S-T111 Series

HIGH RIPPLE-REJECTION LOW DROPOUT CMOS VOLTAGE REGULATOR

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The S-T111 Series is a positive voltage regulator with a low dropout voltage, high-accuracy output voltage, and low current consumption developed based on CMOS technology.
A built-in low on-resistance transistor provides a low dropout voltage and large output current, and a built-in overcurrent protection circuit prevents the load current from exceeding the current capacity of the output transistor. An ON/OFF circuit ensures a long battery life. Compared with the voltage regulators using the conventional CMOS technology, a larger variety of capacitors are available, including small ceramic capacitors. A small SOT-23-5 package realizes high-density mounting.

■ Features

- Output voltage: 1.5 V to 5.5 V, selectable in 0.1 V step
- Output voltage accuracy: ±1.0%
- Dropout voltage: 190 mV typ. (3.0 V output product, I_{OUT} = 100 mA)
- Current consumption: During operation: 50 μA typ., 90 μA max.
  During power-off: 0.1 μA typ., 1.0 μA max.
- Output current: Possible to output 150 mA ($V_{IN} \geq V_{OUT(S)} + 1.0$ V)*1
- Input and output capacitors: A ceramic capacitor of 0.1 μF or more can be used.
- Ripple rejection: 80 dB typ. (f = 1.0 kHz)
- Built-in overcurrent protection circuit: Limits overcurrent of output transistor.
- Built-in ON/OFF circuit: Ensures long battery life.
- Operation temperature range: Ta = −40°C to +85°C
- Lead-free, Sn 100%, halogen-free*2

***1.** Attention should be paid to the power dissipation of the package when the output current is large.
***2.** Refer to "■ **Product Name Structure**" for details.

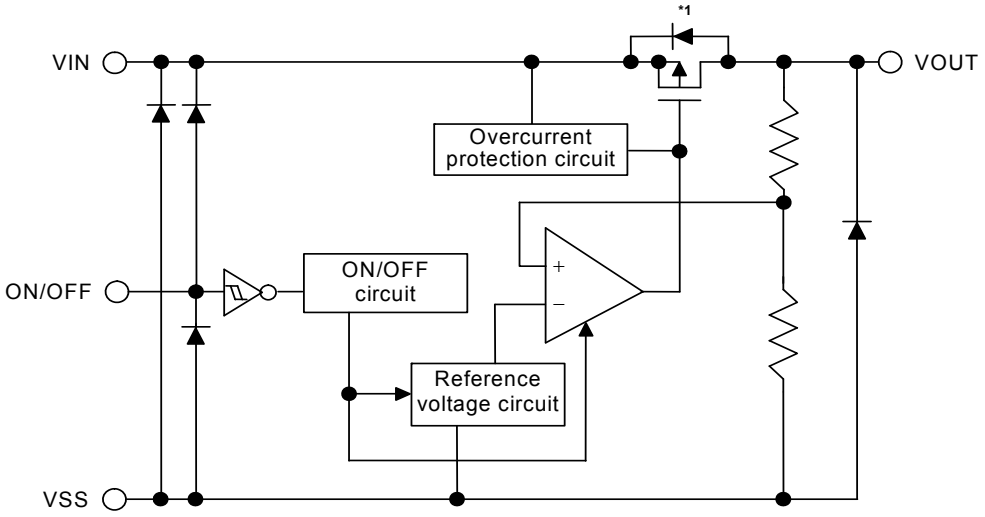
■ Applications

- Constant-voltage power supply for battery-powered device
- Constant-voltage power supply for personal communication device
- Constant-voltage power supply for home electric appliance
- Constant-voltage power supply for cellular phone

■ Package

- SOT-23-5

■ Block Diagram



***1.** Parasitic diode

Figure 1

■ Product Name Structure

- Users can select the product type, output voltage for the S-T111 Series. Refer to "**1. Product name**" regarding the contents of product name, "**2. Package**" regarding the package drawings, "**3. Product name list**" regarding details of the product name.

1. Product name

S-T111 x xx MC - xxx TF x

- Environmental code
  - U: Lead-free (Sn 100%), halogen-free
  - G: Lead-free (for details, please contact our sales office)
- IC direction in tape specifications*1
- Product name (abbreviation)*2
- Package name (abbreviation)
  - MC: SOT-23-5
- Output voltage
  - 15 to 55
  - (e.g. when the output voltage is 1.5 V, it is expressed as 15.)
- Product type*3
  - A: ON/OFF pin negative logic
  - B: ON/OFF pin positive logic

***1.** Refer to the tape drawing.
***2.** Refer to the product name list.
***3.** Refer to "**3. ON/OFF pin**" in "■ **Operation**".

2. Package

Package Name	Drawing Code		
	Package	Tape	Reel
SOT-23-5	MP005-A-P-SD	MP005-A-C-SD	MP005-A-R-SD

3. Product name list

Table 1

Output Voltage	Product Name
1.5V±1.0%	S-T111B15MC-OGATFx
1.6V±1.0%	S-T111B16MC-OGBTFx
1.7V±1.0%	S-T111B17MC-OGCTFx
1.8V±1.0%	S-T111B18MC-OGDTFx
1.9V±1.0%	S-T111B19MC-OGETFx
2.0V±1.0%	S-T111B20MC-OGFTFx
2.1V±1.0%	S-T111B21MC-OGGTFx
2.2V±1.0%	S-T111B22MC-OGHTFx
2.3V±1.0%	S-T111B23MC-OGITFx
2.4V±1.0%	S-T111B24MC-OGJTFx
2.5V±1.0%	S-T111B25MC-OGKTFx
2.6V±1.0%	S-T111B26MC-OGLTFx
2.7V±1.0%	S-T111B27MC-OGMTFx
2.8V±1.0%	S-T111B28MC-OGNTFx
2.9V±1.0%	S-T111B29MC-OGOTFx
3.0V±1.0%	S-T111B30MC-OGPTFx
3.1V±1.0%	S-T111B31MC-OGQTFx
3.2V±1.0%	S-T111B32MC-OGRTFx
3.3V±1.0%	S-T111B33MC-OGSTFx
3.4V±1.0%	S-T111B34MC-OGTTFx
3.5V±1.0%	S-T111B35MC-OGUTFx
3.6V±1.0%	S-T111B36MC-OGVTFx
3.7V±1.0%	S-T111B37MC-OGWTFx
3.8V±1.0%	S-T111B38MC-OGXTFx
3.9V±1.0%	S-T111B39MC-OGYTFx
4.0V±1.0%	S-T111B40MC-OGZTFx
4.1V±1.0%	S-T111B41MC-OHATFx
4.2V±1.0%	S-T111B42MC-OHBTFx
4.3V±1.0%	S-T111B43MC-OHCTFx
4.4V±1.0%	S-T111B44MC-OHDTFx
4.5V±1.0%	S-T111B45MC-OHETFx
4.6V±1.0%	S-T111B46MC-OHFTFx
4.7V±1.0%	S-T111B47MC-OHGTFx
4.8V±1.0%	S-T111B48MC-OHHTFx
4.9V±1.0%	S-T111B49MC-OHITFx
5.0V±1.0%	S-T111B50MC-OHJTFx
5.1V±1.0%	S-T111B51MC-OHKTFx
5.2V±1.0%	S-T111B52MC-OHLTFx
5.3V±1.0%	S-T111B53MC-OHMTFx
5.4V±1.0%	S-T111B54MC-OHNTFx
5.5V±1.0%	S-T111B55MC-OHOTFx

Remark 1. Please contact our sales office for products with type A.
2. x: G or U
3. Please select products of environmental code = U for Sn 100%, halogen-free products.

■ Pin Configuration

SOT-23-5
Top view

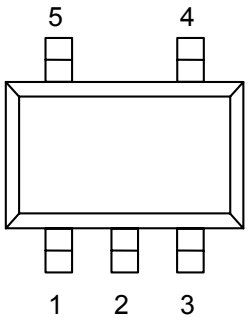


Figure 2

Table 2

Pin No.	Symbol	Description
1	ON/OFF	ON/OFF pin
2	VSS	GND pin
3	NC*1	No connection
4	VOUT	Output voltage pin
5	VIN	Input voltage pin

***1.** The NC pin is electrically open.
The NC pin can be connected to VIN pin or VSS pin.

■ Absolute Maximum Ratings

Table 3

(Ta = 25°C unless otherwise specified)

Item	Symbol	Absolute Maximum Rating	Unit
Input voltage	V_{IN}	V_{SS} − 0.3 to V_{SS} + 7	V
	$V_{ON/OFF}$	V_{SS} − 0.3 to V_{IN} + 0.3	V
Output voltage	V_{OUT}	V_{SS} − 0.3 to V_{IN} + 0.3	V
Power dissipation	P_D	300 (When not mounted on board)	mW
		600*1	mW
Operation ambient temperature	T_{opr}	−40 to +85	°C
Storage temperature	T_{stg}	−40 to +125	°C

***1.** When mounted on board
[Mounted board]
(1) Board size : 114.3 mm × 76.2 mm × t1.6 mm
(2) Board name : JEDEC STANDARD51-7

Caution The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

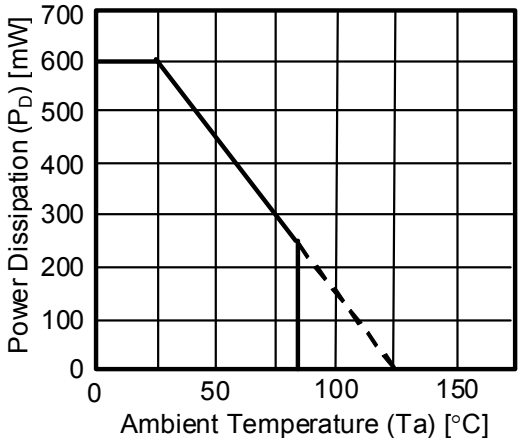


Figure 3 Power Dissipation of Package (When Mounted on Board)

■ Electrical Characteristics

Table 4

(Ta = 25°C unless otherwise specified)

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Test Circuit
Output voltage[*1]	$V_{OUT(E)}$	$V_{IN} = V_{OUT(S)} + 1.0$ V, I_{OUT} = 30 mA		$V_{OUT(S)} \times 0.99$	$V_{OUT(S)}$	$V_{OUT(S)} \times 1.01$	V	1
Output current[*2]	I_{OUT}	$V_{IN} \geq V_{OUT(S)} + 1.0$ V		150[*5]	—	—	mA	3
Dropout voltage[*3]	V_{drop}	I_{OUT} = 50 mA	1.5 V ≤ $V_{OUT(S)}$ ≤ 2.7 V	Not specified			V	1
			2.8 V ≤ $V_{OUT(S)}$ ≤ 5.5 V	—	0.08	0.14	V	1
		I_{OUT} = 100 mA	1.5 V ≤ $V_{OUT(S)}$ ≤ 1.6 V	—	0.32	0.55	V	1
			1.7 V ≤ $V_{OUT(S)}$ ≤ 1.8 V	—	0.28	0.47	V	1
			1.9 V ≤ $V_{OUT(S)}$ ≤ 2.3 V	—	0.25	0.35	V	1
			2.4 V ≤ $V_{OUT(S)}$ ≤ 2.7 V	—	0.20	0.29	V	1
			2.8 V ≤ $V_{OUT(S)}$ ≤ 5.5 V	—	0.19	0.26	V	1
Line regulation	$\frac{\Delta V_{OUT1}}{\Delta V_{IN} \bullet V_{OUT}}$	$V_{OUT(S)} + 0.5$ V ≤ V_{IN} ≤ 6.5 V, I_{OUT} = 30 mA		—	0.05	0.2	%/V	1
Load regulation	ΔV_{OUT2}	$V_{IN} = V_{OUT(S)} + 1.0$ V, 1.0 mA ≤ I_{OUT} ≤ 80 mA		—	12	40	mV	1
Output voltage temperature coefficient[*4]	$\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}$	$V_{IN} = V_{OUT(S)} + 1.0$ V, I_{OUT} = 10 mA, −40°C ≤ Ta ≤ 85°C		—	±100	—	ppm/°C	1
Current consumption during operation	I_{SS1}	$V_{IN} = V_{OUT(S)} + 1.0$ V, ON/OFF pin = ON, no load		—	50	90	μA	2
Current consumption during power-off	I_{SS2}	$V_{IN} = V_{OUT(S)} + 1.0$ V, ON/OFF pin = OFF, no load		—	0.1	1.0	μA	2
Input voltage	V_{IN}	—		2.0	—	6.5	V	—
ON/OFF pin input voltage "H"	V_{SH}	$V_{IN} = V_{OUT(S)} + 1.0$ V, R_L = 1.0 kΩ		1.5	—	—	V	4
ON/OFF pin input voltage "L"	V_{SL}	$V_{IN} = V_{OUT(S)} + 1.0$ V, R_L = 1.0 kΩ		—	—	0.3	V	4
ON/OFF pin input current "H"	I_{SH}	V_{IN} = 6.5 V, $V_{ON/OFF}$ = 6.5 V		−0.1	—	0.1	μA	4
ON/OFF pin input current "L"	I_{SL}	V_{IN} = 6.5 V, $V_{ON/OFF}$ = 0 V		−0.1	—	0.1	μA	4
Ripple rejection	$\lvert RR \rvert$	$V_{IN} = V_{OUT(S)} + 1.0$ V, f = 1.0 kHz, ΔV_{rip} = 0.5 Vrms, I_{OUT} = 30 mA		—	80	—	dB	5
Short-circuit current	I_{short}	$V_{IN} = V_{OUT(S)} + 1.0$ V, ON/OFF pin = ON, V_{OUT} = 0 V		—	200	—	mA	3

***1.** $V_{OUT(S)}$: Set output voltage
$V_{OUT(E)}$: Actual output voltage
Output voltage when fixing I_{OUT} (= 30 mA) and inputting $V_{OUT(S)} + 1.0$ V

***2.** The output current at which the output voltage becomes 95% of $V_{OUT(E)}$ after gradually increasing the output current.

***3.** $V_{drop} = V_{IN1} - (V_{OUT3} \times 0.98)$
V_{OUT3} is the output voltage when $V_{IN} = V_{OUT(S)} + 1.0$ V and I_{OUT} = 50 mA or I_{OUT} = 100 mA.
V_{IN1} is the input voltage at which the output voltage becomes 98% of V_{OUT3} after gradually decreasing the input voltage.

***4.** A change in the temperature of the output voltage [mV/°C] is calculated using the following equation.

$$\frac{\Delta V_{OUT}}{\Delta Ta}\ [\text{mV/°C}]^{*1} = V_{OUT(S)}\ [\text{V}]^{*2} \times \frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}\ [\text{ppm/°C}]^{*3} \div 1000$$

***1.** Change in temperature of output voltage
***2.** Set output voltage
***3.** Output voltage temperature coefficient

***5.** The output current can be at least this value.
Due to restrictions on the package power dissipation, this value may not be satisfied. Attention should be paid to the power dissipation of the package when the output current is large.
This specification is guaranteed by design.

■ Test Circuits

1.

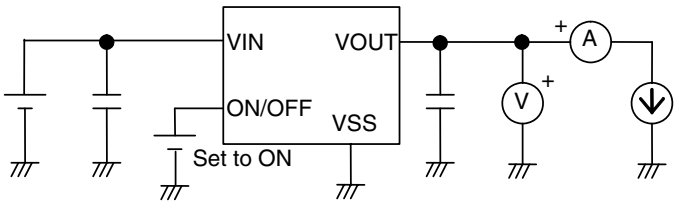


Figure 4

2.

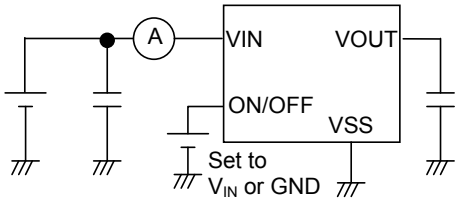


Figure 5

3.

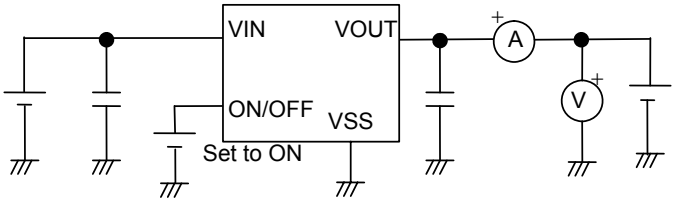


Figure 6

4.

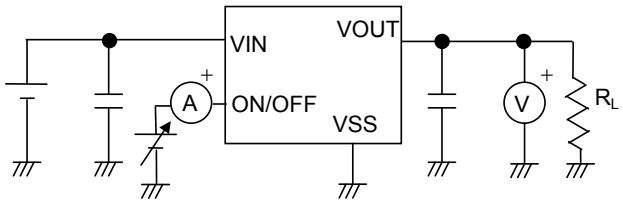


Figure 7

5.

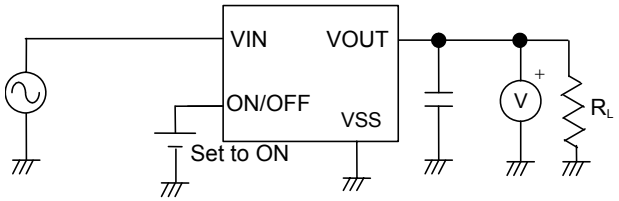
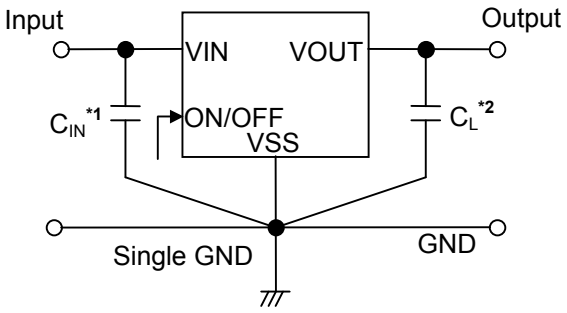


Figure 8

■ Standard Circuit



***1.** C_{IN} is a capacitor for stabilizing the input.
***2.** A ceramic capacitor of 0.1 μF or more can be used for C_L.

Figure 9

Caution The above connection diagram and constant will not guarantee successful operation. Perform thorough evaluation using the actual application to set the constant.

■ Condition of Application

Input capacitor (C_{IN}): 0.1 μF or more
Output capacitor (C_L): 0.1 μF or more
ESR of output capacitor: 10 Ω or less

Caution Generally a series regulator may cause oscillation, depending on the selection of external parts. Check that no oscillation occurs with the application using the above capacitor.

■ Selection of Input and Output Capacitors (C_{IN}, C_L)

The S-T111 Series requires an output capacitor between the VOUT pin and the VSS pin for phase compensation. Operation is stabilized by a ceramic capacitor with an output capacitance of 0.1 μF or more in the entire temperature range. When using an OS capacitor, a tantalum capacitor, or an aluminum electrolytic capacitor, the capacitance must be 0.1 μF or more, and the ESR must be 10 Ω or less.
The value of the output overshoot or undershoot transient response varies depending on the value of the output capacitor. The required capacitance of the input capacitor differs depending on the application.
The recommended value for an application is $C_{IN} \geq 1.0$ μF and $C_L \geq 0.47$ μF; however, when selecting the output capacitor, perform sufficient evaluation, including evaluation of temperature characteristics, on the actual device.

■ Explanation of Terms

1. Low dropout voltage regulator

This voltage regulator has the low dropout voltage due to its built-in low on-resistance transistor.

2. Low ESR

A capacitor whose ESR (Equivalent Series Resistance) is low. The S-T111 Series enables use of a low ESR capacitor, such as a ceramic capacitor, for the output-side capacitor (C_L). A capacitor whose ESR is 10 Ω or less can be used.

3. Output voltage (V_{OUT})

The accuracy of the output voltage is ensured at ±1.0% under the specified conditions of fixed input voltage[*1], fixed output current, and fixed temperature.

***1.** Differs depending on the product.

Caution If the above conditions change, the output voltage value may vary and exceed the accuracy range of the output voltage. Refer to "■ Electrical Characteristics" and "■ Characteristics (Typical Data)" for details.

4. Line Regulation $\left(\frac{\Delta V_{OUT1}}{\Delta V_{IN} \bullet V_{OUT}}\right)$

Indicates the dependency of the output voltage on the input voltage. That is, the values show how much the output voltage changes due to a change in the input voltage with the output current remaining unchanged.

5. Load regulation (ΔV_{OUT2})

Indicates the dependency of the output voltage on the output current. That is, the values show how much the output voltage changes due to a change in the output current with the input voltage remaining unchanged.

6. Dropout voltage (V_{drop})

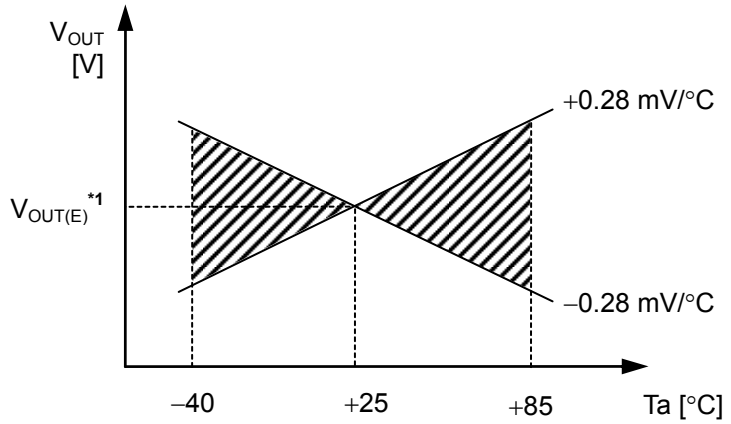
Indicates the difference between input voltage (V_{IN1}) and the output voltage when; decreasing input voltage (V_{IN}) gradually until the output voltage has dropped out to the value of 98% of output voltage (V_{OUT3}), which is at $V_{IN} = (V_{OUT3} \times 0.98)$.

$V_{drop} = V_{IN1} - (V_{OUT3} \times 0.98)$

7. Output Voltage Temperature Coefficient $\left(\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}\right)$

The shaded area in **Figure 10** is the range where V_{OUT} varies in the operation temperature range when the output voltage temperature coefficient is ±100 ppm/°C.

Example of S-T111B28 typ. product



***1.** $V_{OUT(E)}$ is the value of the output voltage measured at Ta = +25°C.

Figure 10

A change in the temperature of the output voltage [mV/°C] is calculated using the following equation.

$$\frac{\Delta V_{OUT}}{\Delta Ta}\ [mV/°C]^{*1} = V_{OUT(S)}\ [V]^{*2} \times \frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}\ [ppm/°C]^{*3} \div 1000$$

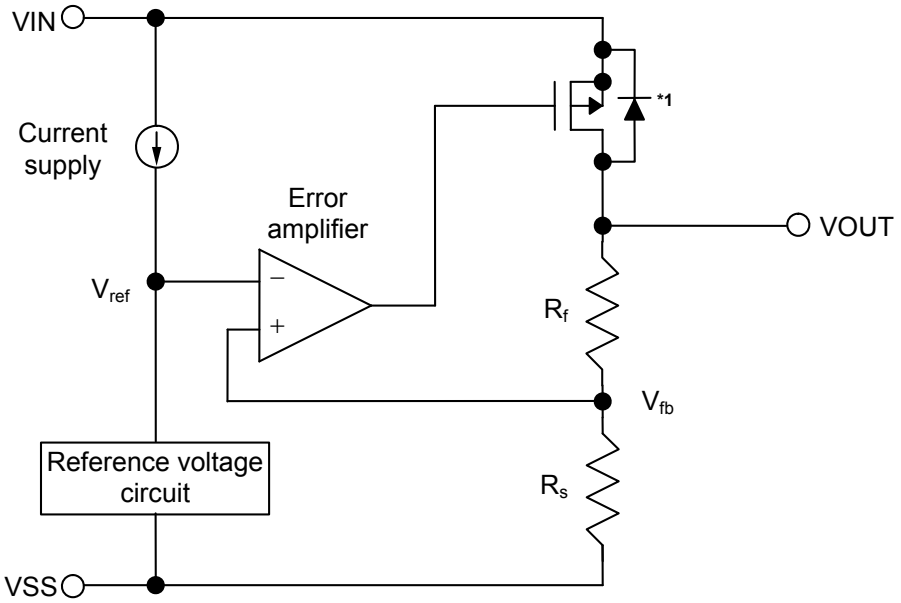
***1.** Change in temperature of output voltage
***2.** Set output voltage
***3.** Output voltage temperature coefficient

■ Operation

1. Basic operation

Figure 11 shows the block diagram of the S-T111 Series.

The error amplifier compares the reference voltage (V_{ref}) with feedback voltage (V_{fb}), which is the output voltage resistance-divided by feedback resistors (R_s and R_f). It supplies the gate voltage necessary to maintain the constant output voltage which is not influenced by the input voltage and temperature change, to the output transistor.



***1**. Parasitic diode

Figure 11

2. Output transistor

In the S-T111 Series, a low on-resistance P-channel MOS FET is used as the output transistor.
Be sure that V_{OUT} does not exceed V_{IN} + 0.3 V to prevent the voltage regulator from being damaged due to reverse current flowing from the VOUT pin through a parasitic diode to the VIN pin, when the potential of V_{OUT} became higher than V_{IN}.

3. ON/OFF pin

This pin starts and stops the regulator.

When the ON/OFF pin is set to OFF level, the entire internal circuit stops operating, and the built-in P-channel MOS FET output transistor between the VIN pin and the VOUT pin is turned off, reducing current consumption significantly. The VOUT pin becomes the V_{SS} level due to the internally divided resistance of several MΩ between the VOUT pin and the VSS pin.
The structure of the ON/OFF pin is as shown in **Figure 12**. Since the ON/OFF pin is neither pulled down nor pulled up internally, do not use it in the floating status. In addition, note that the current consumption increases if a voltage of 0.3 V to V_{IN} – 0.3 V is applied to the ON/OFF pin. When not using the ON/OFF pin, connect it to the VSS pin in the product A type, and connect it to the VIN pin in B type.

Table 5

Product Type	ON/OFF Pin	Internal Circuit	VOUT Pin Voltage	Current Consumption
A	"L": ON	Operate	Set value	I_{SS1}
A	"H": OFF	Stop	V_{SS} level	I_{SS2}
B	"L": OFF	Stop	V_{SS} level	I_{SS2}
B	"H": ON	Operate	Set value	I_{SS1}

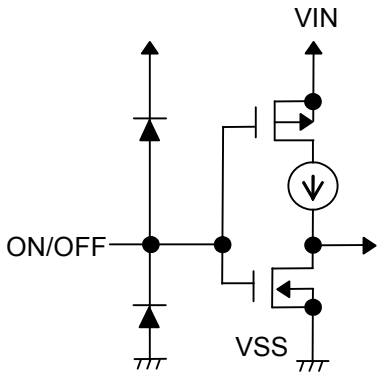


Figure 12

■ Precautions

- Wiring patterns for the VIN pin, the VOUT pin and GND should be designed so that the impedance is low. When mounting an output capacitor between the VOUT pin and the VSS pin (C_L) and a capacitor for stabilizing the input between the VIN pin and the VSS pin (C_{IN}), the distance from the capacitors to these pins should be as short as possible.
- Note that generally the output voltage may increase when a series regulator is used at low load current (1.0 mA or less).
- Generally a series regulator may cause oscillation, depending on the selection of external parts. The following conditions are recommended for S-T111 Series. However, be sure to perform sufficient evaluation under the actual usage conditions for selection, including evaluation of temperature characteristics.

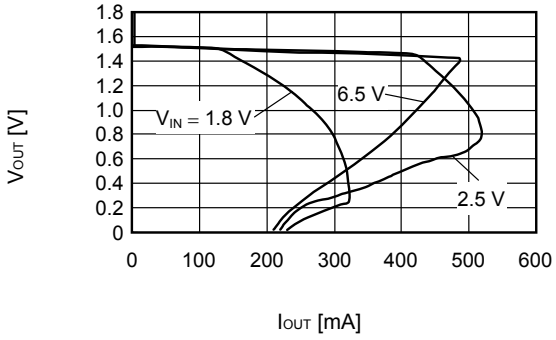
  Input capacitor (C_{IN}): 1.0 μF or more
  Output capacitor (C_L): 0.47 μF or more
  Equivalent series resistance (ESR): 10 Ω or less

- The voltage regulator may oscillate when the impedance of the power supply is high and the input capacitance is small or an input capacitor is not connected.
- Overshoot may occur in the output voltage momentarily if the voltage is rapidly raised at power-on or when the power supply fluctuates. Sufficiently evaluate the output voltage at power-on with the actual device.
- The application conditions for the input voltage, the output voltage, and the load current should not exceed the package power dissipation.
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.
- In determining the output current, attention should be paid to the output current value specified in **Table 4** in "■ **Electrical Characteristics**" and footnote ***5** of the table.
- ABLIC Inc. claims no responsibility for any disputes arising out of or in connection with any infringement by products including this IC of patents owned by a third party.

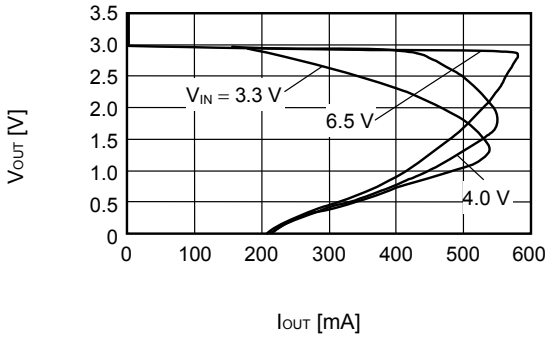
■ Characteristics (Typical Data)

(1) Output Voltage vs. Output current (when load current increases)

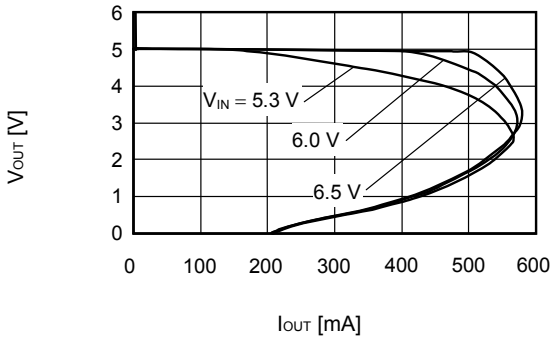
S-T111B15 (Ta = 25°C)



S-T111B30 (Ta = 25°C)



S-T111B50 (Ta = 25°C)



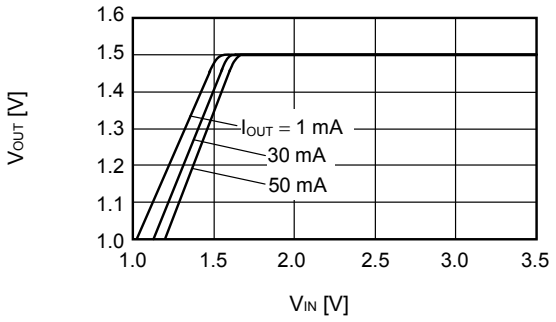
Remark In determining the output current, attention should be paid to the following.

1) The minimum output current value and footnote ***5** in the "■ **Electrical Characteristics**"

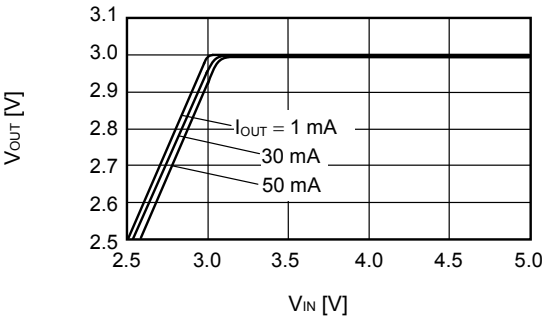
2) The package power dissipation

(2) Output voltage vs. Input voltage

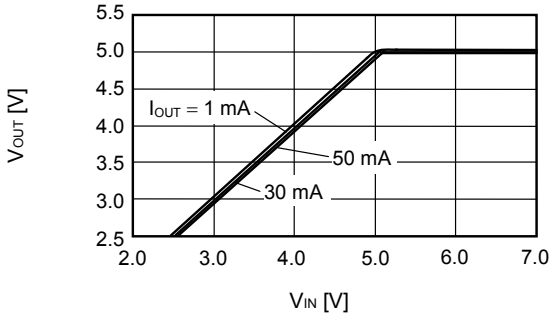
S-T111B15 (Ta = 25°C)



S-T111B30 (Ta = 25°C)

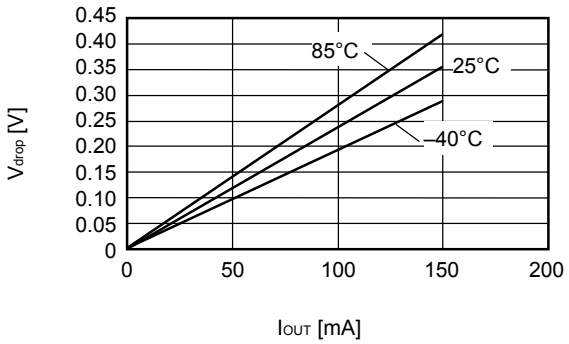


S-T111B50 (Ta = 25°C)

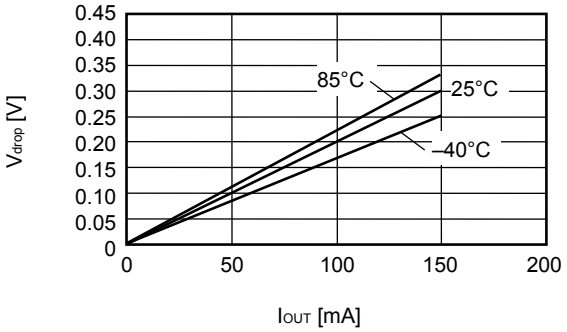


(3) Dropout voltage vs. Output current

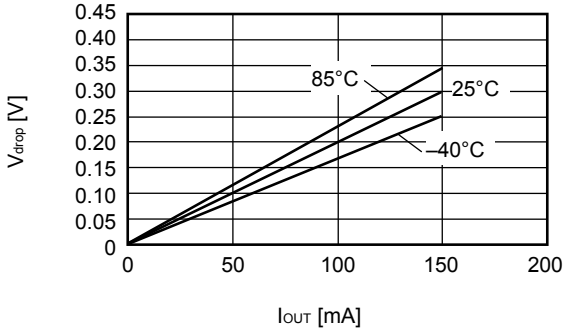
S-T111B15



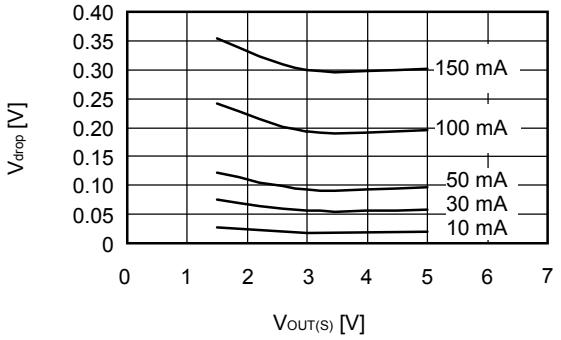
S-T111B30



S-T111B50

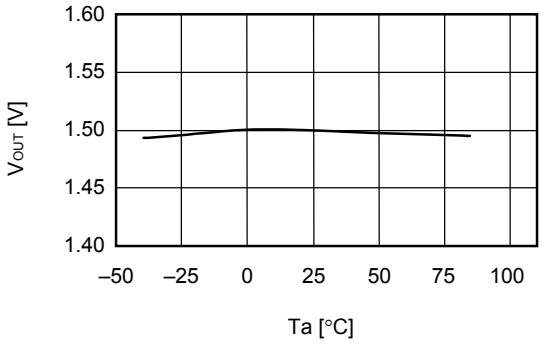


(4) Dropout voltage vs. Set output voltage

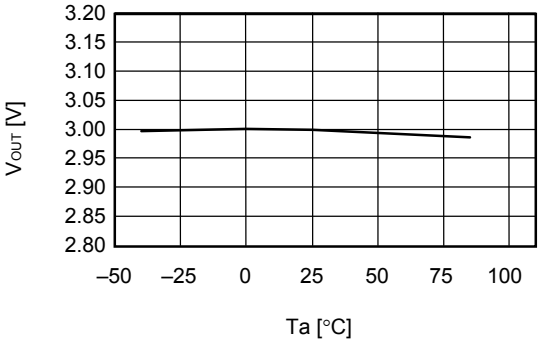


(5) Output voltage vs. Ambient temperature

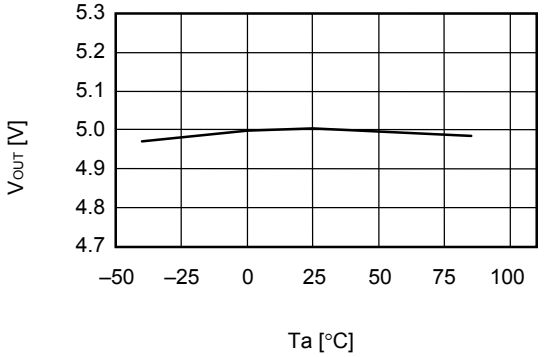
S-T111B15



S-T111B30

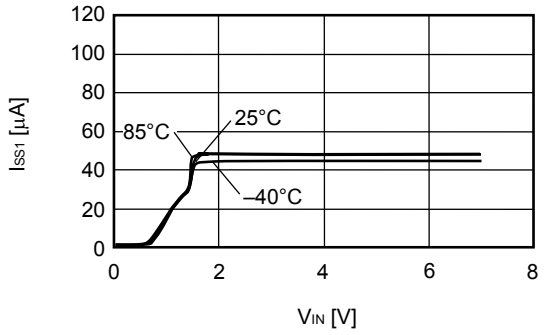


S-T111B50

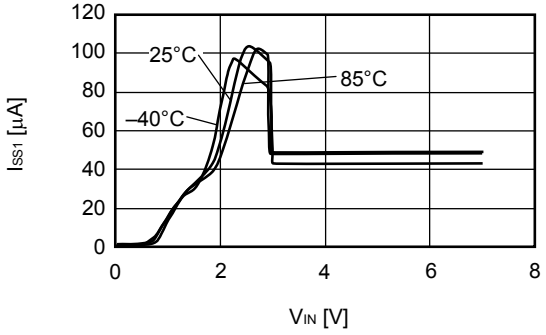


(6) Current consumption vs. Input voltage

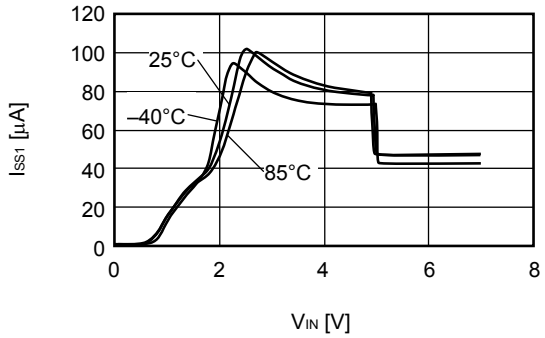
S-T111B15



S-T111B30



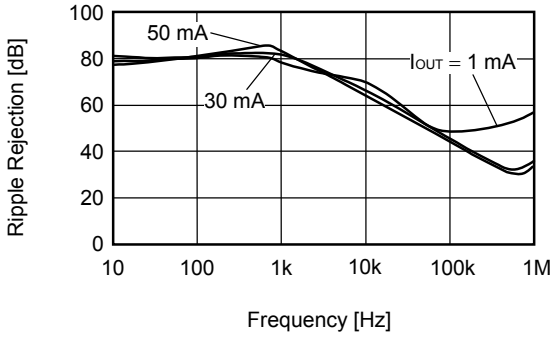
S-T111B50



(7) Ripple rejection

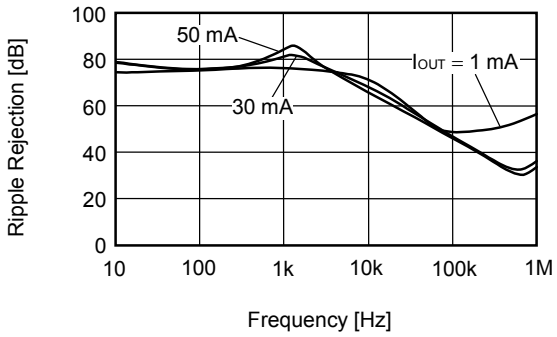
S-T111B15 (Ta = 25°C)

V_{IN} = 2.5 V, C_{OUT} = 0.47 μF



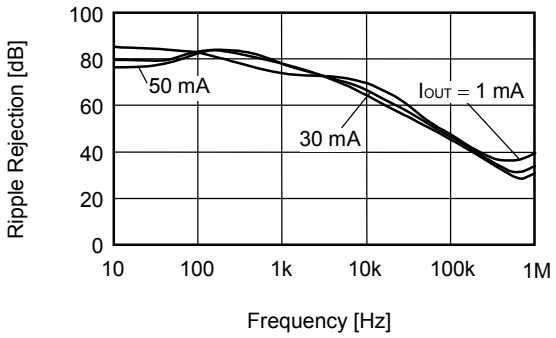
S-T111B30 (Ta = 25°C)

V_{IN} = 4.0 V, C_{OUT} = 0.47 μF



S-T111B50 (Ta = 25°C)

V_{IN} = 6.0 V, C_{OUT} = 0.47 μF

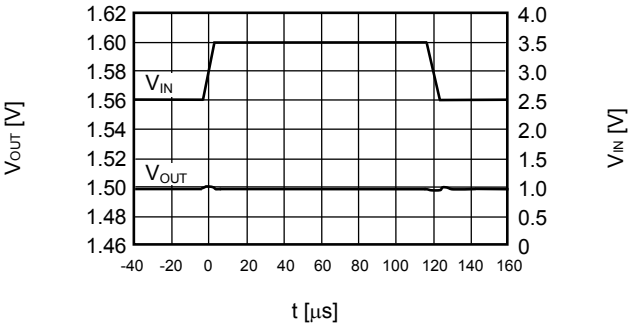


■ Reference Data

(1) Input transient response characteristics

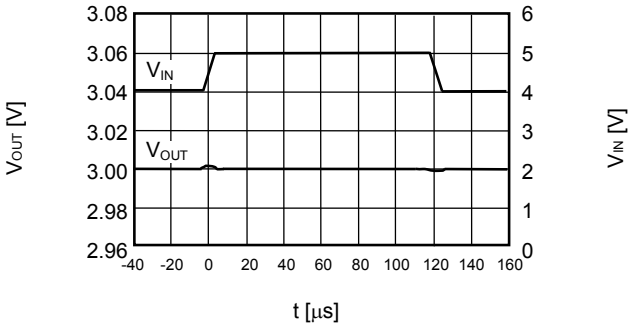
S-T111B15 (Ta = 25°C)

I_{OUT} = 30 mA, $t_r = t_f$ = 5.0 μs, C_{OUT} = 0.47 μF, C_{IN} = 0 μF



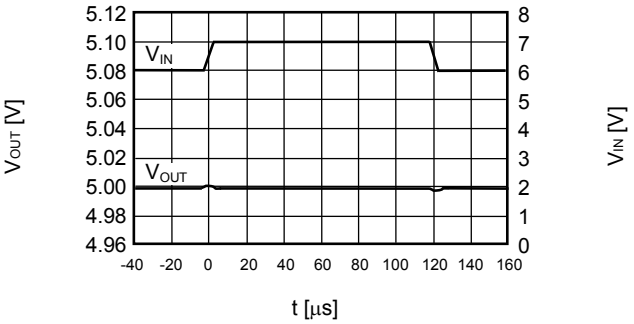
S-T111B30 (Ta = 25°C)

I_{OUT} = 30 mA, $t_r = t_f$ = 5.0 μs, C_{OUT} = 0.47 μF, C_{IN} = 0 μF



S-T111B50 (Ta = 25°C)

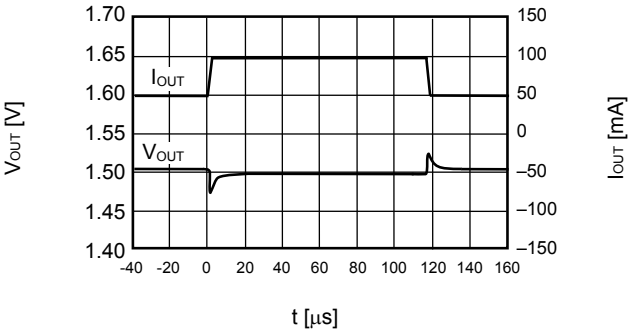
I_{OUT} = 30 mA, $t_r = t_f$ = 5.0 μs, C_{OUT} = 0.47 μF, C_{IN} = 0 μF



(2) Load transient response characteristics

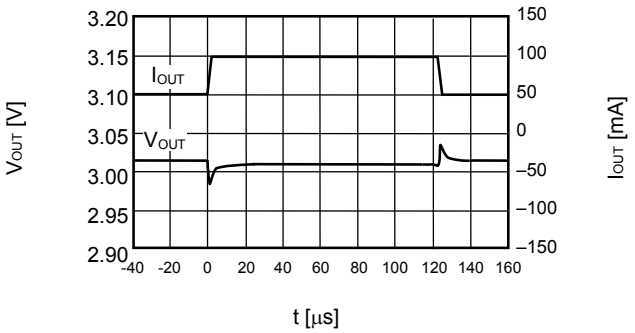
S-T111B15 (Ta = 25°C)

V_{IN} = 2.5 V, C_{OUT} = 0.47 μF, C_{IN} = 1.0 μF, I_{OUT} = 50 mA ↔100 mA



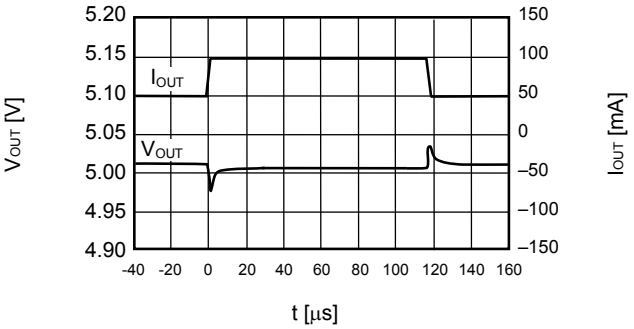
S-T111B30 (Ta = 25°C)

V_{IN} = 4.0 V, C_{OUT} = 0.47 μF, C_{IN} = 1.0 μF, I_{OUT} = 50 mA ↔100 mA



S-T111B50 (Ta = 25°C)

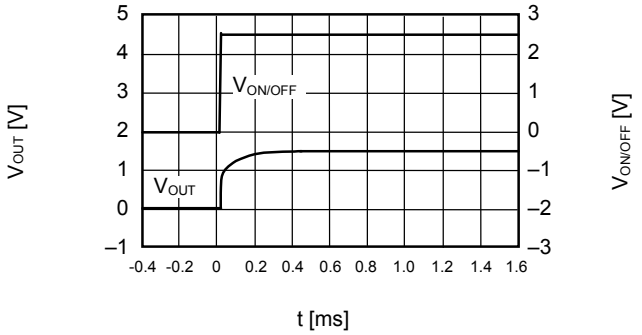
V_{IN} = 6.0 V, C_{OUT} = 0.47 μF, C_{IN} = 1.0 μF, I_{OUT} = 50 mA ↔100 mA



(3) ON/OFF pin transient response characteristics

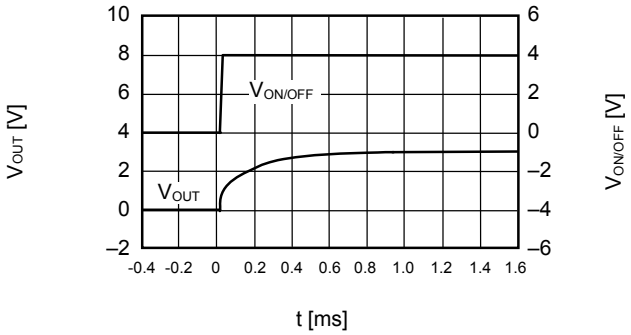
S-T111B15 (Ta = 25°C)

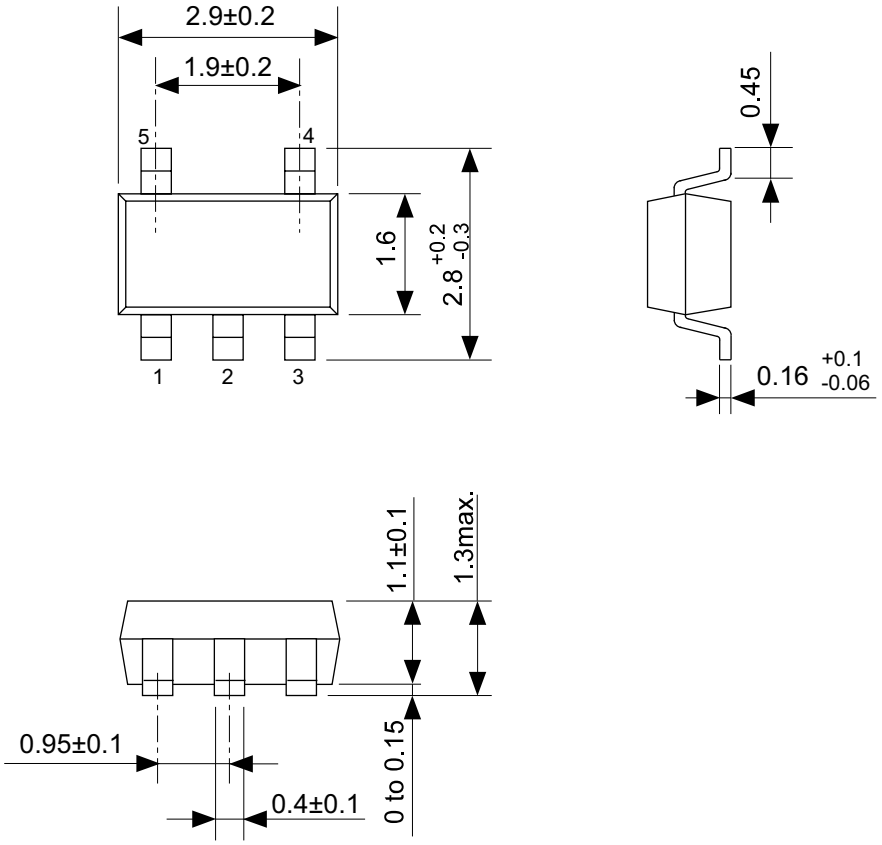
V_{IN} = 2.5 V, C_{OUT} = 0.47 μF, C_{IN} = 1.0 μF, I_{OUT} = 100 mA



S-T111B30 (Ta = 25°C)

V_{IN} = 4.0 V, C_{OUT} = 0.47 μF, C_{IN} = 1.0 μF, I_{OUT} = 100 mA

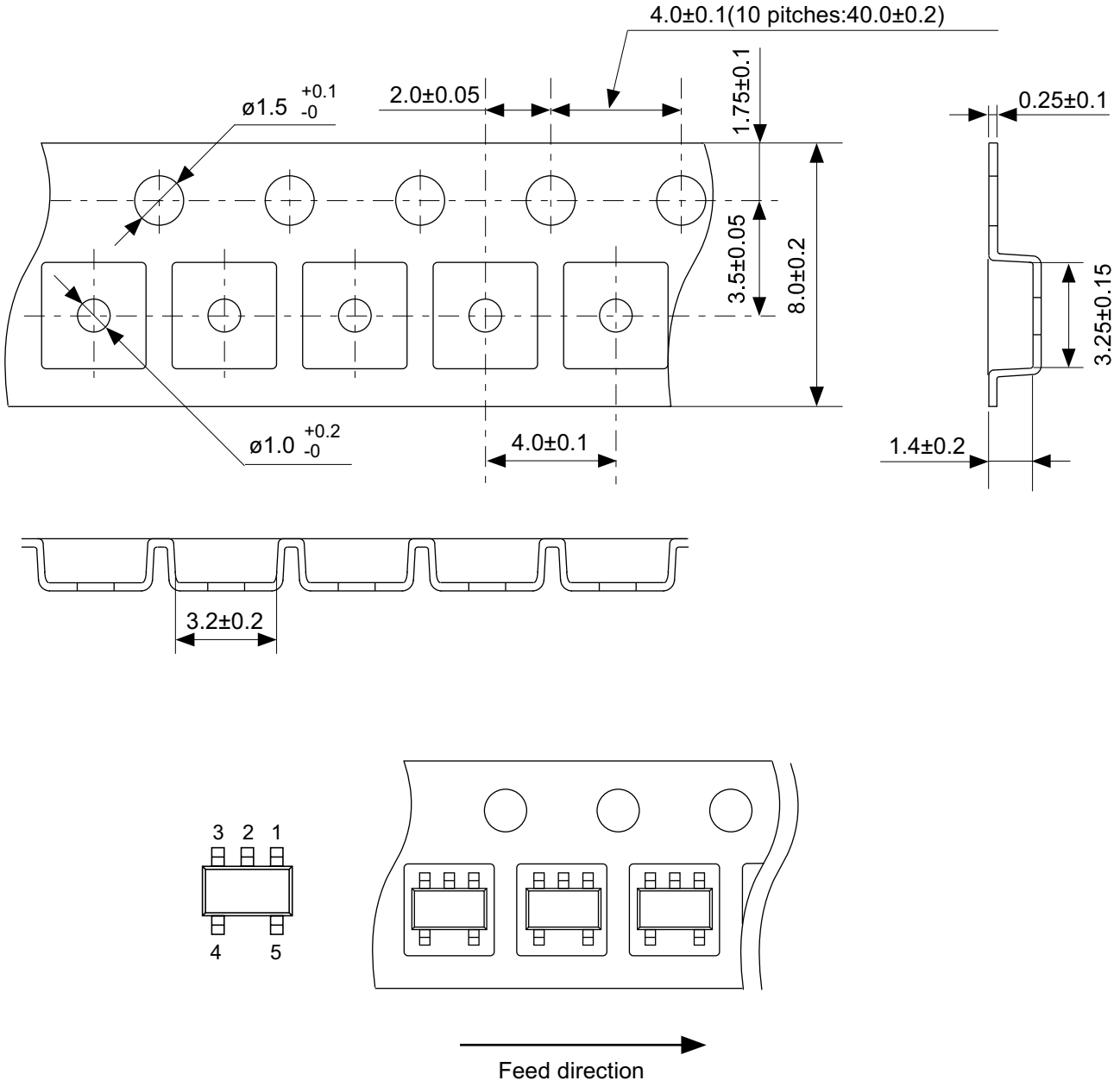




No. MP005-A-P-SD-1.3

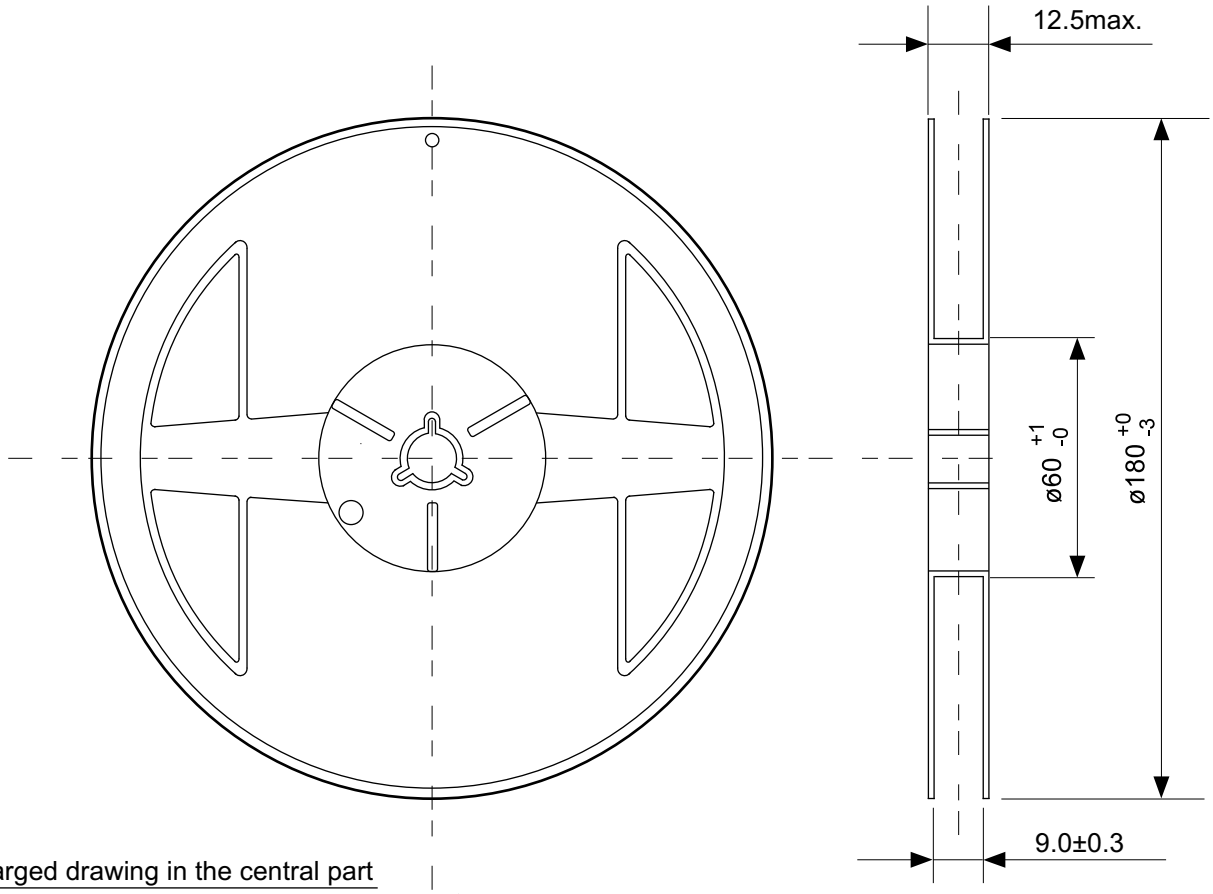
TITLE	SOT235-A-PKG Dimensions
No.	MP005-A-P-SD-1.3
ANGLE	
UNIT	mm

ABLIC Inc.

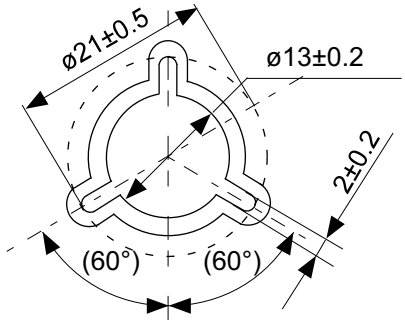


No. MP005-A-C-SD-2.1

TITLE	SOT235-A-Carrier Tape
No.	MP005-A-C-SD-2.1
ANGLE	
UNIT	mm
ABLIC Inc.	



Enlarged drawing in the central part



No. MP005-A-R-SD-1.1

TITLE	SOT235-A-Reel		
No.	MP005-A-R-SD-1.1		
ANGLE		QTY.	3,000
UNIT	mm		
ABLIC Inc.			

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2.4-2019.07

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