150 mA Voltage Regulator (Wide Input Voltage Range)

No. EA-100-230529

OUTLINE

The R1154x is a voltage regulator (VR) featuring high output voltage accuracy and ultra-low supply current. A peak current limit circuit, a short current limit circuit, and a thermal shutdown circuit are built in the R1154x. The regulator output voltage is fixed in the R1154xxxxB, while adjustable type is the R1154x001C. The Output voltage accuracy is ±2.0%.
Since the packages for these ICs are DFN1616-6, SOT-23-5, and SOT-89-5, high density mounting of the ICs on boards is possible.

FEATURES

- Supply Current ..... Typ. 5.0 μA
- Standby Current ..... Typ. 0.1 μA
- Output Current ..... Min. 140 mA (V_{IN} = V_{OUT} + 2.0 V, 2.5 V Output type)
  Min. 150 mA (V_{IN} = V_{OUT} + 2.0 V, 3.0 V Output type)
- Input Voltage ..... Max. 24.0 V
- Wide Output Voltage Range ..... 2.5 V to 12.0 V (0.1 V step) (xxxB)
  Adjustable in the range of 2.5 V to V_{IN} or 24.0 V (001C)
- Output Voltage Accuracy ..... ±2.0%
- Packages DFN1616-6, SOT-23-5, SOT-89-5
- Built-in Peak Current Limit Circuit
- Built-in Short Current Limit Circuit
- Built-in Thermal Shutdown Circuit

APPLICATIONS

- Power source for home appliances such as refrigerators, rice cookers, Electronic water warmers, etc.
- Power source for car audio equipment, car navigation system, and ETC system.
- Power source for notebook PCs, digital TVs, cordless phones, and LAN system.
- Power source for copiers, printers, facsimiles, and scanners.

SELECTION GUIDE

The output voltage can be selected at the user's request.

Selection Guide

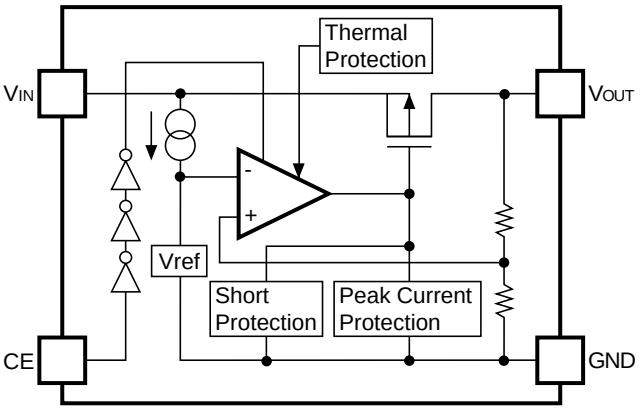
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1154Lxxx∗-TR	DFN1616-6	5,000 pcs	Yes	Yes
R1154Nxxx∗-TR-FE	SOT-23-5	3,000 pcs	Yes	Yes
R1154Hxxx∗-T1-FE	SOT-89-5	1,000 pcs	Yes	Yes

xxx : The output voltage can be designated in the range from 2.5 V (025) to 12.0 V (120) in 0.1 V step.
If the output voltage includes the 3rd digit, indicate the digit of 0.01 V as follows.
5.25 V: R1154x052x5
The output voltage adjustable type is fixed at 001 (Reference voltage = 2.5 V)

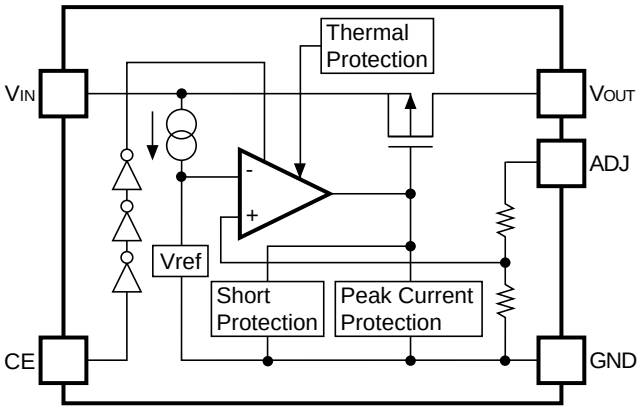
∗ : (B) Fixed Output Type
(C) Adjustable Output Type

BLOCK DIAGRAMS

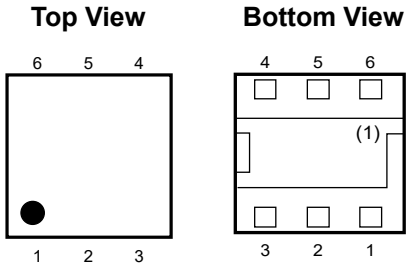
R1154xxxxB
Fixed Output Type



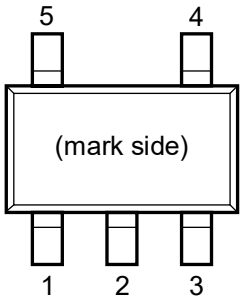
R1154x001C
Adjustable Output Type



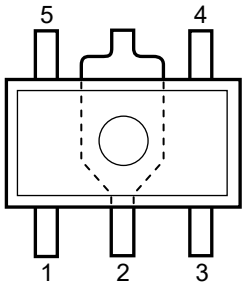
PIN DESCRIPTIONS



DFN1616-6 Pin Configuration



SOT-23-5 Pin Configuration



SOT-89-5 Pin Configuration

DFN1616-6 Pin Descriptions

Pin No	Symbol	Description	
1	VDD	Input Pin	
2	NC	No Connection	
3	VOUT	Voltage Regulator Output Pin	
4	CE	Chip Enable Pin	
5	NC	R1154LxxxB	No Connection
	ADJ	R1154L001C	Reference Voltage of Adjustable Output Pin
6	GND	Ground Pin	

SOT-23-5 Pin Descriptions

Pin No	Symbol	Description	
1	VOUT	Voltage Regulator Output Pin	
2	GND	Ground Pin	
3	VDD	Input Pin	
4	NC	R1154NxxxB	No Connection
	ADJ	R1154N001C	Reference Voltage of Adjustable Output Pin
5	CE	Chip Enable Pin	

(1) The tab on the bottom of the package enhances thermal performance and is electrically connected to GND (substrate level). It is recommended that the tab be connected to the ground plane on the board, or otherwise be left floating.

SOT-89-5 Pin Descriptions

Pin No	Symbol	Description	
1	VOUT	Voltage Regulator Output Pin	
2	GND	Ground Pin	
3	CE	Chip Enable Pin	
4	NC	R1154HxxxB	No Connection
	ADJ	R1154H001C	Reference Voltage of Adjustable Output Pin
5	VDD	Input Pin	

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings

Symbol	Item			Rating	Unit
V_{IN}	Input Voltage			26	V
V_{CE}	Input Voltage (CE Input Pin)			−0.3 to V_{IN} + 0.3	V
V_{OUT}	Output Voltage			−0.3 to V_{IN} + 0.3	V
V_{ADJ}	Output Voltage (ADJ Pin)			−0.3 to V_{IN} + 0.3	V
I_{OUT}	Output Current			250	mA
P_D	Power Dissipation(1)	DFN1616-6	JEDEC STD. 51-7 Test Land Pattern	2400	mW
		SOT-23-5	JEDEC STD. 51-7 Test Land Pattern	660	mW
		SOT-89-5	JEDEC STD. 51-7 Test Land Pattern	2600	mW
Tj	Junction Temperature Range			−40 to 125	°C
Tstg	Storage Temperature Range			−55 to 125	°C

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS

Recommended Operating Conditions

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	Max. 24	V
Ta	Operating Temperature Range	−40 to 105	°C

RECOMMENDED OPERATING CONDITIONS

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

(1) Refer to *POWER DISSIPATION* for detailed information.

ELECTRICAL CHARACTERISTICS

R1154xxxxB Electrical Characteristics (Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	$V_{IN} = V_{SET} + 2.0$ V, $I_{OUT} = 20$ mA	x0.98		x1.02	V
I_{OUT}	Output Current	$V_{IN} - V_{SET} = 2.0$ V	Refer to the *Product-specific Electrical Characteristics*			
I_{SS}	Supply Current	$V_{IN} = V_{CE}$, $V_{IN} - V_{SET} = 2.0$ V		5	10	μA
Istandby	Standby Current	$V_{IN} = 24$ V, $V_{CE} = 0$ V		0.1	1.0	μA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load regulation	$V_{IN} - V_{SET} = 2.0$ V, 1 mA ≤ I_{OUT} ≤ 40 mA	Refer to the *Product-specific Electrical Characteristics*			
$\Delta V_{OUT}/\Delta V_{IN}$	Line regulation	$I_{OUT} = 20$ mA $V_{SET} + 1$ V ≤ V_{IN} ≤ 24 V		0.05	0.20	%/V
V_{DIF}	Dropout Voltage	$I_{OUT} = 20$ mA	Refer to the *Product-specific Electrical Characteristics*			
I_{SC}	Short Current Limit	$V_{OUT} = 0$ V		45		mA
V_{CEH}	CE “H” Input Voltage		2.1		V_{IN}	V
V_{CEL}	CE “L” Input Voltage		0		0.3	V
T_{SD}	Thermal Shutdown Temperature	Junction Temperature		150		°C
T_{SR}	Thermal Shutdown Released Temperature	Junction Temperature		125		°C

Product-specific Electrical Characteristics

Product Name	V_{OUT}			I_{OUT}	V_{OUT}/I_{OUT}		V_{DIF}	
	Min.	Typ.	Max.	Min.	Typ.	Max.	Typ.	Max.
R1154x025x	2.450	2.500	2.550	140	20	50	0.20	0.40
R1154x026x	2.548	2.600	2.652					
R1154x027x	2.646	2.700	2.754					
R1154x028x	2.744	2.800	2.856					
R1154x029x	2.842	2.900	2.958					
R1154x030x	2.940	3.000	3.060	150				
R1154x031x	3.038	3.100	3.162		30	75		
R1154x032x	3.136	3.200	3.264					
R1154x033x	3.234	3.300	3.366					
R1154x034x	3.332	3.400	3.468					
R1154x035x	3.430	3.500	3.570					
R1154x036x	3.528	3.600	3.672					
R1154x037x	3.626	3.700	3.774					
R1154x038x	3.724	3.800	3.876					
R1154x039x	3.822	3.900	3.978					
R1154x040x	3.920	4.000	4.080					
R1154x041x	4.018	4.100	4.182					
R1154x042x	4.116	4.200	4.284					
R1154x043x	4.214	4.300	4.386					
R1154x044x	4.312	4.400	4.488					
R1154x045x	4.410	4.500	4.590					
R1154x046x	4.508	4.600	4.692					
R1154x047x	4.606	4.700	4.794					
R1154x048x	4.704	4.800	4.896					
R1154x049x	4.802	4.900	4.998					
R1154x050x	4.900	5.000	5.100					
R1154x051x	4.998	5.100	5.202		40	115		
R1154x052x	5.096	5.200	5.304					
R1154x052x5	5.145	5.250	5.355					
R1154x053x	5.194	5.300	5.406					
R1154x054x	5.292	5.400	5.508					
R1154x055x	5.390	5.500	5.610					
R1154x056x	5.488	5.600	5.712					
R1154x057x	5.586	5.700	5.814					
R1154x058x	5.684	5.800	5.916					
R1154x059x	5.782	5.900	6.018					
R1154x060x	5.880	6.000	6.120					
R1154x061x	5.978	6.100	6.222					
R1154x062x	6.076	6.200	6.324					
R1154x063x	6.174	6.300	6.426					
R1154x064x	6.272	6.400	6.528					
R1154x065x	6.370	6.500	6.630					
R1154x066x	6.468	6.600	6.732					
R1154x067x	6.566	6.700	6.834					
R1154x068x	6.664	6.800	6.936					
R1154x069x	6.762	6.900	7.038					
R1154x070x	6.860	7.000	7.140					
R1154x071x	6.958	7.100	7.242				0.25	0.50
R1154x072x	7.056	7.200	7.344					
R1154x073x	7.154	7.300	7.446					
R1154x074x	7.252	7.400	7.548					
R1154x075x	7.350	7.500	7.650					

Product-specific Electrical Characteristics

Product Name	V_{OUT}			I_{OUT}	V_{OUT}/I_{OUT}		V_{DIF}	
	Min.	Typ.	Max.	Min.	Typ.	Max.	Typ.	Max.
R1154x076x	7.448	7.600	7.752					
R1154x077x	7.546	7.700	7.854					
R1154x078x	7.644	7.800	7.956					
R1154x079x	7.742	7.900	8.058					
R1154x080x	7.840	8.000	8.160					
R1154x081x	7.938	8.100	8.262					
R1154x082x	8.036	8.200	8.364					
R1154x083x	8.134	8.300	8.466					
R1154x084x	8.232	8.400	8.568					
R1154x085x	8.330	8.500	8.670					
R1154x086x	8.428	8.600	8.772					
R1154x087x	8.526	8.700	8.874					
R1154x088x	8.624	8.800	8.976				0.25	0.50
R1154x089x	8.722	8.900	9.078					
R1154x090x	8.820	9.000	9.180					
R1154x091x	8.918	9.100	9.282					
R1154x092x	9.016	9.200	9.384					
R1154x093x	9.114	9.300	9.486					
R1154x094x	9.212	9.400	9.588					
R1154x095x	9.310	9.500	9.690					
R1154x096x	9.408	9.600	9.792					
R1154x097x	9.506	9.700	9.894					
R1154x098x	9.604	9.800	9.996	150	40	115		
R1154x099x	9.702	9.900	10.098					
R1154x100x	9.800	10.000	10.200					
R1154x101x	9.898	10.100	10.302					
R1154x102x	9.996	10.200	10.404					
R1154x103x	10.094	10.300	10.506					
R1154x104x	10.192	10.400	10.608					
R1154x105x	10.290	10.500	10.710					
R1154x106x	10.388	10.600	10.812					
R1154x107x	10.486	10.700	10.914					
R1154x108x	10.584	10.800	11.016					
R1154x109x	10.682	10.900	11.118					
R1154x110x	10.780	11.000	11.220				0.30	0.55
R1154x111x	10.878	11.100	11.322					
R1154x112x	10.976	11.200	11.424					
R1154x113x	11.074	11.300	11.526					
R1154x114x	11.172	11.400	11.628					
R1154x115x	11.270	11.500	11.730					
R1154x116x	11.368	11.600	11.832					
R1154x117x	11.466	11.700	11.934					
R1154x118x	11.564	11.800	12.036					
R1154x119x	11.662	11.900	12.138					
R1154x120x	11.760	12.000	12.240					

R1154x001C Electrical Characteristics (Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	V_{IN} = V_{SET} + 2.0 V, I_{OUT} = 20 mA	2.45	2.50	2.55	V
I_{OUT}	Output Current	V_{IN} = V_{SET} + 2.0 V,	140			mA
I_{SS}	Supply Current	V_{IN} = V_{SET} + 2.0 V, V_{CE} = V_{IN}		5	10	μA
Istandby	Standby Current	V_{IN} = 24 V, V_{CE} = 0 V		0.1	1.0	μA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load regulation	V_{IN} = V_{SET} + 2.0 V, 1 mA ≤ I_{OUT} ≤ 40 mA		20	50	mV
$\Delta V_{OUT}/\Delta V_{IN}$	Line regulation	V_{SET} + 1 V ≤ V_{IN} ≤ 24 V, I_{OUT} = 20 mA		0.05	0.20	%/V
V_{DIF}	Dropout Voltage	I_{OUT} = 20 mA		0.20	0.40	V
I_{SC}	Short Current Limit	V_{OUT} = 0 V		45		mA
V_{CEH}	CE “H” Input Voltage		2.1		V_{IN}	V
V_{CEL}	CE “L” Input Voltage		0		0.3	V
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature		150		°C
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		125		°C

The above specifications measured at the condition of V_{OUT} = V_{ADJ}.

THEORY OF OPERATION

Thermal Shutdown

Thermal shutdown function is included in the R1154x, if the junction temperature is equal or more than +150°C (Typ.), the operation of regulator would stop. After that, when the junction temperature is equal or less than +125°C (Typ.), the operation of regulator would restart. Unless the cause of rising temperature would remove, the regulator repeats on and off, and output waveform would be like consecutive pulses.

Notes on Output Voltage Setting of R1154x001C

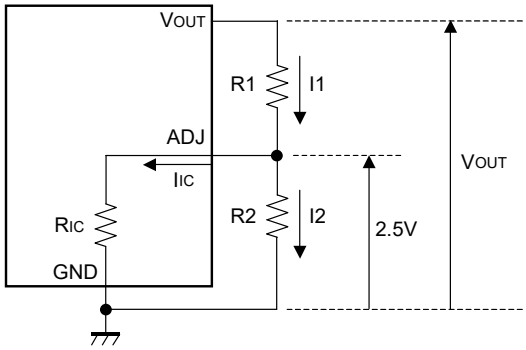


Figure 1. Adjustable Regulator (R1154x001C)

The Output Voltage of Regulator in R1154xxxxC may be adjustable for any output voltage between its 2.5 V reference and its V_{DD} setting level. An external pair of resistors is required, as shown in Figure 1. The complete equation for the output voltage is described step by step as follows.

$$I1 = I_{IC} + I2 \quad \cdots (1)$$
$$I2 = 2.5/R2 \quad \cdots (2)$$

Thus,

$$I1 = I_{IC} + 2.5/R2 \quad \cdots (3)$$

Therefore,

$$V_{OUT} = 2.5 + R1 \times I1 \quad \cdots (4)$$

Put Equation (3) into Equation (4), then

$$V_{OUT} = 2.5 + R1 \times (I_{IC} + 2.5/R2)$$
$$= 2.5 \times (1 + R1/R2) + R1 \times I_{IC} \quad \cdots (5)$$

In 2nd term, or R1 x I_{IC} will produce an error in V_{OUT}.
In Equation (5),

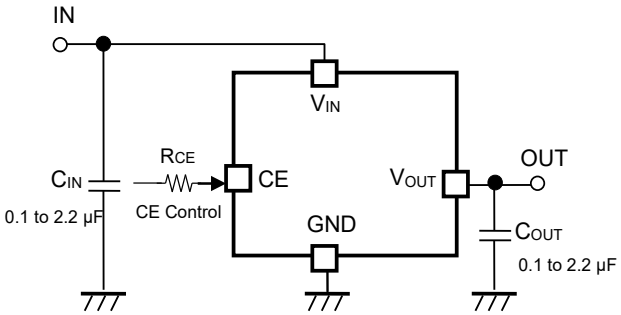
$$I_{IC} = 2.5/R_{IC} \quad \cdots (6)$$
$$R1 \times I_{IC} = R1 \times 2.5/R_{IC}$$
$$= 2.5 \times R1/R_{IC} \quad \cdots (7)$$

For better accuracy, choosing R1 (<< R_{IC}) reduces this error.

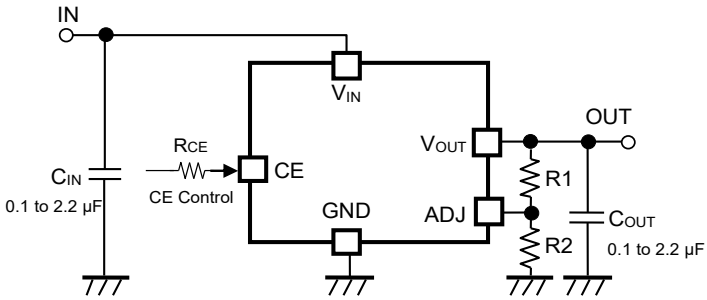
R_{IC} of the R1154x001C is approximately Typ. 17 MΩ (Ta = 25°C, guaranteed by design).
R_{IC} could be affected by the temperature, therefore evaluate the circuit taking the actual conditions of use into account when deciding the resistance values for R1 and R2.

APPLICATION INFORMATION

Typical Application



Fixed Output Voltage Type



Adjustable Type

TECHNICAL NOTES

Notes on Selecting Components

Capacitor C_{IN} and C_{OUT}

Phase Compensation of the R1154x has been made internally for stable operation even though the load current would vary. Therefore, without the capacitors, C_{IN} and C_{OUT}, the output voltage is regulated, however, for more stable operation, use capacitors as C_{IN} and C_{OUT}. Especially, if the input line is long and impedance is high, C_{IN} is necessary, moreover, if you use C_{OUT}, transient response will be improved. Recommended value is in the range from 0.1 µF to 2.2 µF. Wiring should be made as short as possible.

Connect the capacitor, C_{IN} between V_{DD} pin and GND pin and C_{OUT} between V_{OUT} and GND as close as possible.

Chip Enable Input

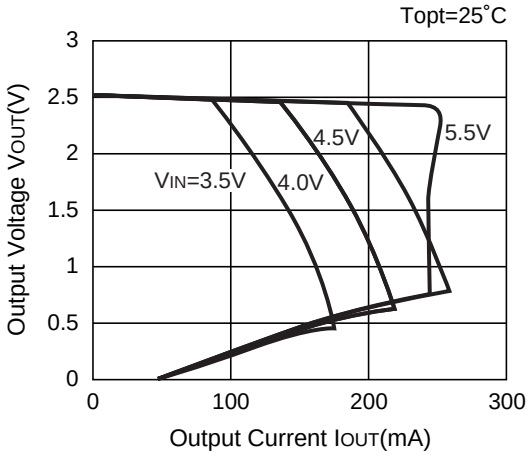
Do not make voltage level of chip enable pin keep floating level, or in between V_{IH} and V_{IL}. Unless otherwise, Output voltage would be unstable or indefinite, or unexpected current would flow internally.

TYPICAL CHARACTERISTICS

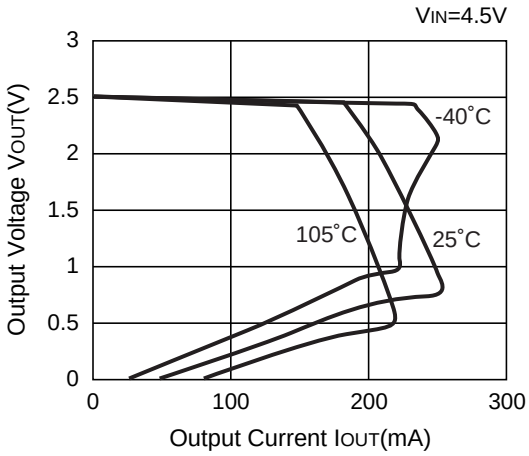
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

1) Output Voltage vs. Output Current

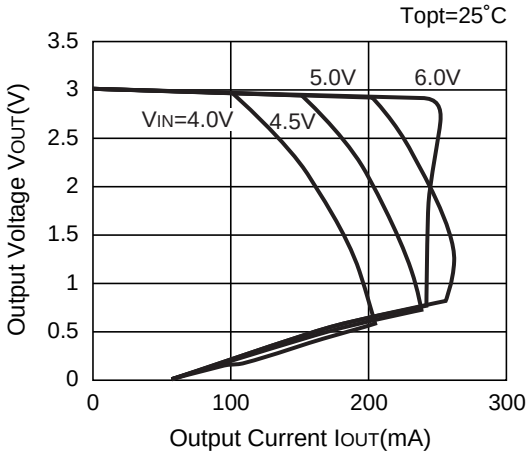
R1154x025B



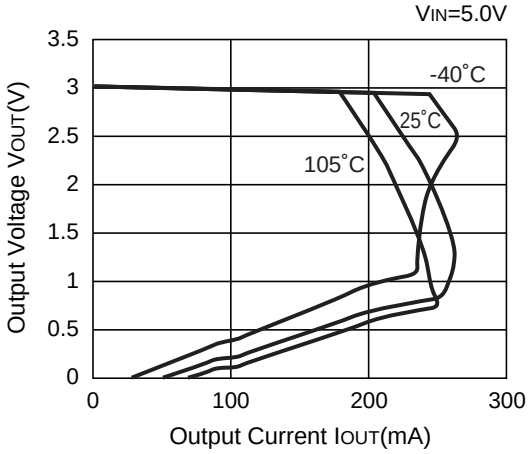
R1154x025B



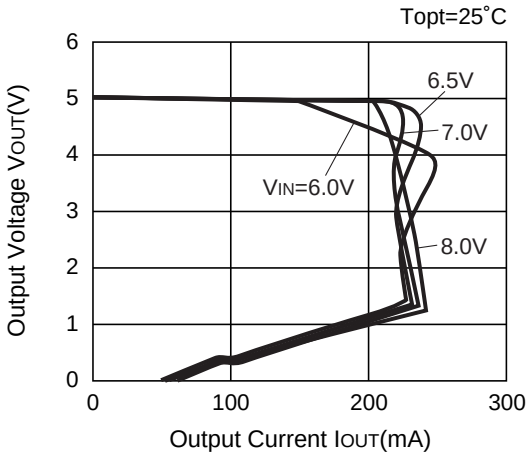
R1154x030B



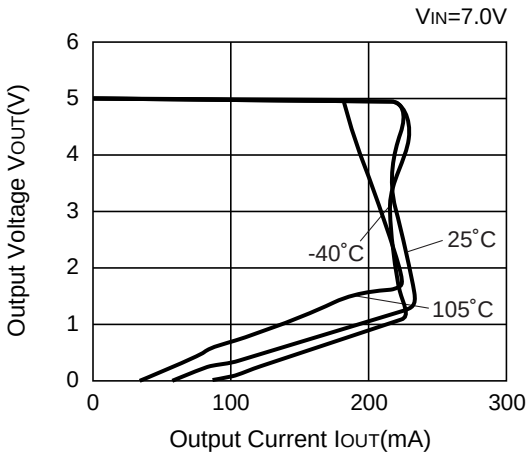
R1154x030B



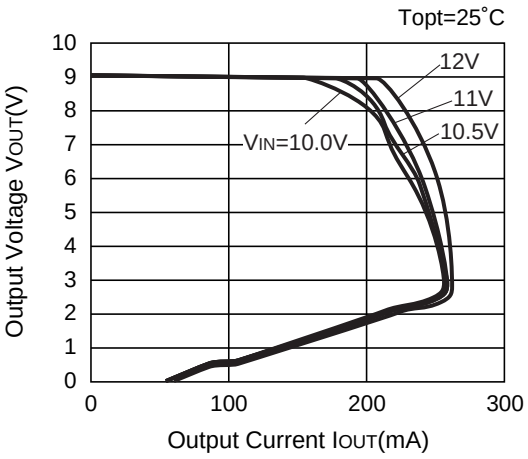
R1154x050B



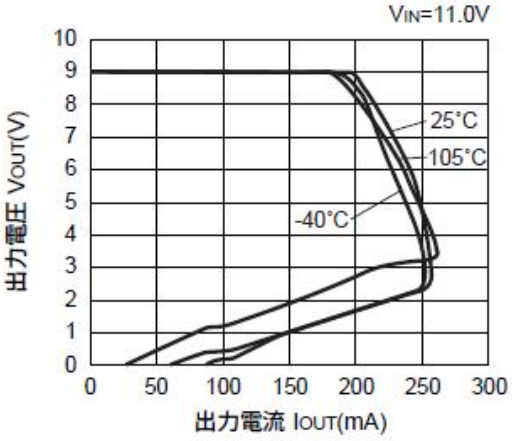
R1154x050B



R1154x090B

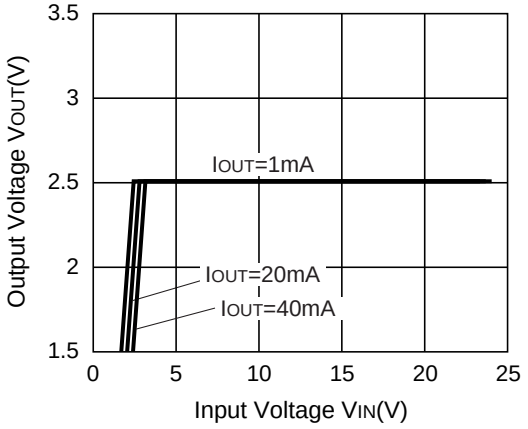


R1154x090B

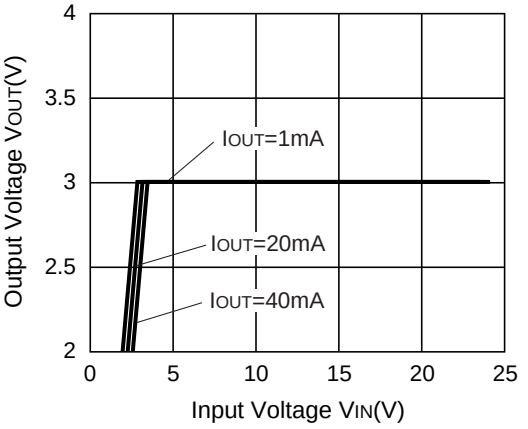


2) Input Voltage vs. Output Voltage (Ta = 25°C)

R1154x025B



R1154x030B



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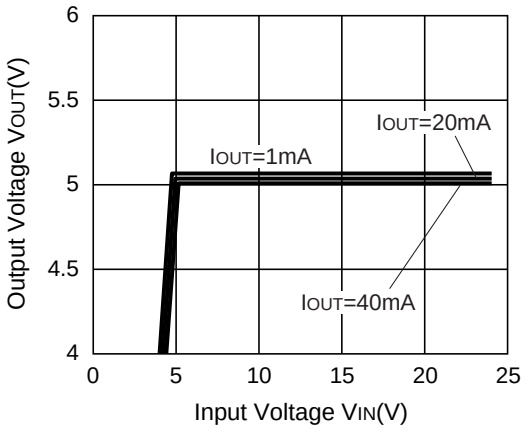

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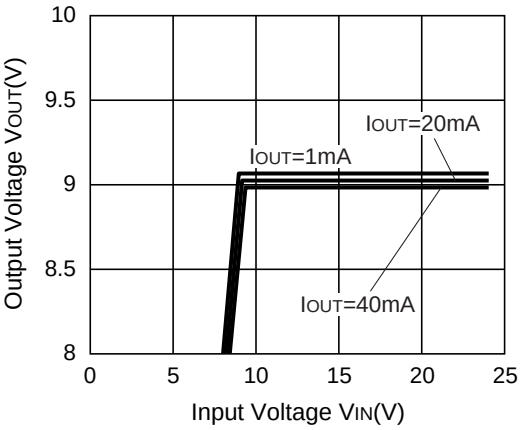
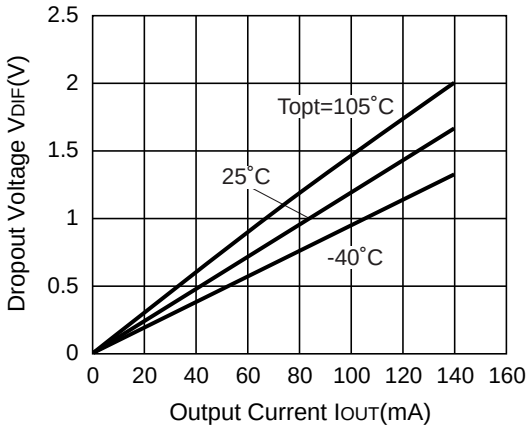


3) Dropout Voltage vs. Output Current

R1154x025B



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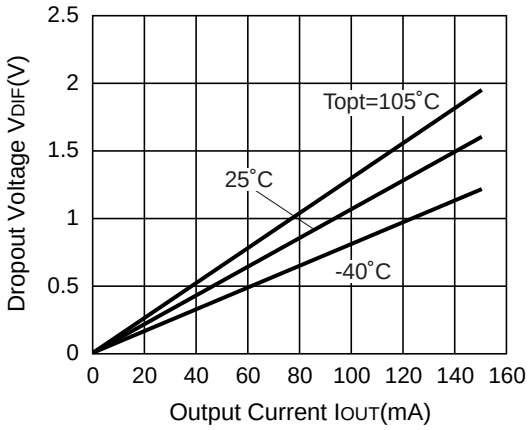

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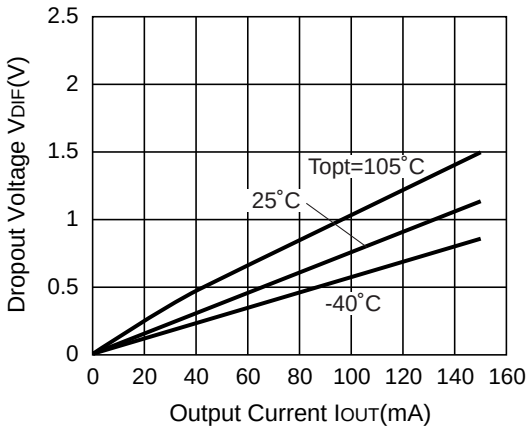
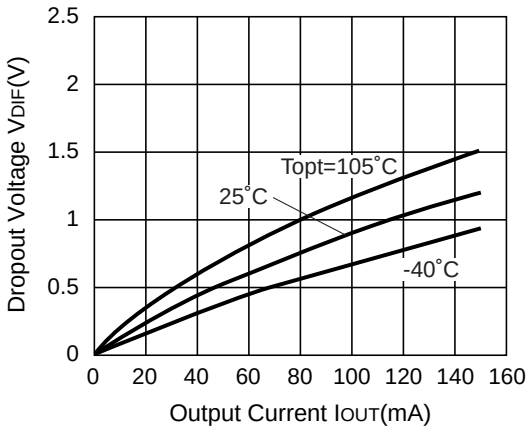
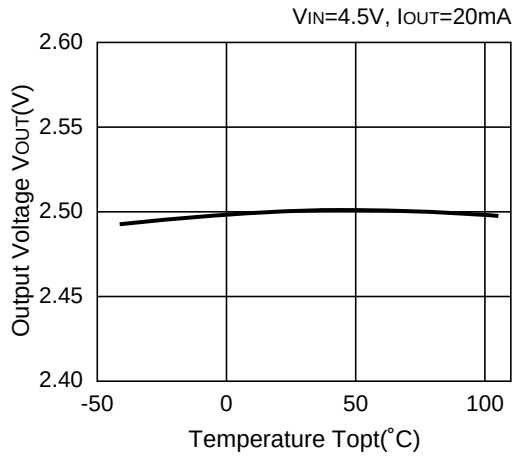


R1154x090B

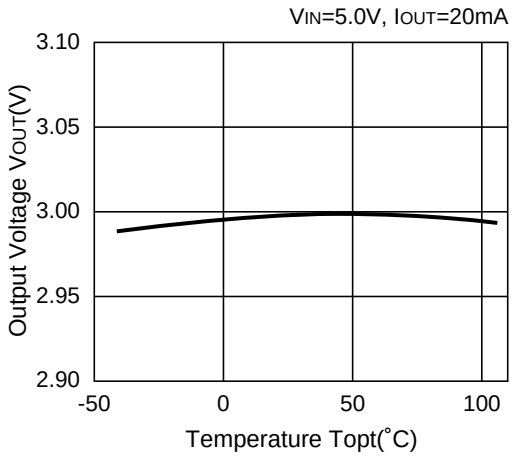


4) Output Voltage vs. Temperature

R1154x025B



R1154x030B



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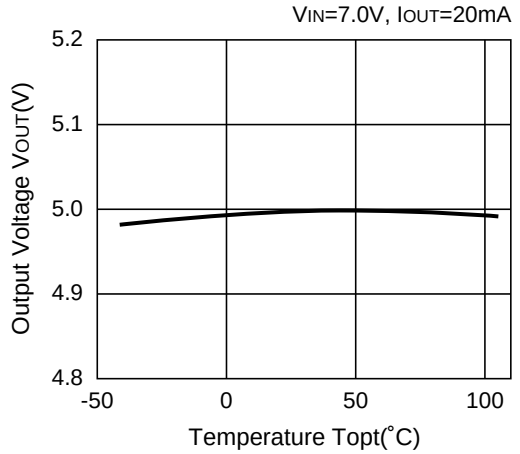
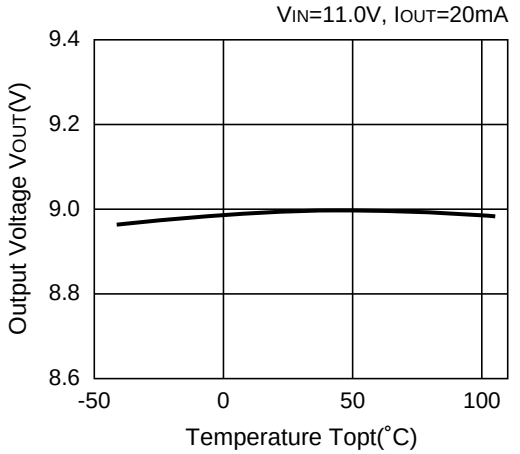
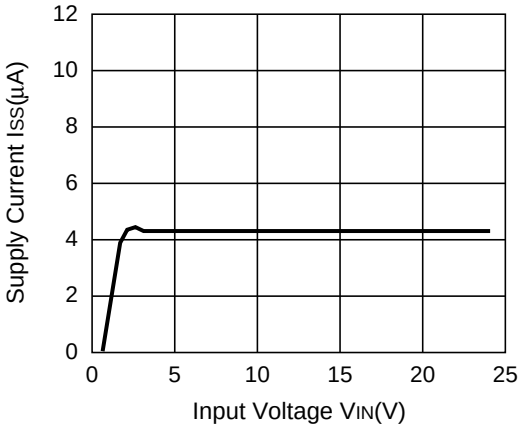


R1154x090B



5) Supply Current vs. Input Voltage (Ta = 25°C)

R1154x025B



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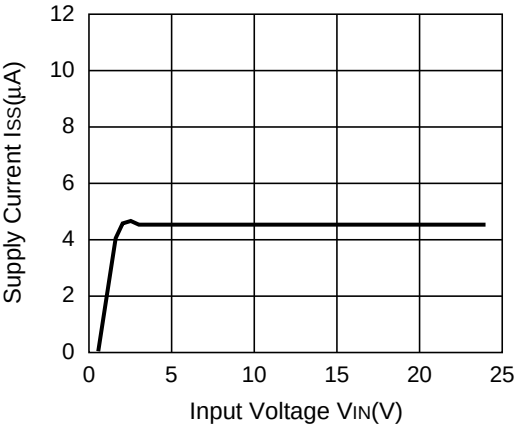

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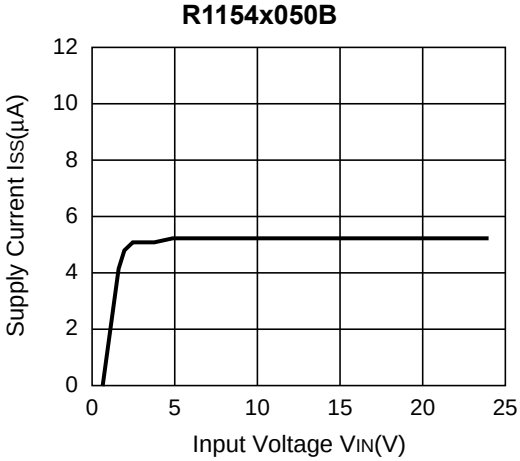
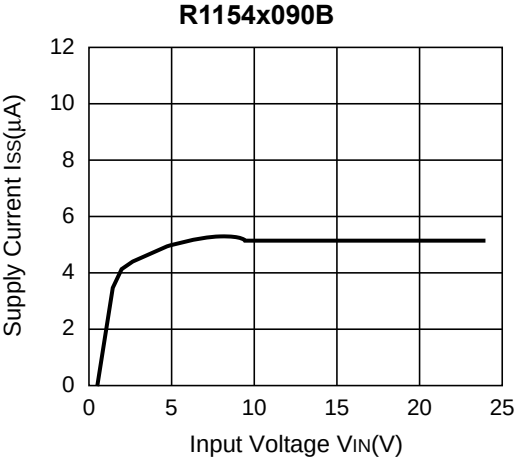
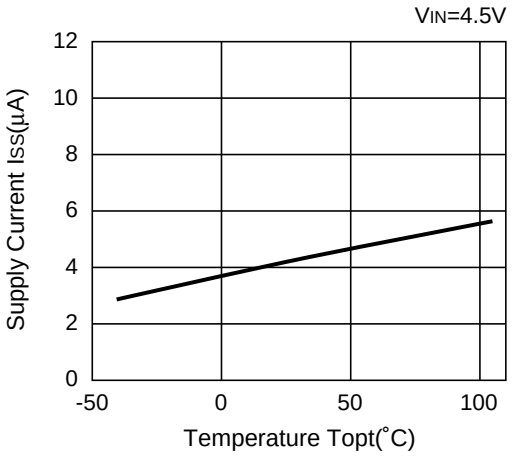


R1154x090B

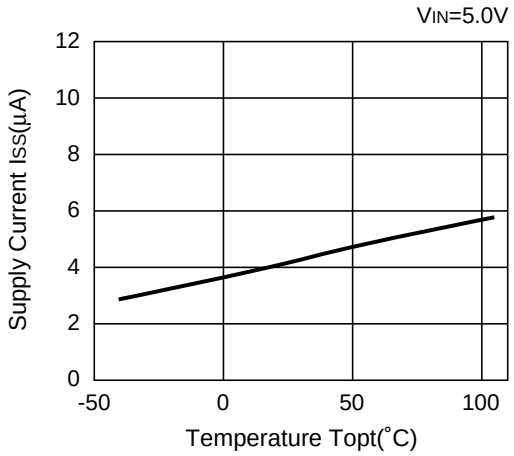


6) Supply Current vs. Temperature

R1154x025B



R1154x030B



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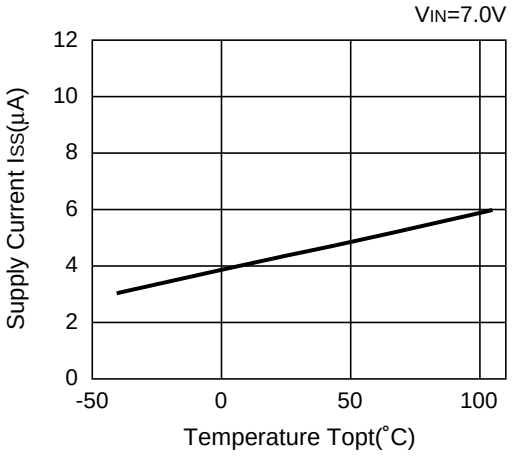
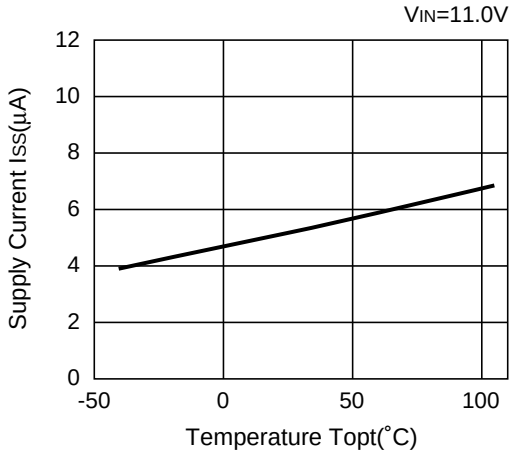
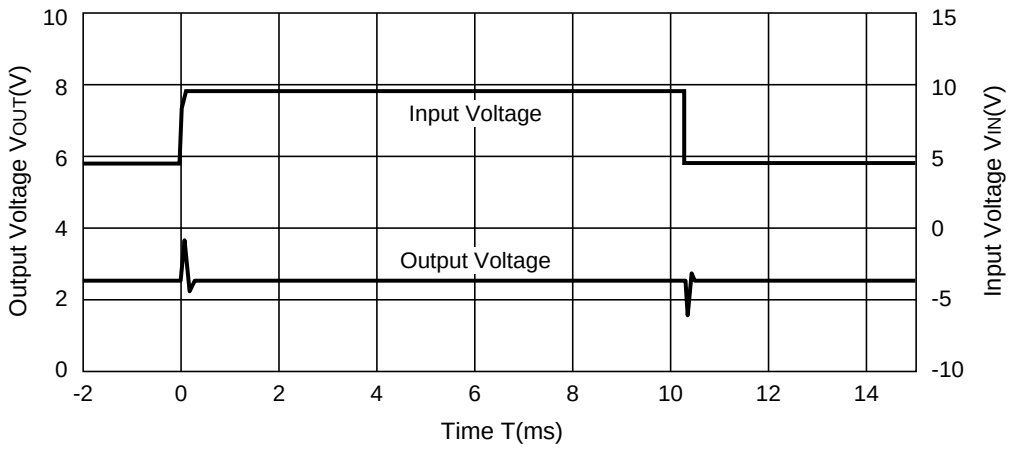


R1154x090B



7) Input Transient Response (I_{OUT} = 20 mA, C_{OUT} = 0.1 µF, Ta = 25°C)

R1154x025B



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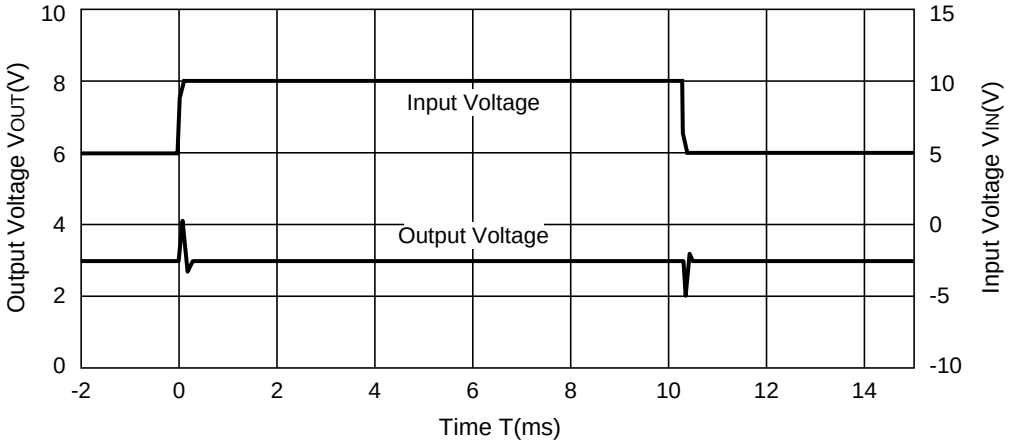

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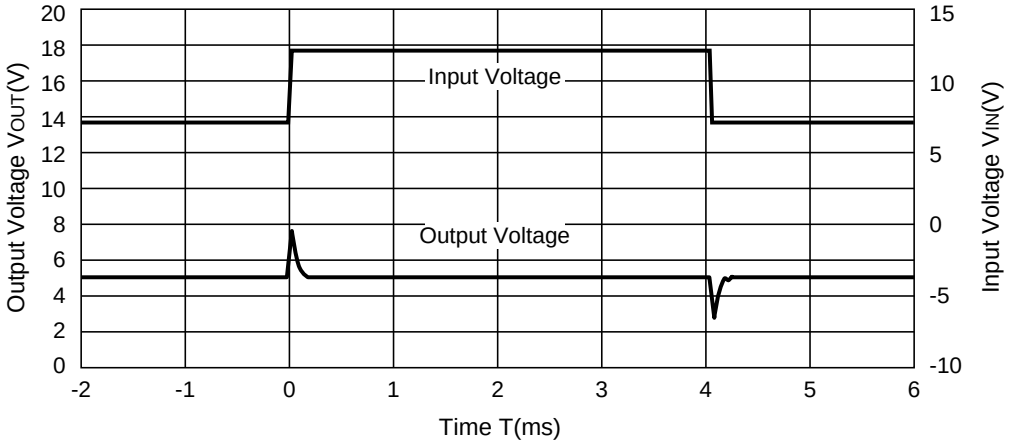
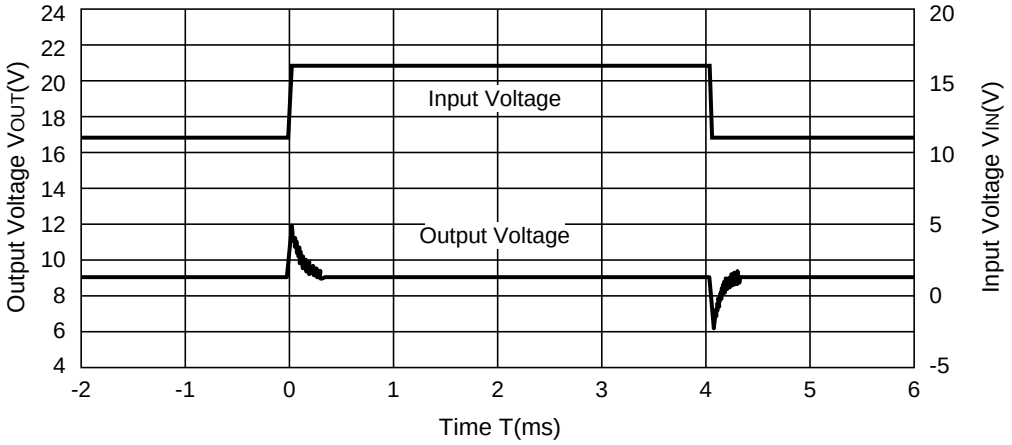
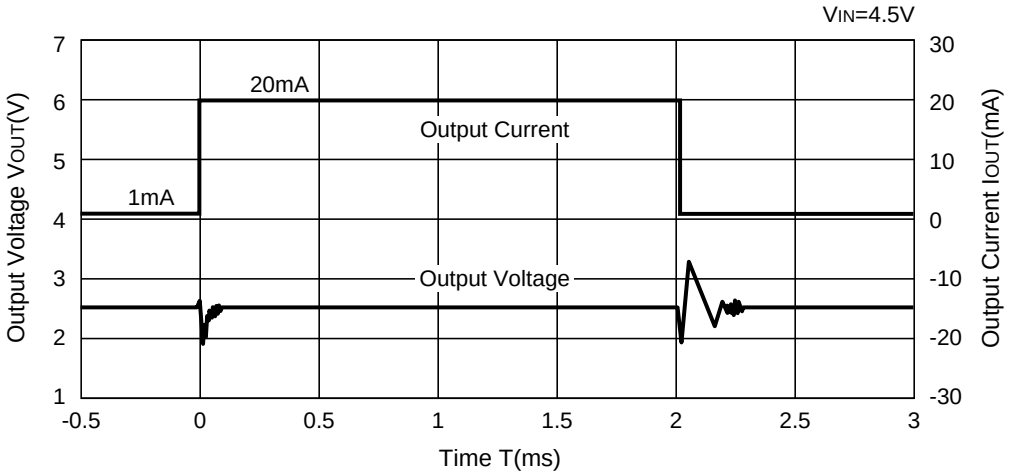


R1154x090B



8) Load Transient Response (C_{OUT} = 0.1 μF, Ta = 25°C)

R1154x025B



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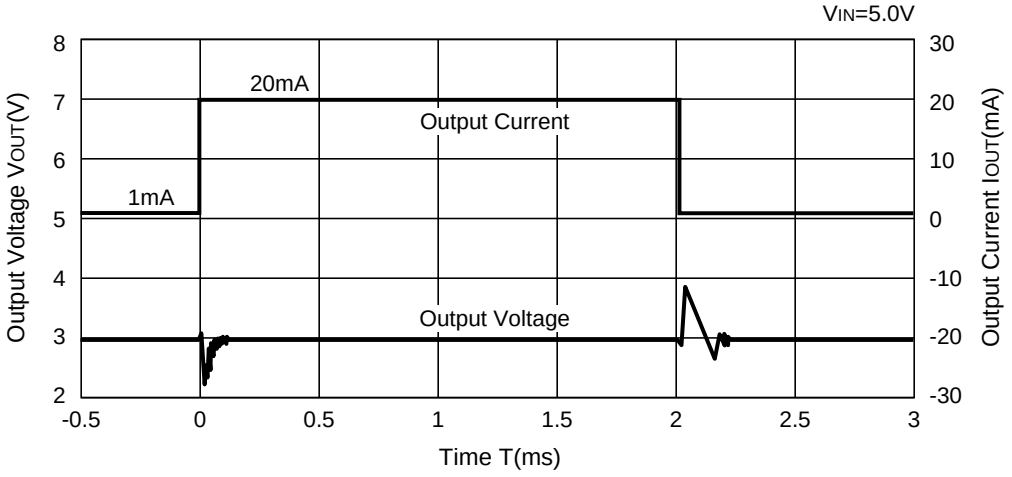
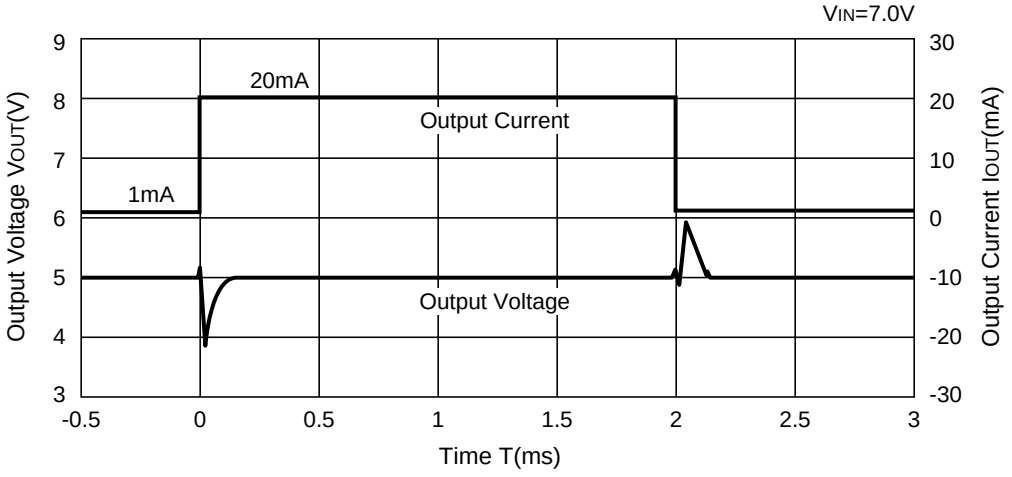
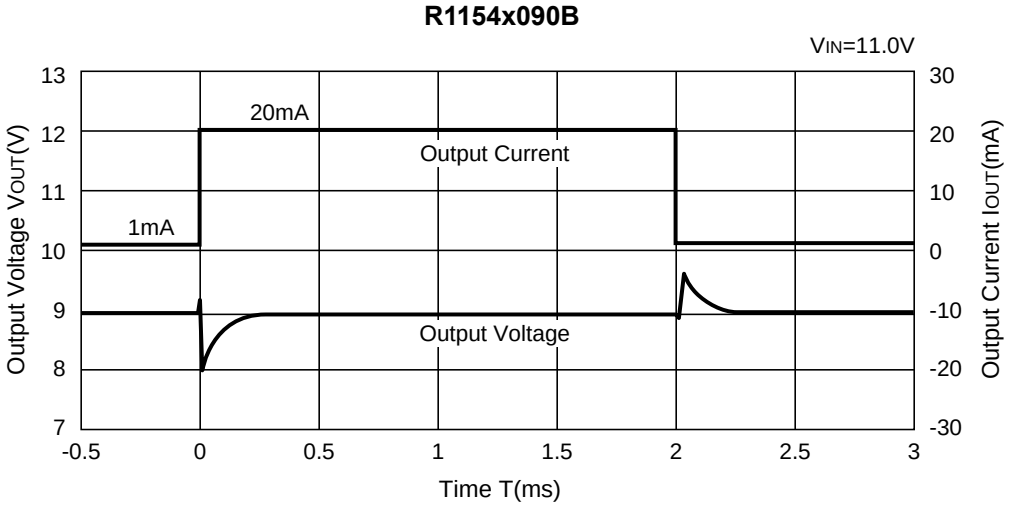
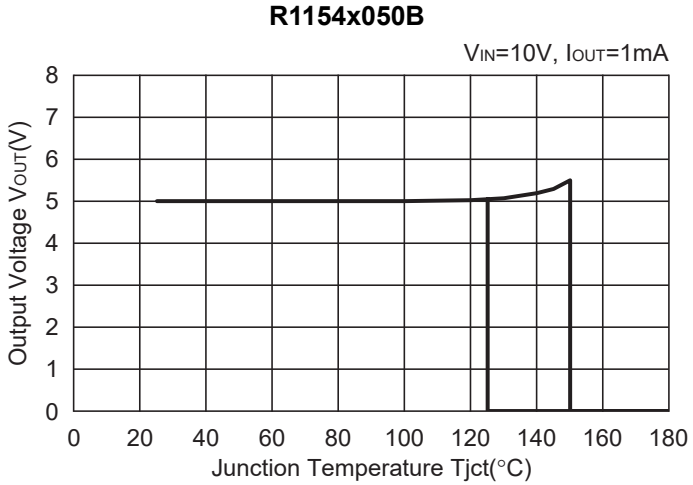


R1154x050B





9) Thermal Shutdown Characteristics



PD-DFN1616-6-(105125)-JE-B

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

Measurement Conditions

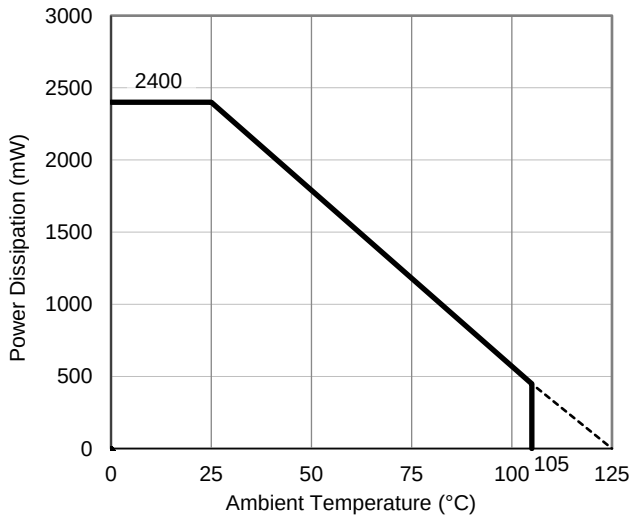
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	ϕ 0.2 mm × 25 pcs

Measurement Result (Ta = 25°C, Tjmax = 125°C)

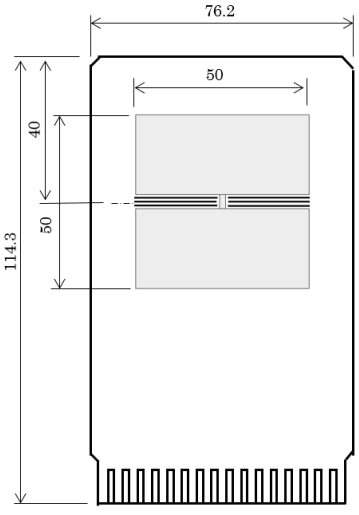
Item	Measurement Result
Power Dissipation	2400 mW
Thermal Resistance (θja)	θja = 41°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 11°C/W

θja: Junction-to-Ambient Thermal Resistance

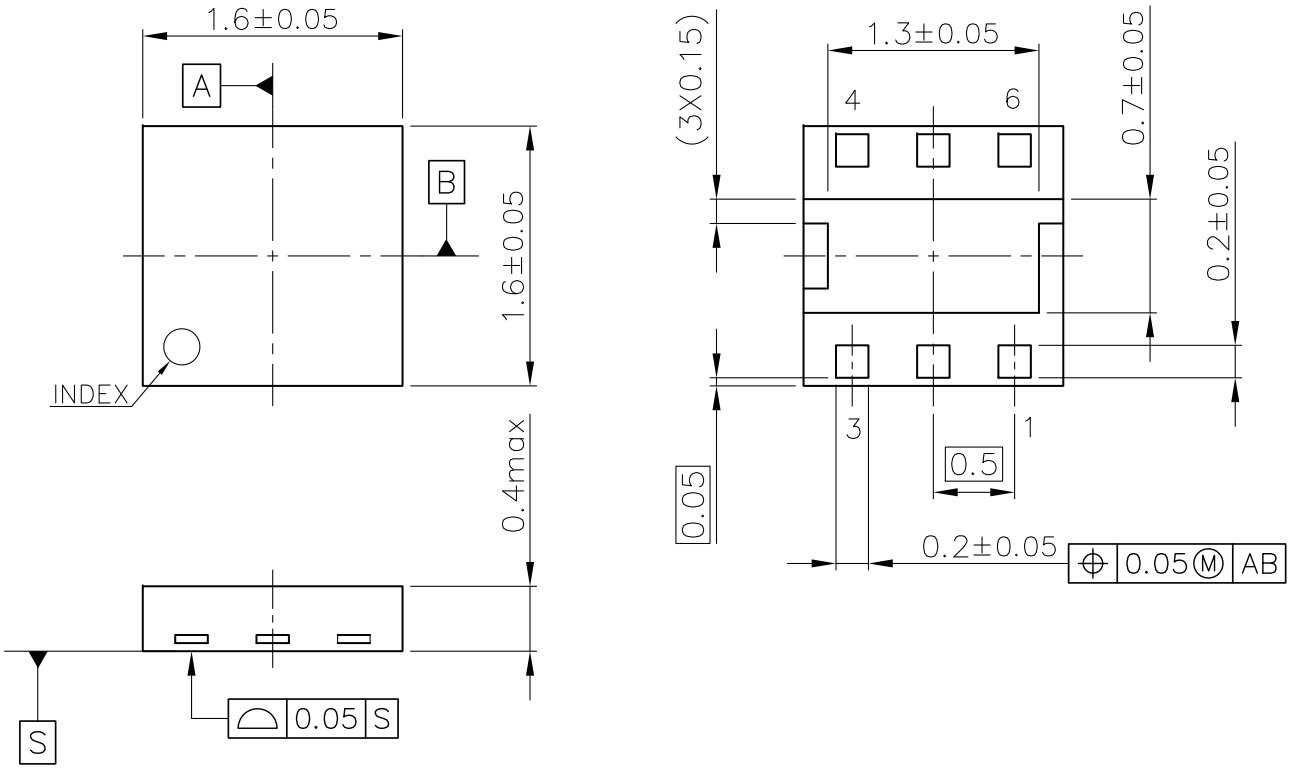
ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern



DFN1616-6 Package Dimensions (Unit: mm)

* The tab on the bottom of the package shown by blue circle is a substrate potential (GND/V_{DD}). It is recommended that this tab be connected to the ground plane/VDD pin on the board but it is possible to leave the tab floating.

Ver. A

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

Measurement Conditions

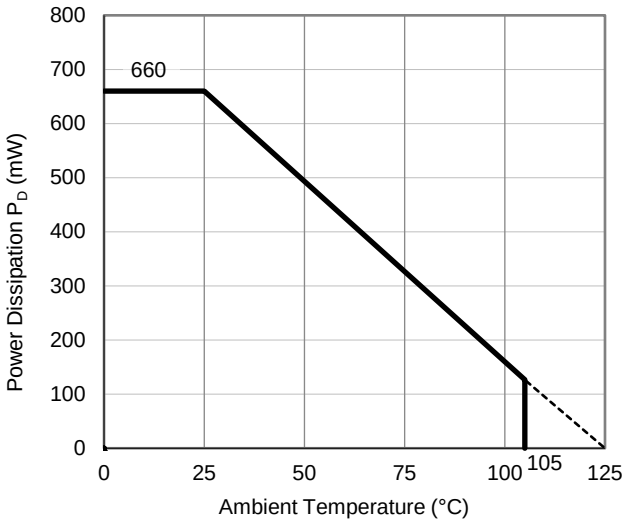
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	ϕ 0.3 mm × 7 pcs

Measurement Result (Ta = 25°C, Tjmax = 125°C)

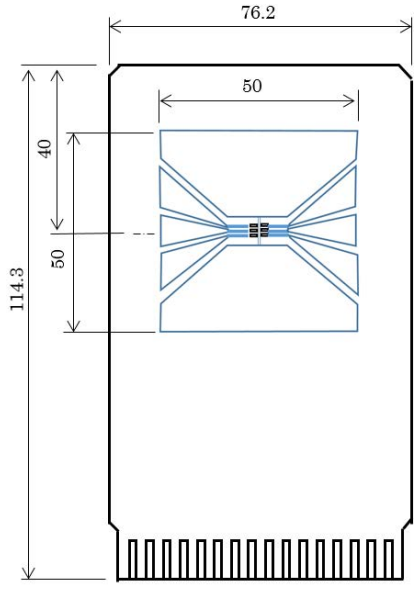
Item	Measurement Result
Power Dissipation	660 mW
Thermal Resistance (θja)	θja = 150°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 51°C/W

θja: Junction-to-Ambient Thermal Resistance

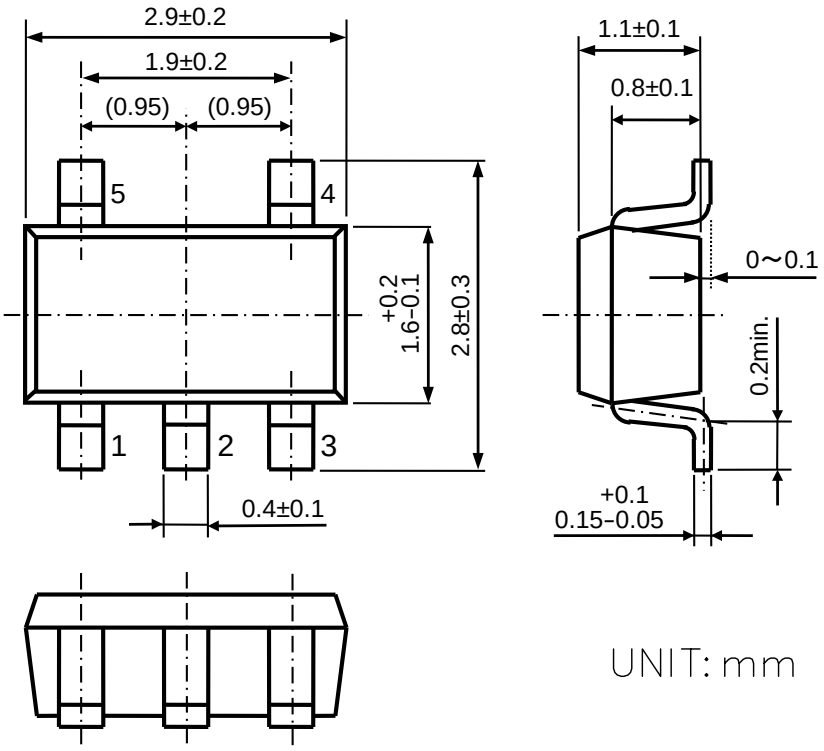
ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern



SOT-23-5 Package Dimensions

Ver. A

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

Measurement Conditions

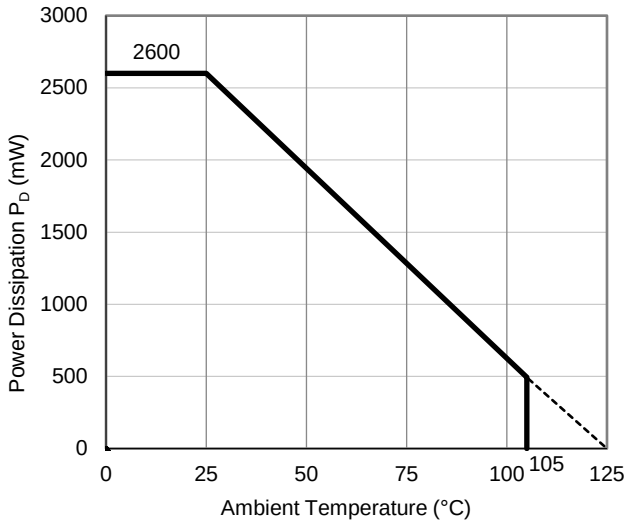
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	ϕ 0.3 mm × 13 pcs

Measurement Result (Ta = 25°C, Tjmax = 125°C)

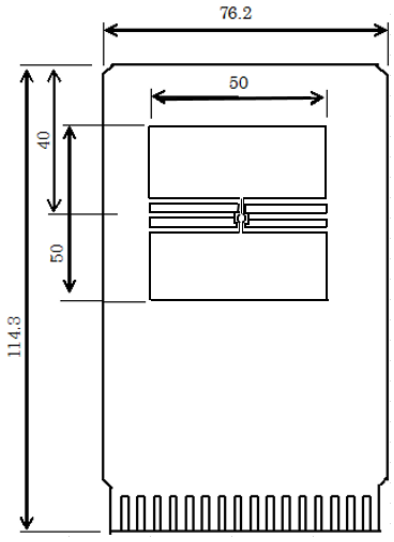
Item	Measurement Result
Power Dissipation	2600 mW
Thermal Resistance (θja)	θja = 38°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 13°C/W

θja: Junction-to-Ambient Thermal Resistance

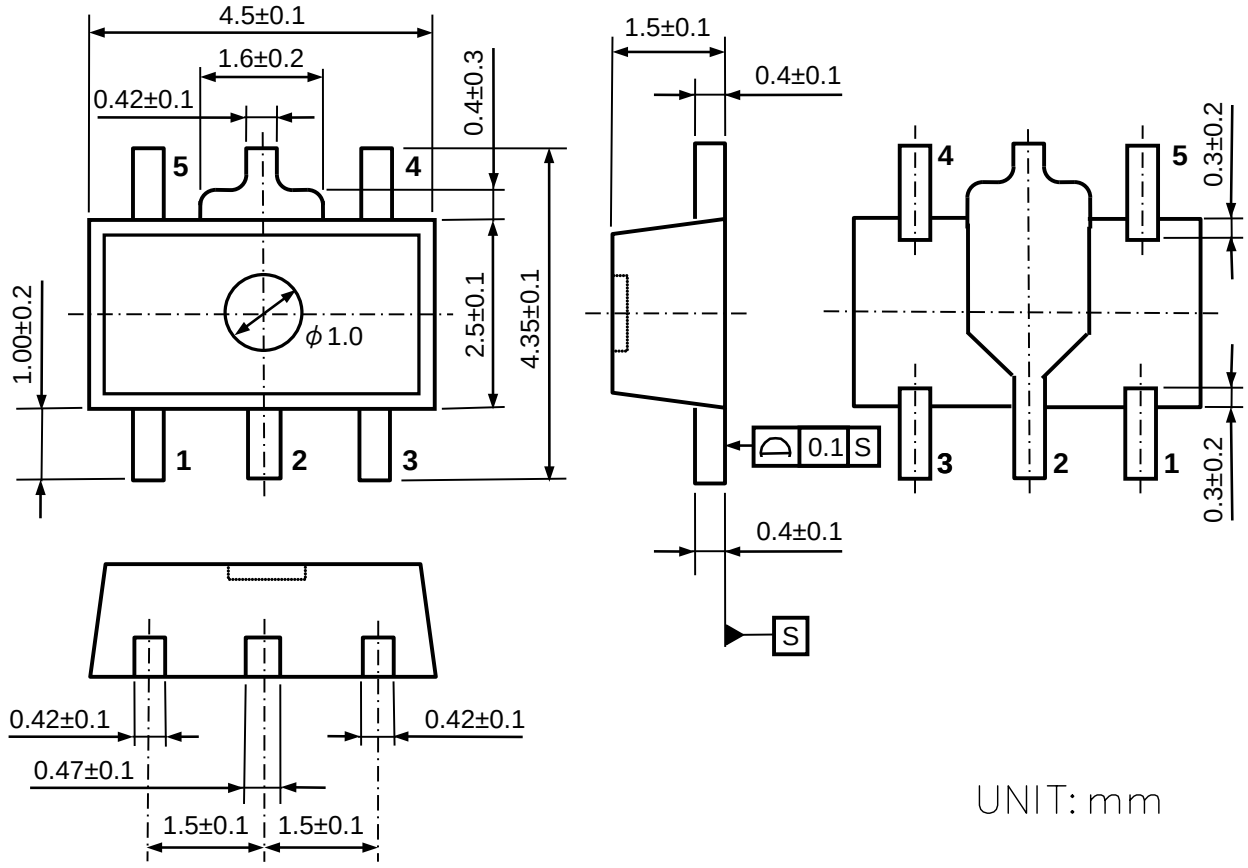
ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern



SOT-89-5 Package Dimensions

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    In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.
    8-2. Quality Warranty Remedies
    When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.
    Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.
    8-3. Remedies after Quality Warranty Period
    With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
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10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
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