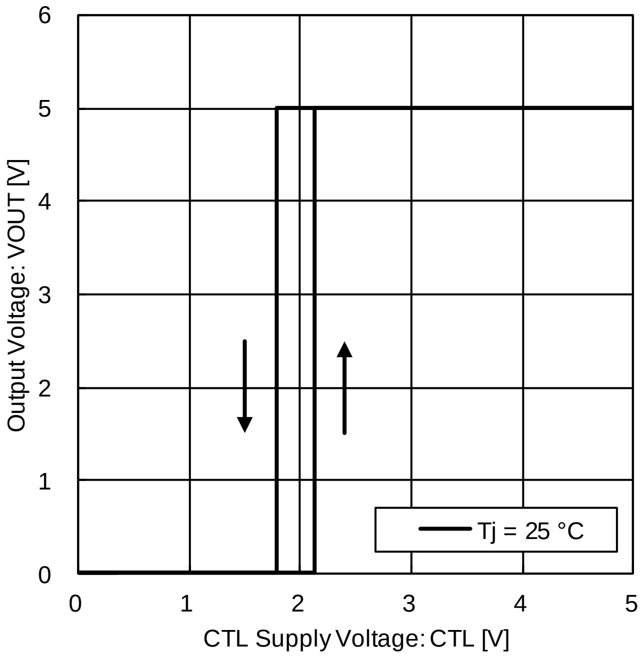


Figure 36. CTL ON / OFF Mode Voltage
(Tj = 25 °C)

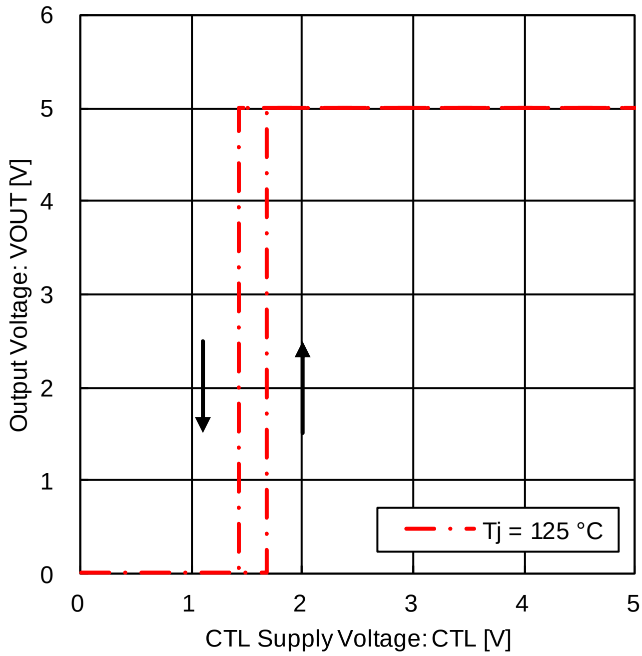


Figure 37. CTL ON / OFF Mode Voltage
(Tj = 125 °C)

Typical Performance Curves (Reference Data) – continued

■For 5.0 V Output with Enable input products
■Applicable Model:BD450S5WEFJ-C

Unless otherwise specified: -40 °C ≤ Tj ≤ +150 °C, VCC = 13.5 V, IOUT = 0 mA

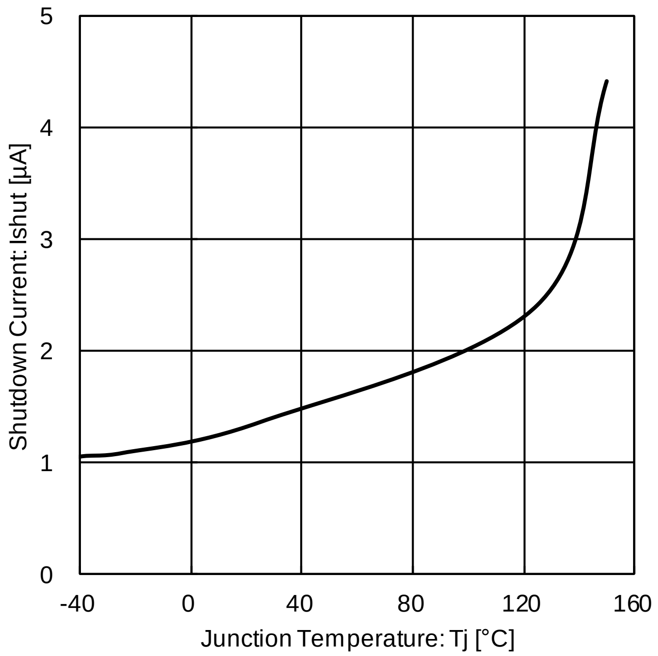


Figure 38. Shutdown Current vs Temperature (CTL = 0 V)

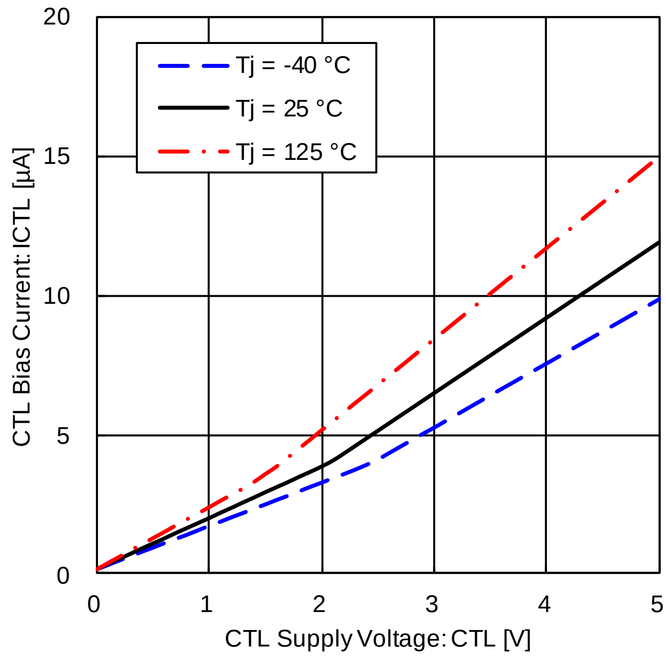
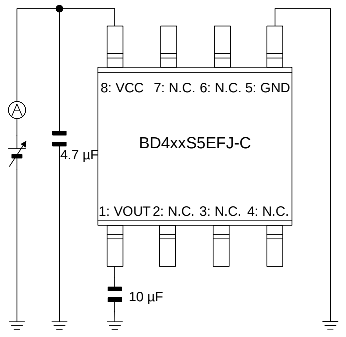
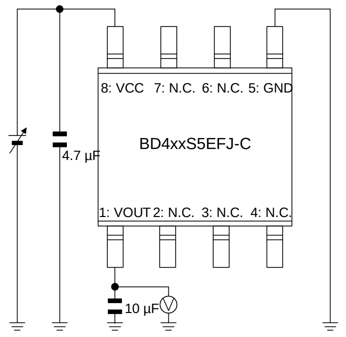


Figure 39. CTL Bias Current vs CTL Supply Voltage

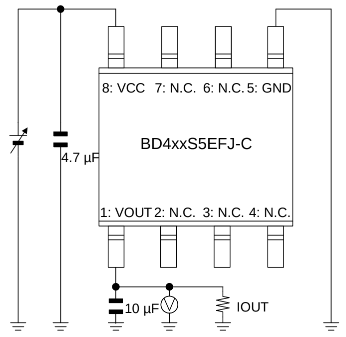
Measurement Circuit for Typical Performance Curves (BD4xxS5EFJ-C)



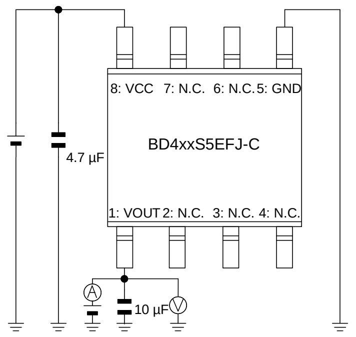
Measurement Setup for
Figure 4, 6, 15,
Figure 22, 24, 33



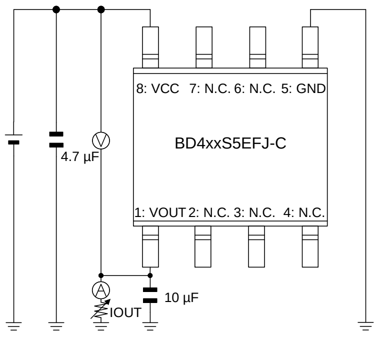
Measurement Setup for
Figure 5, 7, 13, 14,
Figure 23, 25, 31, 32



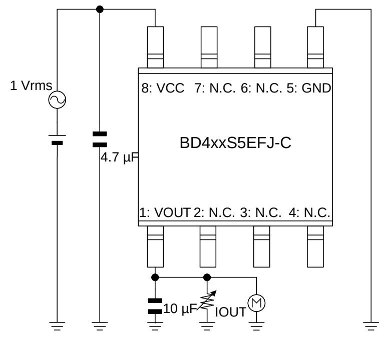
Measurement Setup for
Figure 8, 26



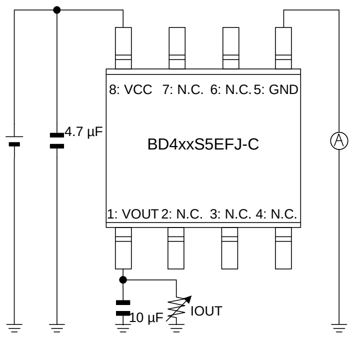
Measurement Setup for
Figure 9, 27



Measurement Setup for
Figure 10, 28

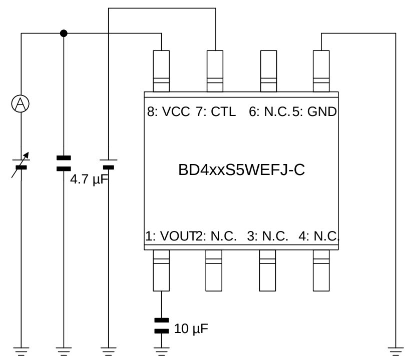


Measurement Setup for
Figure 11, 29

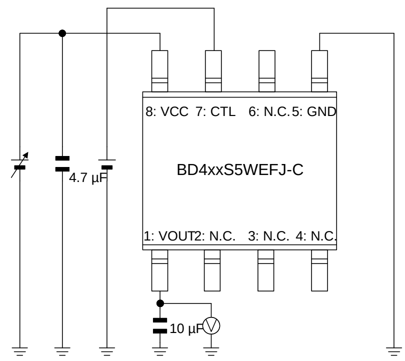


Measurement Setup for
Figure 12, 30

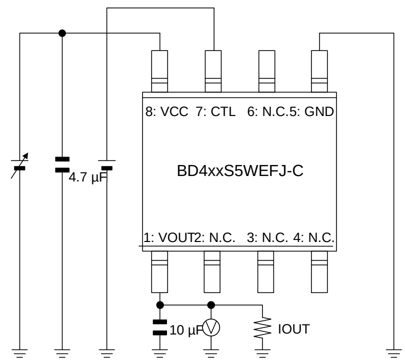
Measurement Circuit for Typical Performance Curves (BD4xxS5WEFJ-C) – continued



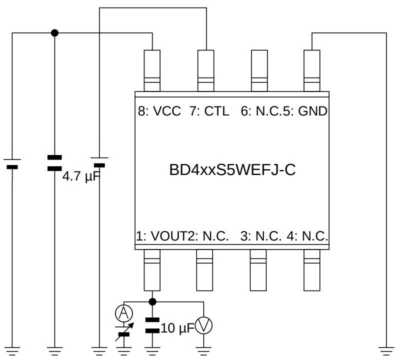
Measurement Setup for
Figure 4, 6, 15, 16, 20,
Figure 22, 24, 33, 34, 38



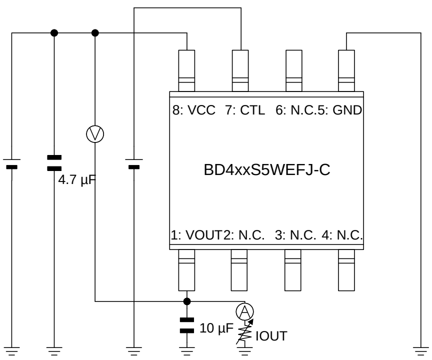
Measurement Setup for
Figure 5, 7, 13, 14,
Figure 23, 25, 31, 32



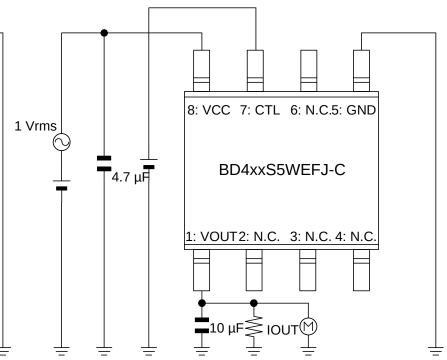
Measurement Setup for
Figure 8, 26



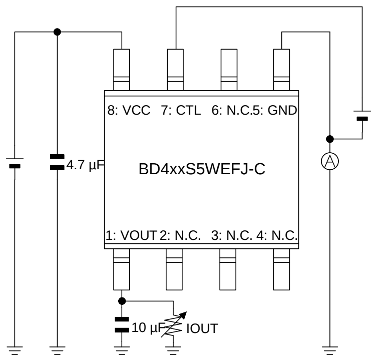
Measurement Setup for
Figure 9, 27



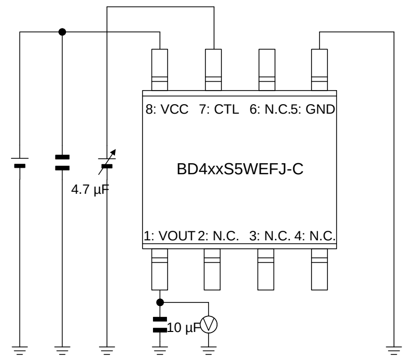
Measurement Setup for
Figure 10, 28



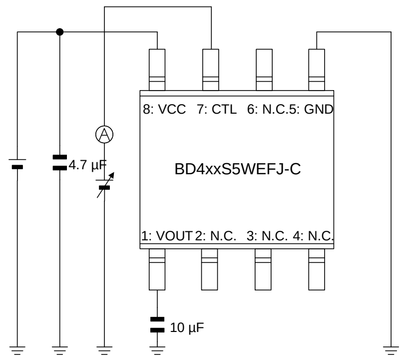
Measurement Setup for
Figure 11, 29



Measurement Setup for
Figure 12, 30



Measurement Setup for
Figure 17, 18, 19,
Figure 35, 36, 37



Measurement Setup for
Figure 21, 39

Selection of Components Externally Connected

VCC

Insert capacitors with a capacitance of 0.1 μF or higher between the VCC and the GND. Choose the capacitance according to the line between the power smoothing circuit and the VCC. Selection of the capacitance also depends on the application. Verify the application and allow sufficient margins in the design. We recommend using a capacitor with excellent voltage and temperature characteristics.

Output Pin Capacitor

In order to prevent oscillation, a capacitor needs to be placed between the output pin and GND. We recommend using a capacitor with a capacitance of 10 μF (Typ) or higher. Electrolytic, tantalum and ceramic capacitors can be used. When selecting the capacitor ensure that the capacitance of 6 μF or higher is maintained at the intended applied voltage and temperature range. Due to changes in temperature the capacitor's capacitance can fluctuate possibly resulting in oscillation. For selection of the capacitor refer to the data of Figure 40.

The stable operation range given in the data of Figure 40 and Figure 41 is based on the standalone IC and resistive load. For actual applications the stable operating range is influenced by the PCB impedance, input supply impedance and load impedance. Therefore verification of the final operating environment is needed.

When selecting a ceramic type capacitor, we recommend using X5R, X7R or better with excellent temperature and DC-biasing characteristics and high voltage tolerance.

Also, in case of rapidly fluctuation of input voltage and load current, select the capacitance in accordance with verifying that the actual application meets with the required specification. Mount the capacitor as much as possible near connected pin.

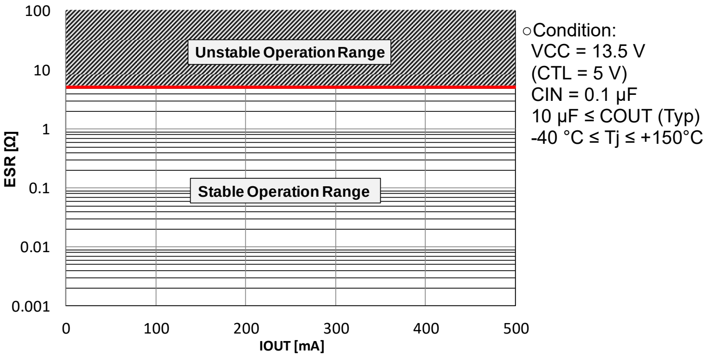


Figure 40. ESR vs IOUT

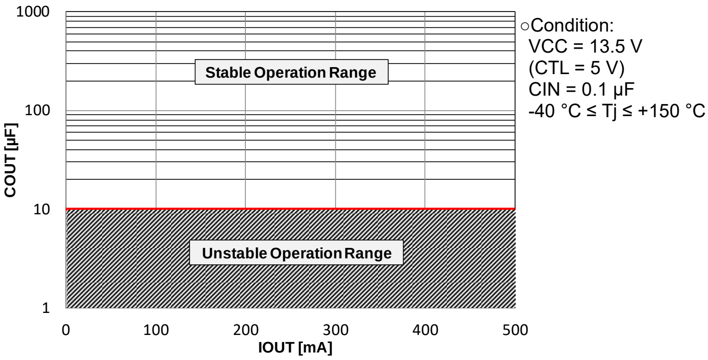


Figure 41. COUT vs IOUT

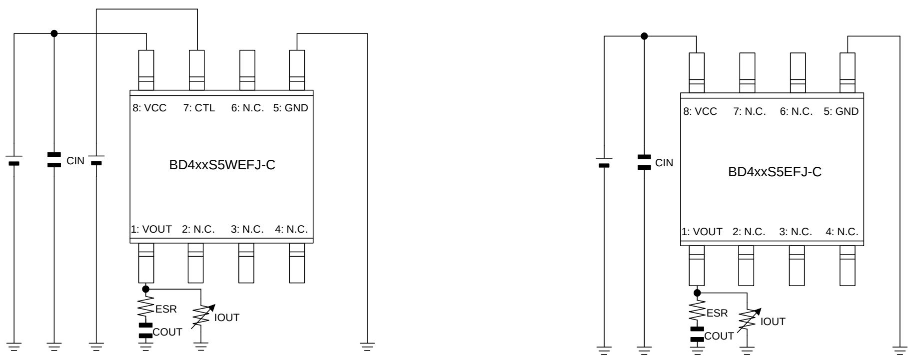


Figure 42. Measurement Setups for ESR Reference Data
(about Output Pin Capacitor)

Power Dissipation

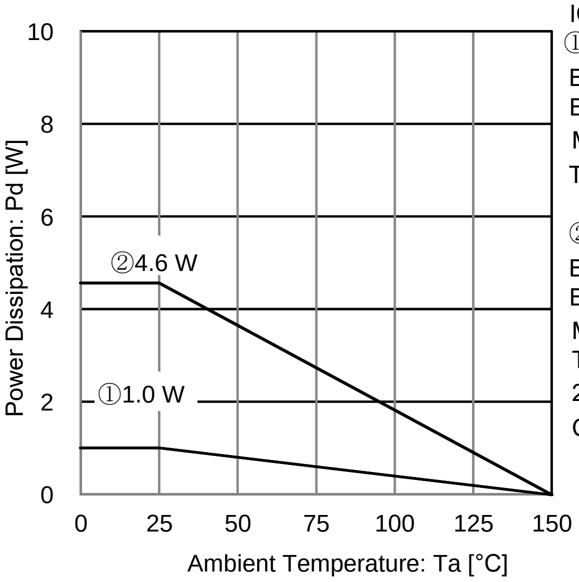


Figure 43. Package Data
(HTSOP-J8)

IC mounted on ROHM standard board based on JEDEC.

①1-layer PCB (Copper foil area on the reverse side of PCB: 0 mm × 0 mm)
Board material: FR4
Board size: 114.3 mm × 76.2 mm × 1.57 mmt
Mount condition: PCB and exposed pad are soldered.
Top copper foil: ROHM recommended footprint + wiring to measure, 2 oz. copper.

②4-layer PCB (Copper foil area on the reverse side of PCB: 74.2 mm × 74.2 mm)
Board material: FR4
Board size: 114.3 mm × 76.2 mm × 1.60 mmt
Mount condition: PCB and exposed pad are soldered.
Top copper foil: ROHM recommended footprint + wiring to measure, 2 oz. copper.
2 inner layers copper foil area of PCB: 74.2 mm × 74.2 mm, 1 oz. copper.
Copper foil area on the reverse side of PCB: 74.2 mm × 74.2 mm, 2 oz. copper.

Condition①: θ_{JA} = 126 °C/W, Ψ_{JT} (top center) = 9 °C/W
Condition②: θ_{JA} = 27 °C/W, Ψ_{JT} (top center) = 2 °C/W

Thermal Design

This product exposes a frame on the back side of the package for thermal efficiency improvement.
Within this IC, the power consumption is decided by the dropout voltage condition, the load current and the circuit current. Refer to power dissipation curves illustrated in Figure 43 when using the IC in an environment of Ta ≥ 25 °C. Even if the ambient temperature Ta is at 25 °C, depending on the input voltage and the load current, chip junction temperature can be very high. Consider the design to be Tj ≤ Tjmax = 150 °C in all possible operating temperature range.
Should by any condition the maximum junction temperature Tjmax = 150 °C rating be exceeded by the temperature increase of the chip, it may result in deterioration of the properties of the chip. The thermal impedance in this specification is based on recommended PCB and measurement condition by JEDEC standard. Verify the application and allow sufficient margins in the thermal design by the following method is used to calculate the junction temperature Tj.
Tj can be calculated by either of the two following methods.

1. The following method is used to calculate the junction temperature Tj.

$$Tj = Ta + P_C \times \theta_{JA} \text{ [°C]}$$

Tj	: Junction Temperature
Ta	: Ambient Temperature
P_C	: Power Consumption
θ_{JA}	: Thermal Impedance (Junction to Ambient)

2. The following method is also used to calculate the junction temperature Tj.

$$Tj = T_T + P_C \times \Psi_{JT} \text{ [°C]}$$

Tj	: Junction Temperature
T_T	: Top Center of Case's (mold) Temperature
P_C	: Power consumption
Ψ_{JT}	: Thermal Impedance (Junction to Top Center of Case)

The following method is used to calculate the power consumption Pc (W).

$$Pc = (VCC - VOUT) \times IOUT + VCC \times I_{CC} \text{ [W]}$$

P_C	: Power Consumption
VCC	: Input Voltage
VOUT	: Output Voltage
IOUT	: Load Current
Icc	: Circuit Current

Calculation Example

If VCC = 13.5 V, VOUT = 5.0 V, IOUT = 200 mA, Icc = 38 μA, the power consumption Pc can be calculated as follows:

$$
\begin{aligned}
Pc &= (VCC - VOUT) \times IOUT + VCC \times I_{CC} \\
&= (13.5\,V - 5.0\,V) \times 200\,mA + 13.5\,V \times 38\,\mu A \\
&= 1.7\,W
\end{aligned}
$$

At the ambient temperature Ta = 85 °C, the thermal impedance (Junction to Ambient) θ_{JA} = 27 °C/W(4-layer PCB),

$$
\begin{aligned}
Tj &= Ta + P_C \times \theta_{JA} \\
&= 85\,°C + 1.7\,W \times 27\,°C/W \\
&= 130.9\,°C
\end{aligned}
$$

When operating the IC, the top center of case's (mold) temperature T_T = 100 °C, Ψ_{JT} = 9 °C/W(1-layer PCB),

$$
\begin{aligned}
Tj &= T_T + P_C \times \Psi_{JT} \\
&= 100\,°C + 1.7\,W \times 9°C/W \\
&= 115.3\,°C
\end{aligned}
$$

For optimum thermal performance, it is recommended to expand the copper foil area of the board, increasing the layer and thermal via between thermal land pad.

Application Examples

Applying positive surge to the VCC

If the possibility exists that surges higher than 45 V will be applied to the VCC, a Zener Diode should be placed between the VCC and the GND as shown in the figure below.

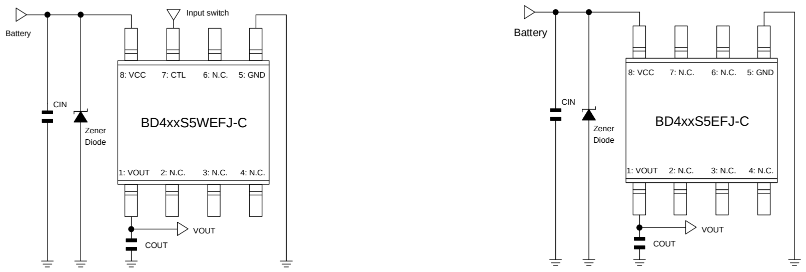


Figure 44. Sample Application Circuit 1

Applying negative surge to the VCC

If the possibility exists that negative voltage lower than the GND are applied to the VCC, a Schottky Diode should be place between the VCC and GND as shown in the figure below.

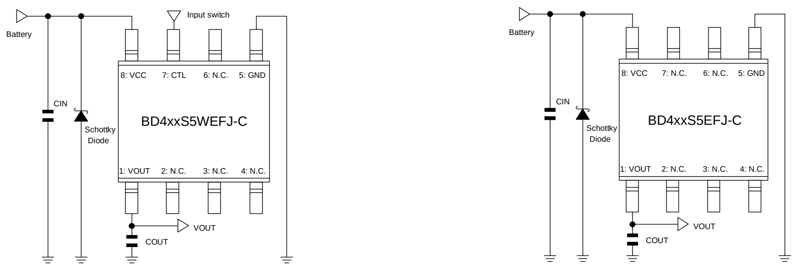


Figure 45. Sample Application Circuit 2

Implementing a Protection Diode

If the possibility exists that a large inductive load is connected to the output pin resulting in back-EMF at time of startup and shutdown, a protection diode should be placed as shown in the figure below.

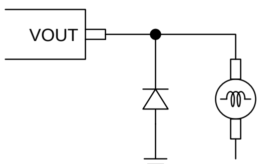


Figure 46. Sample Application Circuit 3

I/O Equivalence Circuit

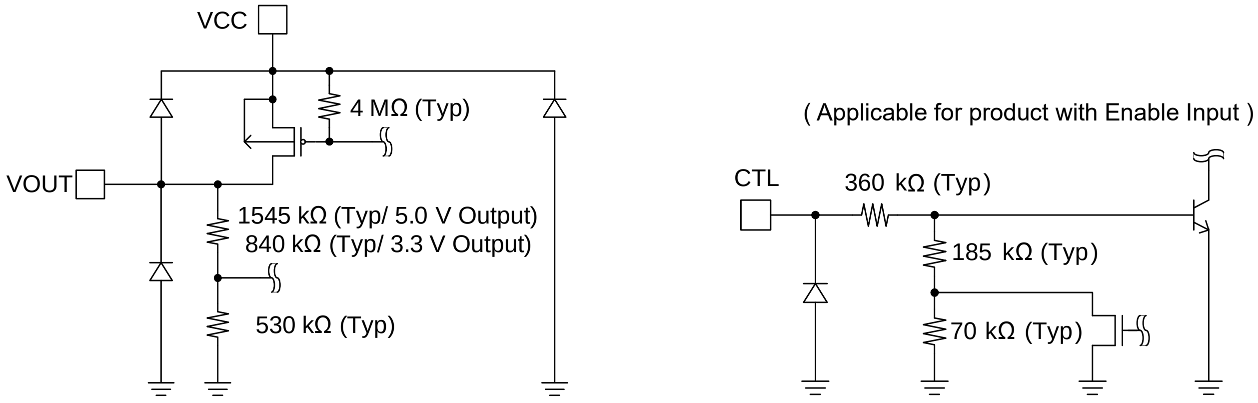


Figure 47. Input / Output Equivalence Circuit

Operational Notes

1. **Reverse Connection of Power Supply**
   Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
   Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
   When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Operating Conditions**
   The function and operation of the IC are guaranteed within the range specified by the operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

6. **Inrush Current**
   When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

7. **Testing on Application Boards**
   When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

8. **Inter-pin Short and Mounting Errors**
   Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

Operational Notes – continued

9. Regarding the Input Pin of the IC

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.
When GND > Pin B, the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

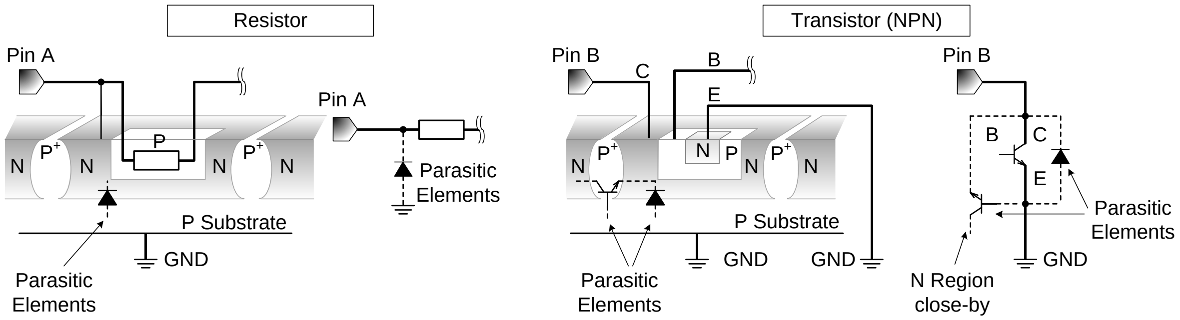


Figure 48. Example of Monolithic IC Structure

10. Ceramic Capacitor

When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

11. Thermal Shutdown Circuit (TSD)

This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC’s maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature (Tj) will rise which will activate the TSD circuit that will turn OFF power output pins. When the Tj falls below the TSD threshold, the circuits are automatically restored to normal operation.
Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

12. Over Current Protection Circuit (OCP)

This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

13. Thermal Consideration

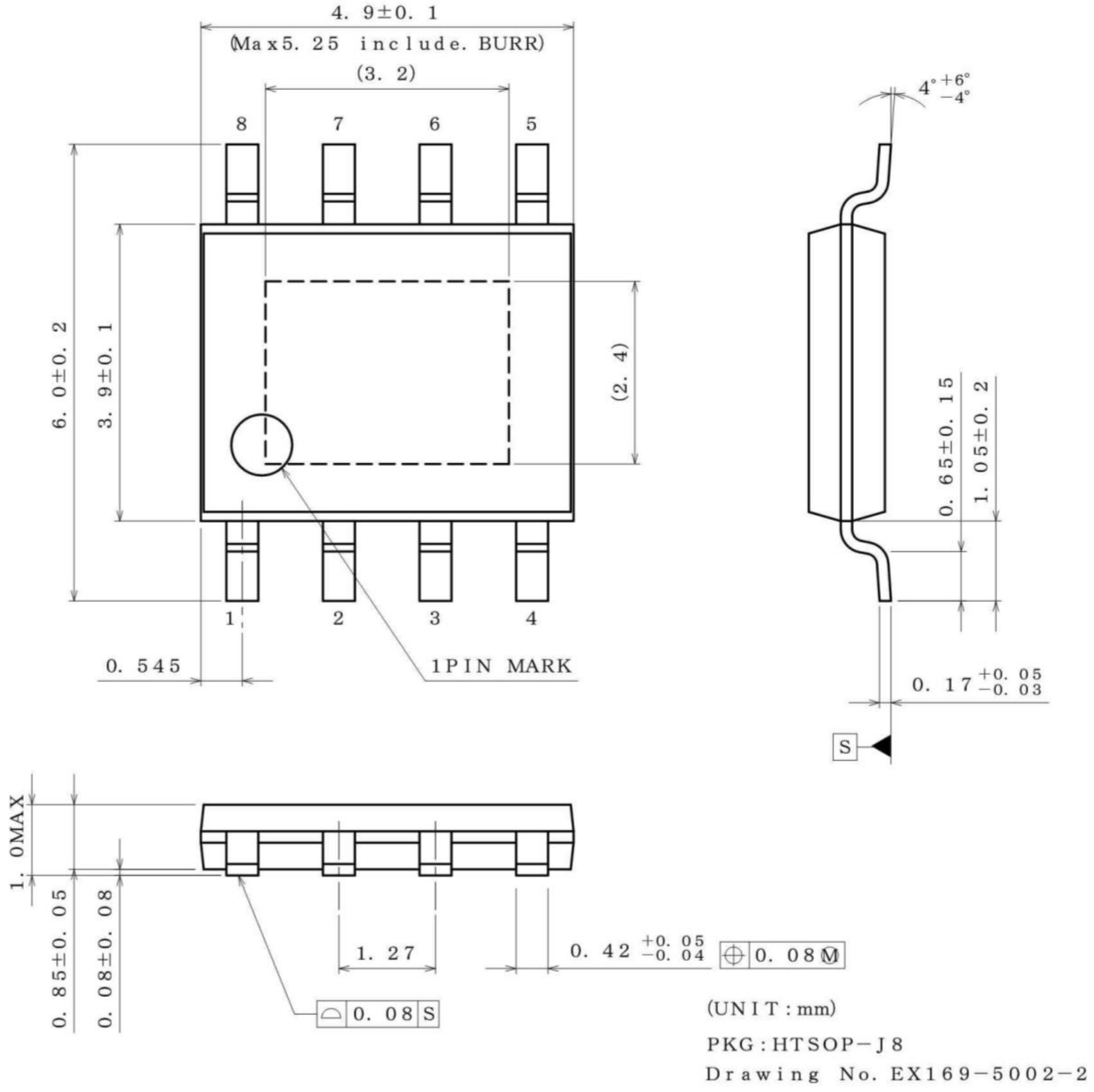
The power dissipation under actual operating conditions should be taken into consideration and a sufficient margin should be allowed in the thermal design. On the reverse side of the package this product has an exposed heat pad for improving the heat dissipation. The amount of heat generation depends on the voltage difference between the input and output, load current, and bias current. Therefore, when actually using the chip, ensure that the generated heat does not exceed the Pd rating. If Junction temperature is over Tjmax (= 150 °C), IC characteristics may be worse due to rising chip temperature. Heat resistance in specification is measurement under PCB condition and environment recommended in JEDEC. Ensure that heat resistance in specification is different from actual environment.

14. CTL Pin

The CTL pin is for controlling ON/OFF the output voltage. Do not make voltage level of chip enable keep floating level, or between VthH and VthL. Otherwise, the output voltage would be unstable or indefinite.

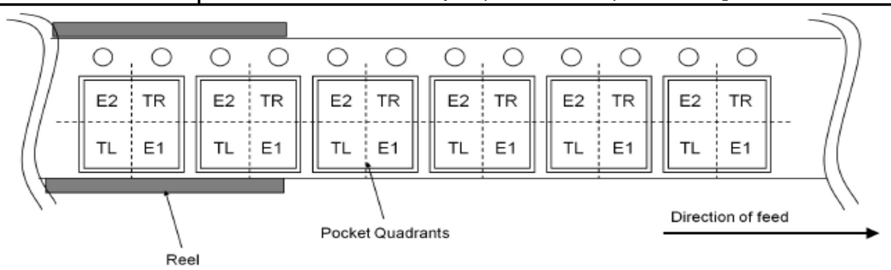
Physical Dimension and Packing Information

Package Name	HTSOP-J8



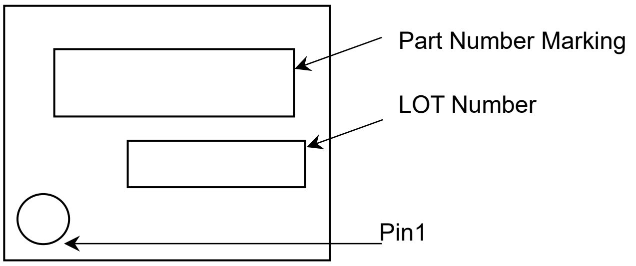
< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 The direction is the pin 1 of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand



Marking Diagrams (Top View)

HTSOP-J8 (Top View)



Part Number Marking	Output Voltage [V]	Enable Input(Note 1)	Orderable Part Number
433S5W	3.3	○	BD433S5WEFJ-CE2
450S5W	5.0	○	BD450S5WEFJ-CE2
433S5	3.3	–	BD433S5EFJ-CE2
450S5	5.0	–	BD450S5EFJ-CE2

(Note 1) ○: Includes Enable Input
–: Not includes Enable Input

Revision History

Date	Revision	Changes
24.Jun.2022	001	New Release

Notice

Precaution on using ROHM Products

1. If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment [Note 1], aircraft/spacecraft, nuclear power controllers, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are not designed under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

Precaution Regarding Intellectual Property Rights

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General Precaution

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