S-19318 Series

AUTOMOTIVE, 125°C OPERATION, 36 V INPUT, 500 mA, VOLTAGE REGULATOR, WITH RESET FUNCTION

www.ablic.com

Rev.1.0_00

This IC is a high-withstand voltage and low dropout positive voltage regulator with a reset function and has a built-in ON / OFF circuit, developed using high-withstand voltage CMOS process technology.
This IC operates at the maximum operation voltage of 36 V and a low current consumption of 3.0 µA typ. A built-in overcurrent protection circuit to limit overcurrent of the output transistor and a built-in thermal shutdown circuit to limit heat are included. Regarding a release signal output in the reset function, this IC enables delay time adjustment by an external capacitor.

ABLIC Inc. offers a "thermal simulation service" which supports the thermal design in conditions when our power management ICs are in use by customers. Our thermal simulation service will contribute to reducing the risk in the thermal design at customers' development stage.
ABLIC Inc. also offers FIT rate calculated based on actual customer usage conditions in order to support customer functional safety design.
Contact our sales representatives for details.

Caution **This product can be used in vehicle equipment and in-vehicle equipment. Before using the product for these purposes, it is imperative to contact our sales representatives.**

■ Features

Regulator block

- Output voltage: 3.3 V, 5.0 V
- Input voltage: 3.0 V to 36.0 V
- Output voltage accuracy: ±2.0% (T_j = –40°C to +150°C)
- Dropout voltage: 100 mV typ. (5.0 V output product, I_{OUT} = 100 mA)
- Output current: Possible to output 500 mA (V_{IN} = $V_{OUT(S)}$ + 1.0 V)*1
- Input and output capacitors: A ceramic capacitor of 1.0 µF or more can be used.
- Built-in overcurrent protection circuit: Limits overcurrent of output transistor.
- Built-in thermal shutdown circuit: Detection temperature 170°C typ.
- Built-in ON / OFF circuit: Ensures long battery life.

Detector block

- Detection voltage: 2.6 V to 4.7 V, selectable in 0.1 V step
- Detection voltage accuracy: ±2.0% (T_j = –40°C to +150°C)
- Hysteresis width: 0.12 V min.
- Release delay time is adjustable*2: 20 ms typ. (C_{DLY} = 10 nF)

Overall

- Current consumption: 3.0 µA typ. (During regulator operation)
  0.1 µA typ. (During regulator stop)
- Operation temperature range: Ta = –40°C to +125°C
- Lead-free (Sn 100%), halogen-free
- Withstand 45 V load dump
- AEC-Q100 qualified*3

***1.** Please make sure that the loss of the IC will not exceed the power dissipation when the output current is large.
***2.** The release delay time can be adjusted by connecting C_{DLY} to the DLY pin.
***3.** Contact our sales representatives for details.

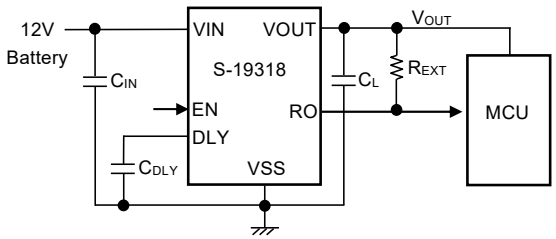
■ Applications

- Constant-voltage power supply and reset circuit for automotive electric component

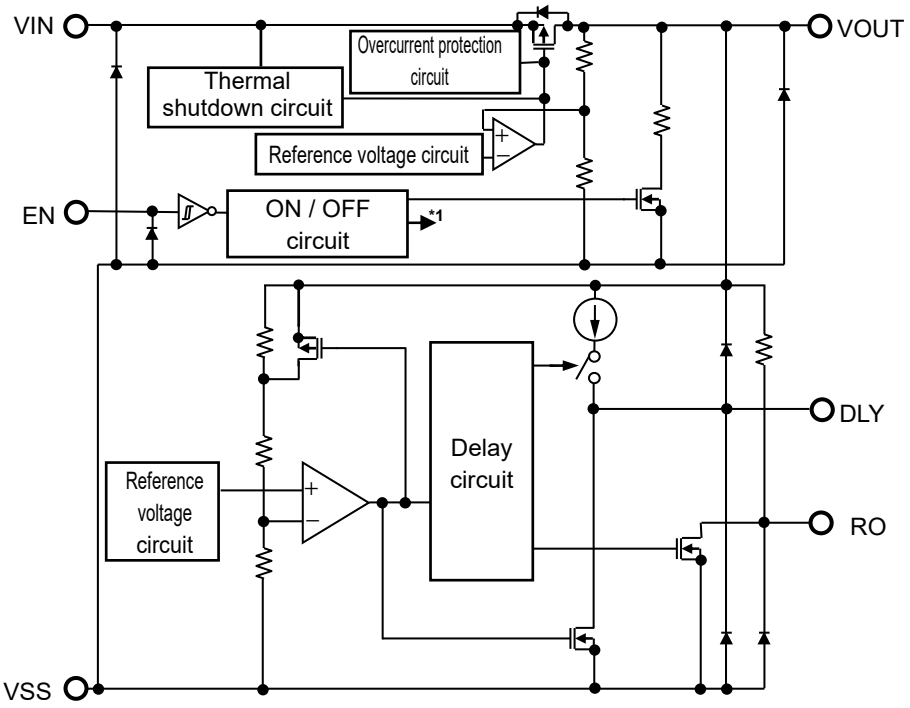
■ Packages

- TO-252-9S
- HSOP-8A

■ Typical Application Circuit



■ Block Diagrams



***1.** The ON / OFF circuit controls the internal circuit and the output transistor.

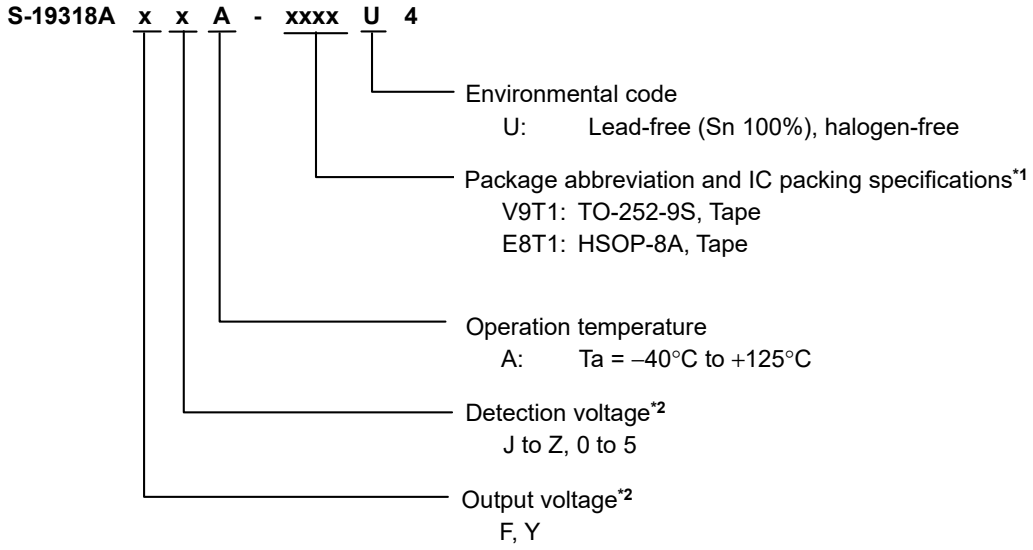
Figure 1

■ AEC-Q100 Qualified

This IC supports AEC-Q100 for the operation temperature grade 1.
Contact our sales representatives for details of AEC-Q100 reliability specification.

■ Product Name Structure

1. Product name



***1.** Refer to the tape drawing.
***2.** Refer to "**2. Product option list**".

2. Product option list

Table 1 Output Voltage

Set Output Voltage	Symbol
5.0 V	F
3.3 V	Y

Table 2 Detection Voltage

Set Detection Voltage	Symbol	Set Detection Voltage	Symbol
4.7 V	J	3.6 V	V
4.6 V	K	3.5 V	W
4.5 V	L	3.4 V	X
4.4 V	M	3.3 V	Y
4.3 V	N	3.2 V	Z
4.2 V	P	3.1 V	0
4.1 V	Q	3.0 V	1
4.0 V	R	2.9 V	2
3.9 V	S	2.8 V	3
3.8 V	T	2.7 V	4
3.7 V	U	2.6 V	5

Remark Set output voltage ≥ Set detection voltage + 0.3 V

3. Packages

Table 3 Package Drawing Codes

Package Name	Dimension	Tape	Reel	Land
TO-252-9S	VA009-A-P-SD	VA009-A-C-SD	VA009-A-R-SD	VA009-A-L-SD
HSOP-8A	FH008-A-P-SD	FH008-A-C-SD	FH008-A-R-SD	FH008-A-L-SD

4. Product name list

Table 4

Output Voltage (V_{OUT})	Detection Voltage ($-V_{DET}$)	TO-252-9S	HSOP-8A
3.3 V ± 2.0%	2.8 V ± 2.0%	S-19318AY3A-V9T1U4	S-19318AY3A-E8T1U4
3.3 V ± 2.0%	2.9 V ± 2.0%	S-19318AY2A-V9T1U4	S-19318AY2A-E8T1U4
3.3 V ± 2.0%	3.0 V ± 2.0%	S-19318AY1A-V9T1U4	S-19318AY1A-E8T1U4
5.0 V ± 2.0%	4.2 V ± 2.0%	S-19318AFPA-V9T1U4	S-19318AFPA-E8T1U4
5.0 V ± 2.0%	4.6 V ± 2.0%	S-19318AFKA-V9T1U4	S-19318AFKA-E8T1U4
5.0 V ± 2.0%	4.7 V ± 2.0%	S-19318AFJA-V9T1U4	S-19318AFJA-E8T1U4

Remark Please contact our sales representatives for products other than the above.

■ Pin Configurations

1. TO-252-9S

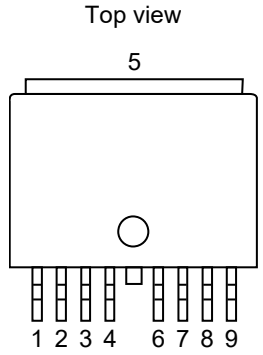


Figure 2

Table 5

Pin No.	Symbol	Description
1	VOUT	Voltage output pin (Regulator block)
2	NC*1	No connection
3	DLY	Connection pin for release delay time adjustment capacitor
4	NC*1	No connection
5	VSS	GND pin
6	RO	Reset output pin
7	NC*1	No connection
8	EN	Enable pin
9	VIN	Voltage input pin (Regulator block)

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

2. HSOP-8A

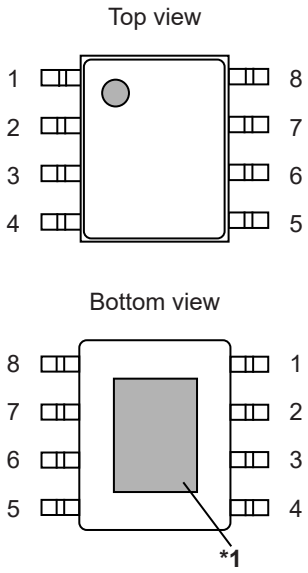


Figure 3

Table 6

Pin No.	Symbol	Description
1	VOUT	Voltage output pin (Regulator block)
2	NC*2	No connection
3	VSS	GND pin
4	DLY	Connection pin for release delay time adjustment capacitor
5	RO	Reset output pin
6	NC*2	No connection
7	EN	Enable pin
8	VIN	Voltage input pin (Regulator block)

***1.** Connect the heat sink of backside at shadowed area to the board, and set electric potential GND.
However, do not use it as the function of electrode.
***2.** The NC pin is electrically open.
The NC pin can be connected to the VIN pin or the VSS pin.

■ Absolute Maximum Ratings

Table 7

(T_j = –40°C to +150°C unless otherwise specified)

Item	Symbol	Absolute Maximum Rating	Unit
VIN pin voltage	V_{IN}	V_{SS} – 0.3 to V_{SS} + 45.0	V
EN pin voltage	V_{EN}	V_{SS} – 0.3 to V_{SS} + 45.0	V
VOUT pin voltage	V_{OUT}	V_{SS} – 0.3 to V_{IN} + 0.3 ≤ V_{SS} + 7.0	V
DLY pin voltage	V_{DLY}	V_{SS} – 0.3 to V_{OUT} + 0.3 ≤ V_{SS} + 7.0	V
RO pin voltage	V_{RO}	V_{SS} – 0.3 to V_{OUT} + 0.3 ≤ V_{SS} + 7.0	V
Output current	I_{OUT}	650	mA
	I_{RO}	30	mA
Junction temperature	T_j	–40 to +150	°C
Operation ambient temperature	T_{opr}	–40 to +125	°C
Storage temperature	T_{stg}	–40 to +150	°C

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.

■ Thermal Resistance Value

Table 8

Item	Symbol	Condition		Min.	Typ.	Max.	Unit
Junction-to-ambient thermal resistance*1, *2	θ_{JA}	TO-252-9S	Board A	–	84	–	°C/W
			Board B	–	–	–	°C/W
			Board C	–	–	–	°C/W
			Board D	–	–	–	°C/W
			Board E	–	24	–	°C/W
		HSOP-8A	Board A	–	105	–	°C/W
			Board B	–	–	–	°C/W
			Board C	–	–	–	°C/W
			Board D	–	–	–	°C/W
			Board E	–	31	–	°C/W

***1.** Test environment: compliance with JEDEC STANDARD JESD51-2A

***2.** Measurement values when this IC is mounted on each board

Remark Refer to "■ **Power Dissipation**" and "**Test Board**" for details.

■ Recommended Operation Conditions

Table 9

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
VIN pin voltage	V_{IN}	–	3.0	–	36.0	V
EN pin voltage	V_{EN}	–	0	–	V_{IN}	V
Input capacitance	C_{IN}	–	1.0	–	–	μF
Output capacitance	C_L	–	1.0	–	–	μF
Equivalent series resistance	R_{ESR}	Output capacitor (C_L)	–	–	100	Ω
Release delay time adjustment capacitance*1	C_{DLY}	–	1	10	–	nF
External pull-up resistance for output pin	R_{ext}	Connected to RO pin	3	–	–	kΩ

***1.** Refer to "**2. Release delay time adjustment capacitor (C_{DLY})**" in "**■ Selection of External Parts**" for the details.

Caution Generally a series regulator may cause oscillation, depending on the selection of external parts. Confirm that no oscillation occurs in the actual application using capacitors that meet the above C_{IN}, C_L, and R_{ESR}.

■ Electrical Characteristics

1. Regulator block

Table 10

(V_{IN} = 13.5 V, T_j = –40°C to +150°C unless otherwise specified)

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Test Circuit
Output voltage*1	$V_{OUT(E)}$	$V_{OUT(S)}$ + 1.0 V ≤ V_{IN} ≤ 18.0 V, 1 mA ≤ I_{OUT} ≤ 100 mA		$V_{OUT(S)}$ × 0.98	$V_{OUT(S)}$	$V_{OUT(S)}$ × 1.02	V	1
Output current*2	I_{OUT}	V_{IN} ≥ $V_{OUT(S)}$ + 1.0 V		500*7	–	–	mA	2
Dropout voltage*3	V_{drop}	I_{OUT} = 100 mA	$V_{OUT(S)}$ = 3.3 V	–	120	240	mV	1
			$V_{OUT(S)}$ = 5.0 V	–	100	200	mV	1
		I_{OUT} = 500 mA	$V_{OUT(S)}$ = 3.3 V	–	650	1200	mV	1
			$V_{OUT(S)}$ = 5.0 V	–	510	1000	mV	1
Line regulation*4	$\frac{\Delta V_{OUT1}}{\Delta V_{IN} \bullet V_{OUT}}$	$V_{OUT(S)}$ + 1.0 V ≤ V_{IN} ≤ 36.0 V, I_{OUT} = 1 mA		–	0.01	0.02	%/V	1
Load regulation*5	ΔV_{OUT2}	V_{IN} = $V_{OUT(S)}$ + 1.0 V, 1 mA ≤ I_{OUT} ≤ 250 mA, Ta = +25°C		–	10	50	mV	1
Input voltage	V_{IN}	–		3.0	–	36.0	V	–
EN pin input voltage "H"	V_{SH}	–		2	–	–	V	4
EN pin input voltage "L"	V_{SL}	–		–	–	0.8	V	4
EN pin input current "H"	I_{SH}	V_{EN} = V_{IN}		–	–	1	µA	4
EN pin input current "L"	I_{SL}	V_{EN} = 0 V		–	–	0.1	µA	4
Ripple rejection	|RR|	V_{IN} = 13.5 V, I_{OUT} = 30 mA, f = 100 Hz, ΔV_{rip} = 1.0 V_{p-p}	$V_{OUT(S)}$ = 3.3 V	–	65	–	dB	3
			$V_{OUT(S)}$ = 5.0 V	–	60	–	dB	3
Limit current*6	I_{LIM}	V_{IN} = $V_{OUT(S)}$ + 1.0 V, Ta = +25°C		490	700	960	mA	2
Short-circuit current	I_{short}	V_{IN} = 13.5 V, V_{OUT} = 0 V, Ta = +25°C		75	160	245	mA	2
Thermal shutdown detection temperature	T_{SD}	Junction temperature		–	170	–	°C	–
Thermal shutdown release temperature	T_{SR}	Junction temperature		–	135	–	°C	–

***1.** The accuracy is guaranteed when the input voltage, output current, and temperature satisfy the conditions listed above.

$V_{OUT(S)}$: Set output voltage

$V_{OUT(E)}$: Actual output voltage

***2.** The output current when increasing the output current gradually until the output voltage has reached the value of 95% of $V_{OUT(E)}$.

***3.** 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}).

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

V_{OUT3}: Output voltage when V_{IN} = $V_{OUT(S)}$ + 1.0 V

***4.** The dependency of the output voltage against the input voltage. The value shows how much the output voltage changes due to a change in the input voltage while keeping output current constant.

***5.** The dependency of the output voltage against the output current. The value shows how much the output voltage changes due to a change in the output current while keeping input voltage constant.

***6.** The current limited by overcurrent protection circuit.

***7.** Due to limitation of the power dissipation, this value may not be satisfied. Attention should be paid to the power dissipation when the output current is large.
This specification is guaranteed by design.

2. Detector block

Table 11

(T_j = –40°C to +150°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
Detection voltage*1	$-V_{DET}$	–	$-V_{DET(S)}$ –2.0%	$-V_{DET(S)}$	$-V_{DET(S)}$ +2.0%	V	5
Hysteresis width*2	V_{HYS}	–	120	150	180	mV	5
Reset output voltage "H"	V_{ROH}	–	$V_{OUT(S)}$ × 0.9	–	–	V	5
Reset output voltage "L"	V_{ROL}	$V_{OUT} \geq$ 1.0 V, $R_{ext} \geq$ 3 kΩ, Connected to VOUT pin	–	0.2	0.4	V	5
Reset pull-up resistance	R_{RO}	VOUT pin internal resistance, $V_{OUT} \geq +V_{DET}$	20	30	45	kΩ	–
Reset output current	I_{RO}	V_{RO} = 0.4 V, $V_{OUT} = -V_{DET(S)} \times 0.95$	3.0	–	–	mA	6
Release delay time*3	t_{rd}	C_{DLY} = 10 nF	16	20	24	ms	5
Reset reaction time*4	t_{rr}	–	–	–	200	µs	5

***1.** The VOUT pin voltage at which the output of the RO pin switches from "H" to "L".

$-V_{DET(S)}$: Set detection voltage

$-V_{DET}$: Actual detection voltage

***2.** The voltage difference between the detection voltage ($-V_{DET}$) and the release voltage ($+V_{DET}$). The relation between the actual output voltage ($V_{OUT(E)}$) of the regulator block and the actual release voltage ($+V_{DET} = -V_{DET} + V_{HYS}$) of the detector block is as follows.

$V_{OUT(E)} > +V_{DET}$

***3.** The time from when V_{OUT} exceeds $+V_{DET}$ to when the RO pin output inverts (Refer to **Figure 4**). This value changes according to the release delay time adjustment capacitor (C_{DLY}).

***4.** The time from when V_{OUT} falls below $-V_{DET}$ to when the RO pin output inverts (Refer to **Figure 5**).

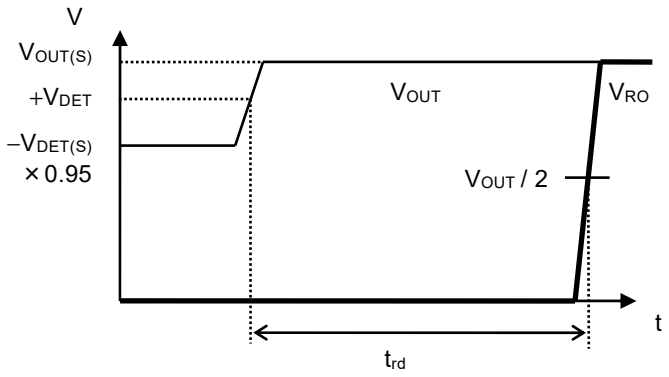


Figure 4 Release Delay Time

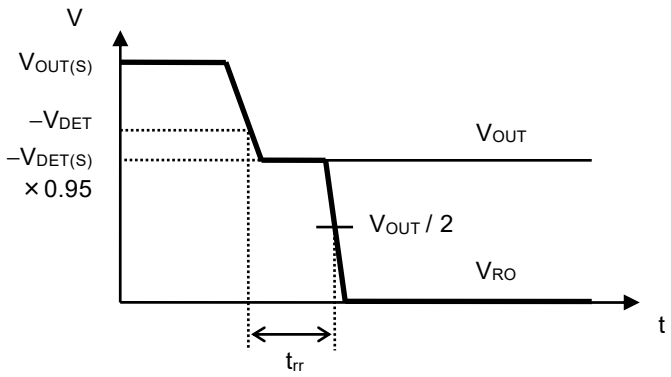


Figure 5 Reset Reaction Time

3. Overall

Table 12

(V_{IN} = 13.5 V, T_j = –40°C to +150°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
Current consumption during operation	I_{SS1}	$V_{EN} = V_{IN}$, $I_{OUT} \leq$ 10 µA	–	3.0	9.5	µA	7
Current consumption during power-off	I_{SS2}	V_{EN} = 0 V, I_{OUT} = 0 mA	–	0.1	4.0	µA	8

■ Test Circuits

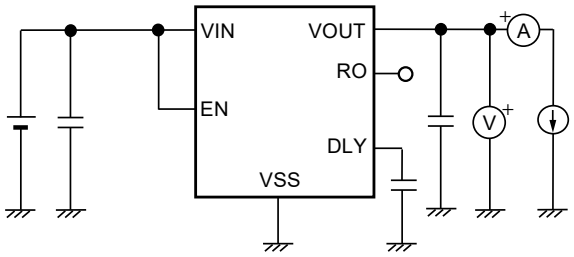


Figure 6 Test Circuit 1

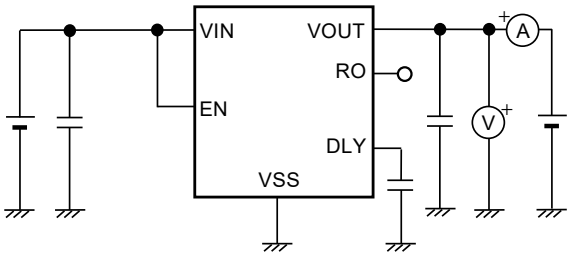


Figure 7 Test Circuit 2

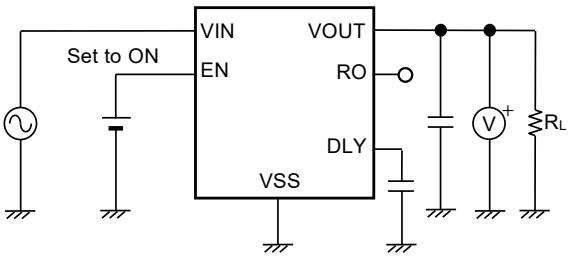


Figure 8 Test Circuit 3

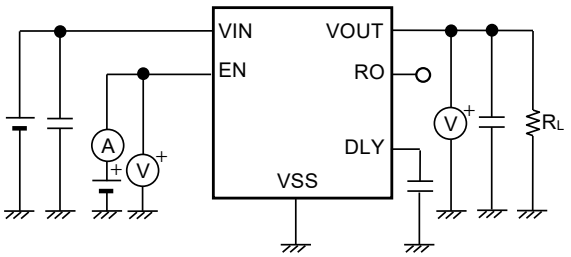


Figure 9 Test Circuit 4

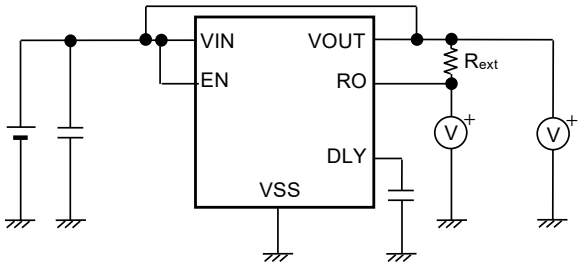


Figure 10 Test Circuit 5

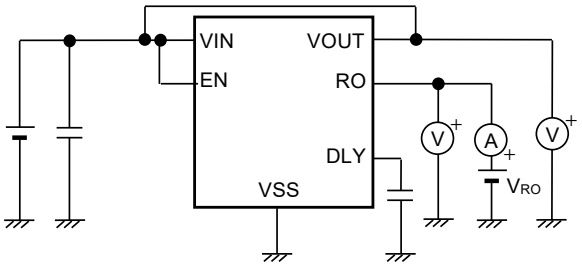


Figure 11 Test Circuit 6

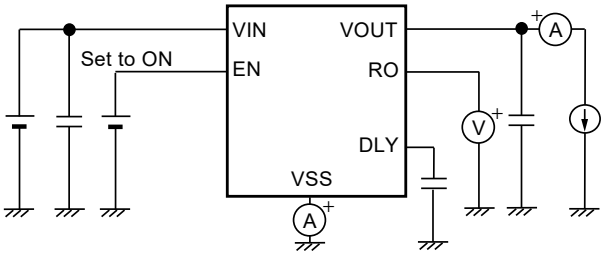


Figure 12 Test Circuit 7

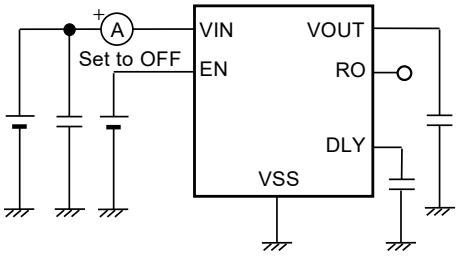


Figure 13 Test Circuit 8

■ Standard Circuits

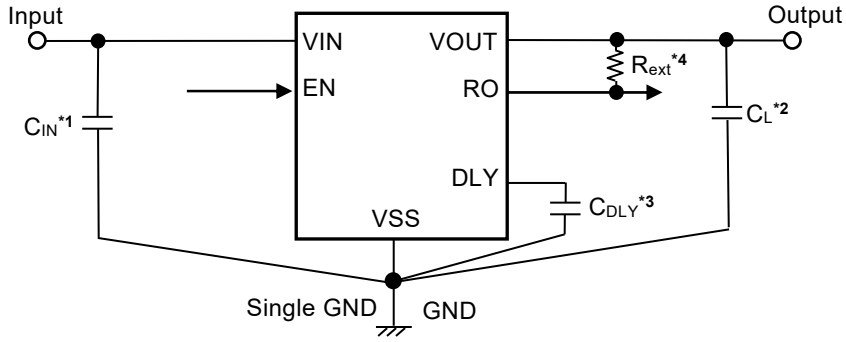


Figure 14

***1.** C_{IN} is a capacitor for stabilizing the input.

***2.** C_L is a capacitor for stabilizing the output.

***3.** C_{DLY} is the release delay time adjustment capacitor.

***4.** Connection of the external pull-up resistor is not absolutely essential since this IC has a built-in pull-up resistor.

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

■ Selection of External Parts

1. Input and output capacitors (C_{IN}, C_L)

This IC requires C_L between the VOUT pin and the VSS pin for phase compensation. Operation is stabilized by a ceramic capacitor with an output capacitance of 1.0 μF or more over the entire temperature range. When using an OS capacitor, a tantalum capacitor, or an aluminum electrolytic capacitor, the capacitance must be 1.0 μF or more, and the ESR must be 100 Ω or less.
The values of output overshoot and undershoot, which are transient response characteristics, vary depending on the value of the output capacitor.
The required value of capacitance for the input capacitor differs depending on the application.

Caution Define the capacitance of C_{IN} and C_L by sufficient evaluation including the temperature characteristics under the actual usage conditions.

2. Release delay time adjustment capacitor (C_{DLY})

In this IC, the release delay time adjustment capacitor (C_{DLY}) is necessary between the DLY pin and the VSS pin to adjust the release delay time (t_{rd}) of the detector.The set release delay time ($t_{rd(S)}$) is calculated by using following equations.
The release delay time (t_{rd}) at the time of the condition of C_{DLY} = 10 nF is shown in "**■ Electrical Characteristics**".

$$t_{rd(S)}\ [\text{ms}] = t_{rd}\ [\text{ms}] \times \frac{C_{DLY}\ [\text{nF}]}{10\ [\text{nF}]}$$

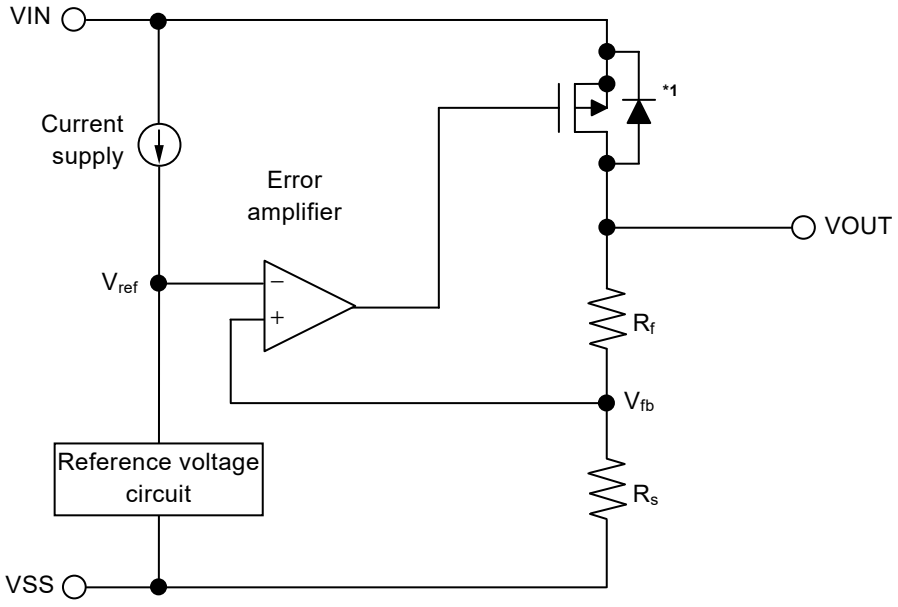
Caution 1. The above equations will not guarantee successful operation. Perform thorough evaluation including the temperature characteristics using an actual application to set the constants.
2. Mounted board layout should be made in such a way that no current flows into or flows from the DLY pin since the impedance of the DLY pin is high, otherwise correct delay time may not be provided.
3. Select C_{DLY} whose leakage current can be ignored against the built-in constant current (0.6 μA typ.). The leakage current may cause deviation in delay time. When the leakage current is larger than the built-in constant current, no release takes place.
4. Deviations of C_{DLY} are not included in the equations mentioned above. Be sure to determine the constants considering the deviation of C_{DLY} to be used.

■ Operation

1. Regulator block

1. 1 Basic operation

Figure 15 shows the block diagram of the regulator in the this IC.
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 15

1. 2 Output transistor

In this IC, 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}.

1. 3 Overcurrent protection circuit

This IC includes an overcurrent protection circuit which having the characteristics shown in "**1. 1 Output voltage vs. Output current (When load current increases) (Ta = +25°C)"** of "**1. Regulator block**" in "**■ Characteristics (Typical Data)**", in order to limit an excessive output current and overcurrent of the output transistor due to short-circuiting between the VOUT pin and the VSS pin. The current when the output pin is short-circuited (I_{short}) is internally set at 160 mA typ., and the load current when short-circuiting is limited based on this value. The output voltage restarts regulating if the output transistor is released from overcurrent status.

Caution This overcurrent protection circuit does not work as for thermal protection. If this IC long keeps short circuiting, pay attention to the conditions of input voltage and load current so that, under the usage conditions including short circuit, the loss of the IC will not exceed power dissipation.

1. 4 Thermal shutdown circuit

This IC has a thermal shutdown circuit to limit self-heating. When the junction temperature rises to 170°C typ., the thermal shutdown circuit operates to stop regulating. After that, when the junction temperature drops to 135°C typ., the thermal shutdown circuit is released to restart regulating.

Due to self-heating of this IC, if the thermal shutdown circuit starts operating, it stops regulating so that the output voltage drops. For this reason, self-heating is limited and the IC's temperature drops.

When the temperature drops, the thermal shutdown circuit is released to restart regulating, thus self-heating is generated again due to rising of the output voltage. Repeating this procedure makes the waveform of the VOUT pin output into a pulse-like form. This phenomenon continues unless decreasing either or both of the input voltage and the output current in order to reduce the internal power consumption or decreasing the ambient temperature. Note that the product may suffer physical damage such as deterioration if the above phenomenon occurs continuously.

Table 13

Thermal Shutdown Circuit	VOUT Pin Voltage
Detect: 170°C typ.*1	V_{SS} level
Release: 135°C typ.*1	Set value

***1.** Junction temperature

1. 5 ON / OFF circuit

The ON / OFF circuit controls the internal circuit and the output transistor in order to start and stop the regulator. When the EN pin is set to "L" (OFF), the internal circuit stops operating and the output transistor between the VIN pin and the VOUT pin is turned off, reducing current consumption significantly. When the EN pin is set to "L" (OFF), the reset output pin outputs "L" if the VOUT pin decreases to the detection voltage ($-V_{DET}$) or lower.

The internal equivalent circuit related to the EN pin is configured as shown in **Figure 16**. Since the EN pin is internally pulled down by the constant current source, the EN pin is set to "L" if it is used in the floating status, and the output transistor is turned off. However, in order that the EN pin becomes OFF certainly, connect the EN pin to GND so that "L" is certainly input to the EN pin, since the impedance of the EN pin becomes high when using the EN pin in the floating status.

When not using the EN pin, connect it to the VIN pin. Note that the current consumption increases when an intermediate voltage is applied to the EN pin.

Table 14

EN Pin	Internal Circuit	VOUT Pin Voltage	Current Consumption
"H": ON	Operate	Constant value*1	I_{SS1}
"L": OFF	Stop	Pulled down to V_{SS}*2	I_{SS2}

***1.** The constant value is output due to the regulating based on the set output voltage value.

***2.** The VOUT pin voltage is pulled down to V_{SS} due to combined resistance (R_{LOW} = 1.2 kΩ typ.) of the discharge shunt circuit and the feedback resistors, and a load.

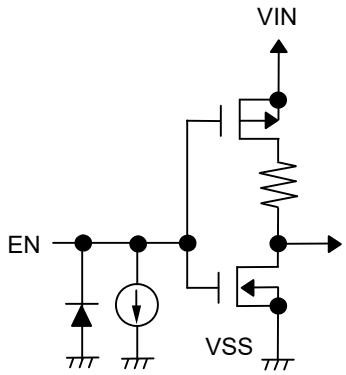


Figure 16

2. Detector block

2. 1 Basic operation

(1) When the output voltage (V_{OUT}) of the regulator is release voltage ($+V_{DET}$) of the detector or higher, the Nch transistor (N1 and N2) are turned off and "H" is output to the RO pin. Since the Pch transistor (P1) is turned on, the input voltage to the comparator (C1) is $\frac{R_B \bullet V_{OUT}}{R_A + R_B}$.

(2) Even if V_{OUT} decreases to $+V_{DET}$ or lower, "H" is output to the RO pin when V_{OUT} is the detection voltage ($-V_{DET}$) or higher. When V_{OUT} decreases to $-V_{DET}$ (point A in **Figure 18**) or lower, N1 which is controlled by C1 is turned on, and C_{DLY} is discharged. At the same time, N2, which is controlled by the delay circuit, is turned on, and "L" is output to the RO pin. At this time, P1 is turned off, and the input voltage to C1 is $\frac{R_B \bullet V_{OUT}}{R_A + R_B + R_C}$.

(3) If V_{OUT} further decreases to the IC's minimum operation voltage or lower, the RO pin output becomes uncertain. If the RO pin is pulled up, "H" is output.

(4) When V_{OUT} increases to the IC's minimum operation voltage or higher, "L" is output to the RO pin. Moreover, even if V_{OUT} exceeds $-V_{DET}$, the output is "L" when V_{OUT} is lower than $+V_{DET}$.

(5) When V_{OUT} increases to $+V_{DET}$ (point B in **Figure 18**) or higher, N1 is turned off and C_{DLY} is charged. When V_{DLY} increases to the threshold voltage (1.25 V typ.), N2, which is controlled by a delay circuit, is turned off and "H" is output to the RO pin.

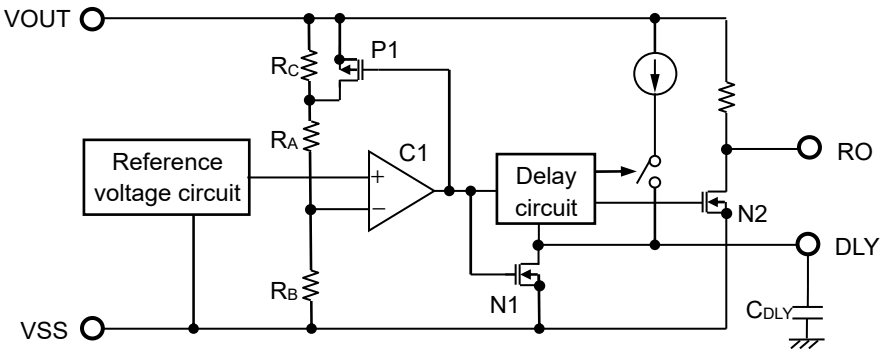


Figure 17 Operation of Detector Block

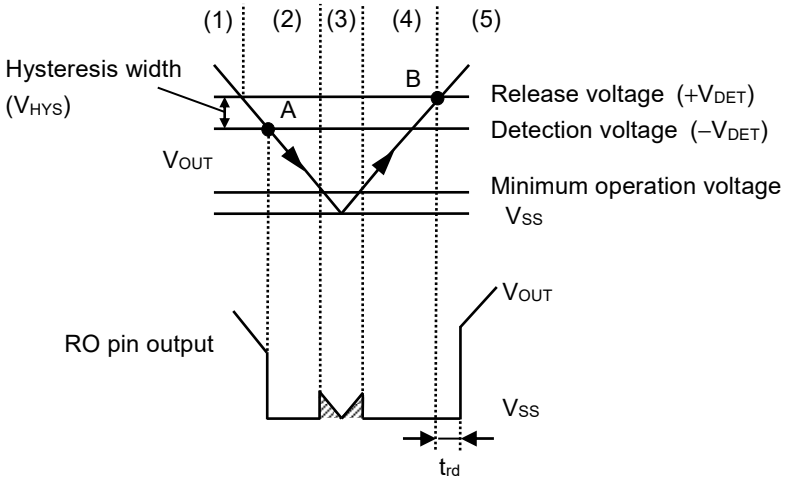


Figure 18 Timing Chart of Detector Block

2. 2 Delay circuit

When the output voltage (V_{OUT}) of the regulator rises under the status that "L" is output to the RO pin, the reset release signal is output to the RO pin later than when V_{OUT} becomes $+V_{DET}$. The release delay time (t_{rd}) changes according to C_{DLY}. Refer to "**2. Release delay time adjustment capacitor (C_{DLY})**" in"**■ Selection of External Parts**" for details.
In addition, if the time from when V_{OUT} decreases to $-V_{DET}$ or lower to when V_{OUT} increases to $+V_{DET}$ or higher is significantly shorter compared to the length of the reset reaction time (t_{rr}), "H" output may remain in the RO pin.

Caution Since t_{rd} depends on the charge time of C_{DLY}, t_{rd} may be shorter than the set value if the charge operation is initiated under the condition that a residual electric charge is left in C_{DLY}.

2. 3 Output circuit

Since the RO pin has a built-in resistor to pull up to the VOUT pin internally, the RO pin can output a signal without an external pull-up resistor.
Do not connect to the pin other than VOUT pin when connecting an external pull-up resistor.

Caution Define the external pull-up resistance by sufficient evaluation including the temperature characteristics under the actual usage conditions.

■ 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 an input capacitor 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 (0.1 mA or less).
- Note that generally the output voltage may increase due to the leakage current from an output transistor when a series regulator is used at high temperature.
- Generally, a series regulator may cause oscillation, depending on the selection of external parts. The following conditions are recommended for this IC. However, be sure to perform sufficient evaluation under the actual usage conditions for selection, including evaluation of temperature characteristics. Refer to "**6. Example of equivalent series resistance vs. Output current characteristics (Ta = –40°C to +125°C)**" in "**■ Reference Data**" for the equivalent series resistance (R_{ESR}) of the output capacitor.

  Input capacitor (C_{IN}): 1.0 μF or more
  Output capacitor (C_L): 1.0 μF or more

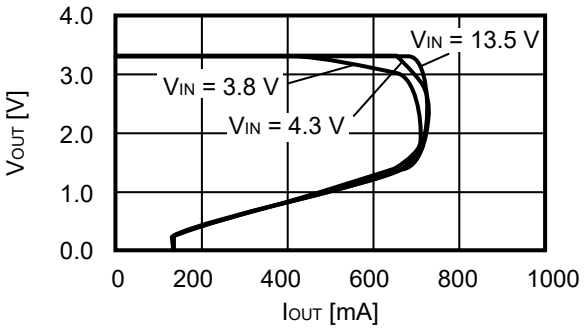
- In a series regulator, generally the values of overshoot and undershoot in the output voltage vary depending on the variation factors of power-on, power supply fluctuation and load fluctuation, or output capacitance.
  Determine the conditions of the output capacitor after sufficiently evaluating the temperature characteristics of overshoot or undershoot in the output voltage with the actual device.
- 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 that time with the actual device.
- If the VOUT pin is steeply shorted with GND, a negative voltage exceeding the absolute maximum ratings may occur to the VOUT pin due to resonance of the wiring inductance and the output capacitance in the application. The negative voltage can be limited by inserting a protection diode between the VOUT pin and the VSS pin or inserting a series resistor to the output capacitor.
- The application conditions for the input voltage, the output voltage, and the load current should not exceed the 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 10** in "**■ Electrical Characteristics**" and footnote ***7** 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)

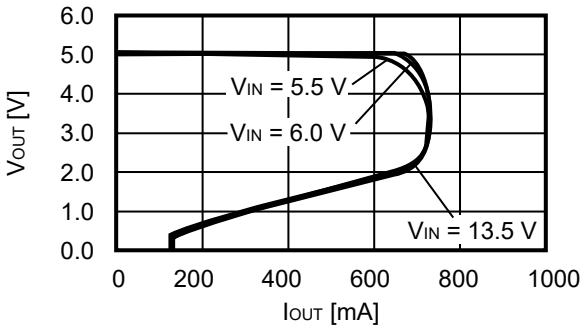
1. Regulator block

1. 1 Output voltage vs. Output current (When load current increases) (Ta = +25°C)

1. 1. 1 V_{OUT} = 3.3 V

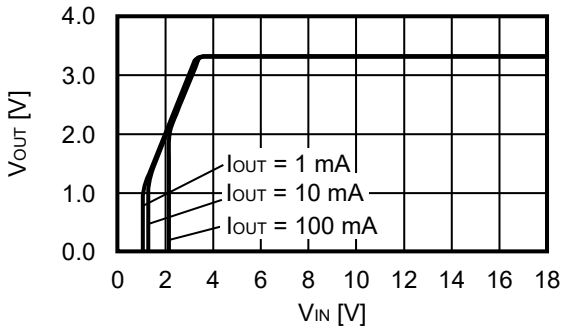


1. 1. 2 V_{OUT} = 5.0 V

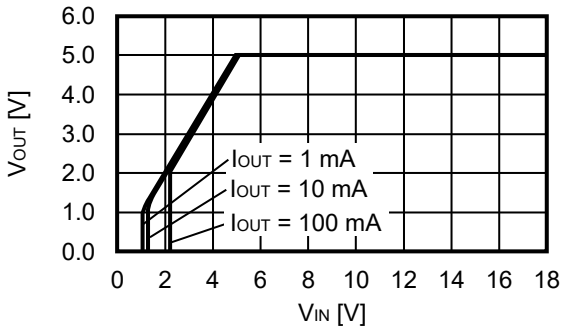


1. 2 Output voltage vs. Input voltage (Ta = +25°C)

1. 2. 1 V_{OUT} = 3.3 V

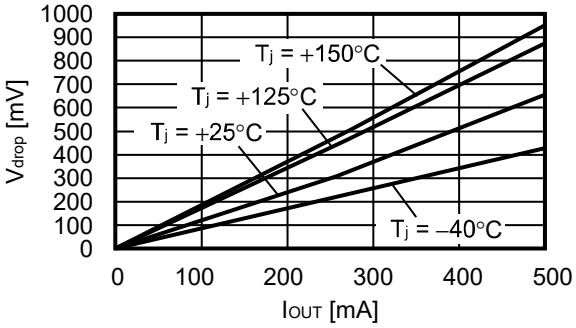


1. 2. 2 V_{OUT} = 5.0 V

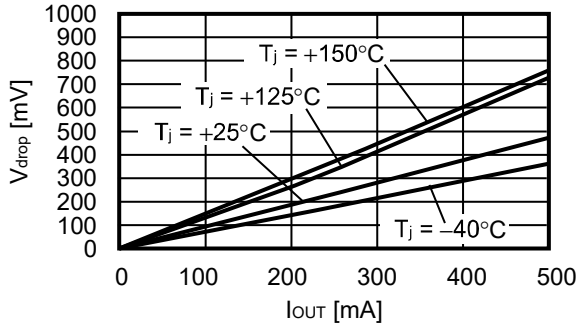


1. 3 Dropout voltage vs. Output current

1. 3. 1 V_{OUT} = 3.3 V

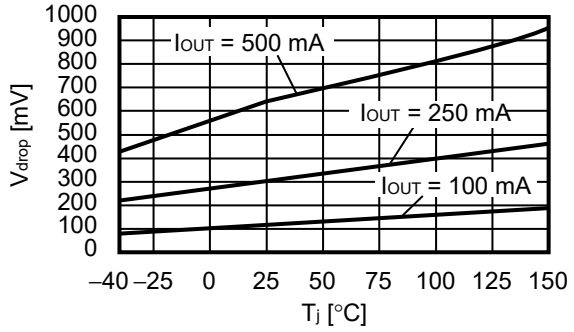


1. 3. 2 V_{OUT} = 5.0 V

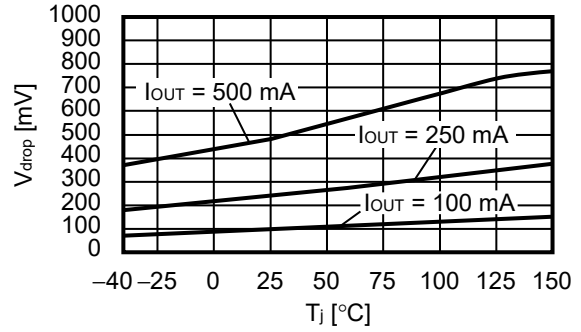


1. 4 Dropout voltage vs. Junction temperature

1. 4. 1 V_{OUT} = 3.3 V

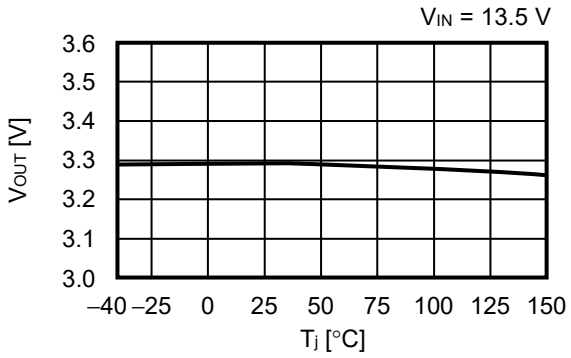


1. 4. 2 V_{OUT} = 5.0 V

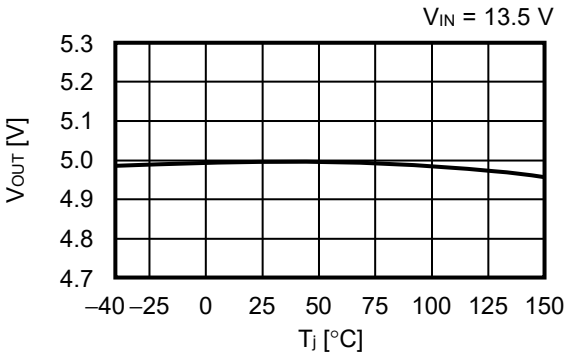


1. 5 Output voltage vs. Junction temperature

1. 5. 1 V_{OUT} = 3.3 V

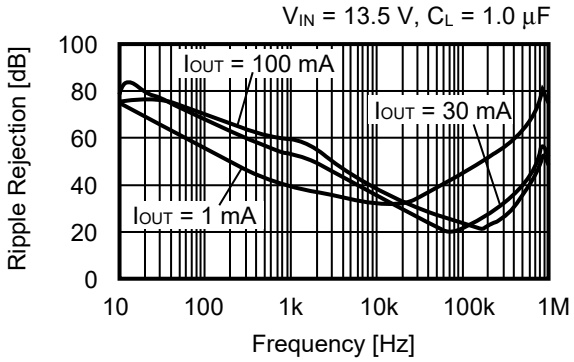


1. 5. 2 V_{OUT} = 5.0 V

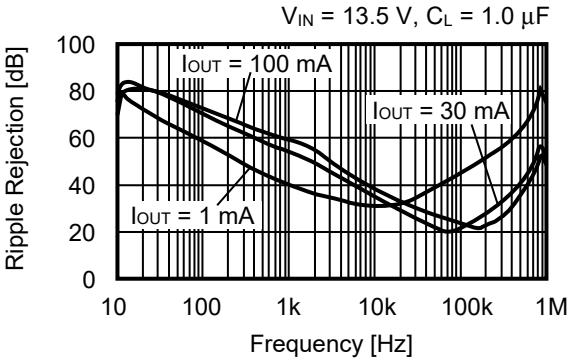


1. 6 Ripple rejection (Ta = +25°C)

1. 6. 1 V_{OUT} = 3.3 V



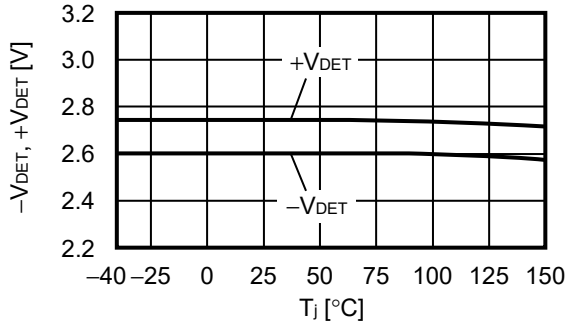
1. 6. 2 V_{OUT} = 5.0 V



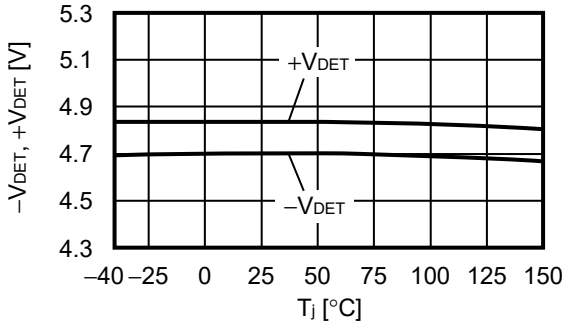
2. Detector block

2. 1 Detection voltage, Release voltage vs. Junction temperature

2. 1. 1 $-V_{DET}$ = 2.6 V

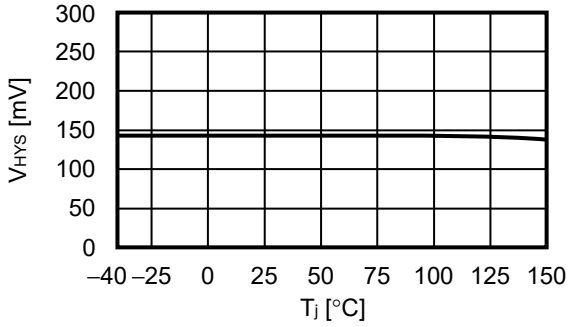


2. 1. 2 $-V_{DET}$ = 4.7 V

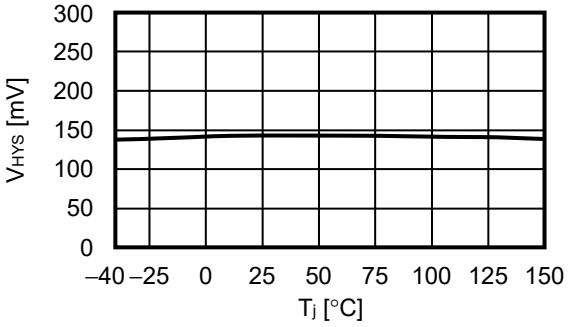


2. 2 Hysteresis width vs. Junction temperature

2. 2. 1 $-V_{DET}$ = 2.6 V

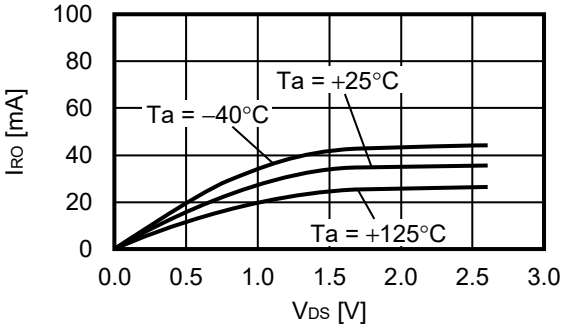


2. 2. 2 $-V_{DET}$ = 4.7 V

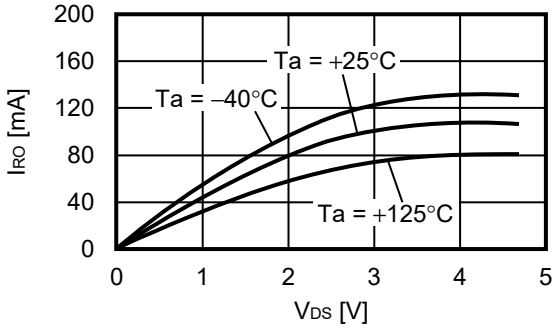


2. 3 Reset output current vs. V_{DS}

2. 3. 1 $-V_{DET}$ = 2.6 V

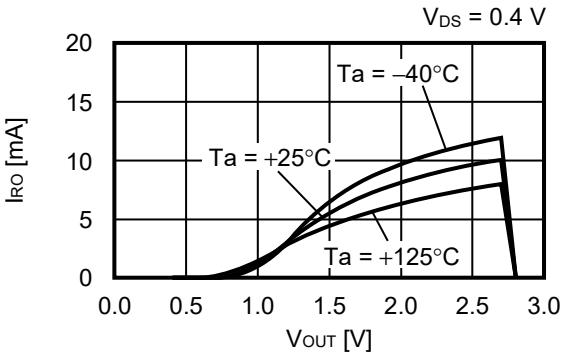


2. 3. 2 $-V_{DET}$ = 4.7 V

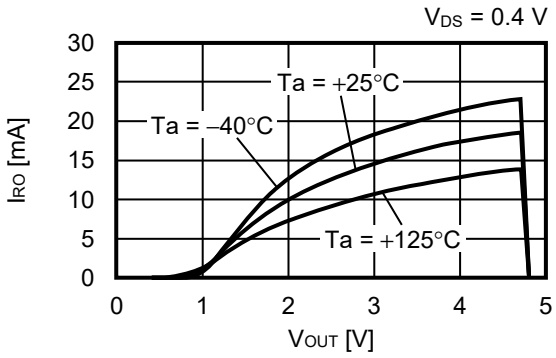


2. 4 Reset output current vs. Output voltage

2. 4. 1 $-V_{DET}$ = 2.6 V

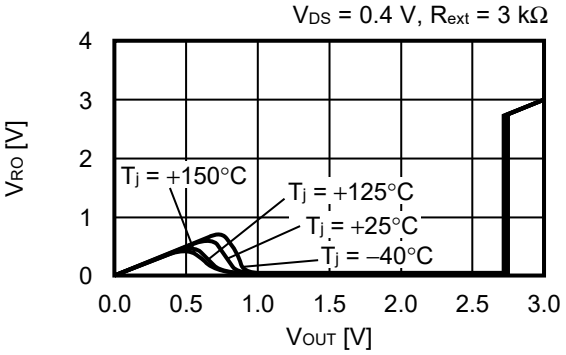


2. 4. 2 $-V_{DET}$ = 4.7 V

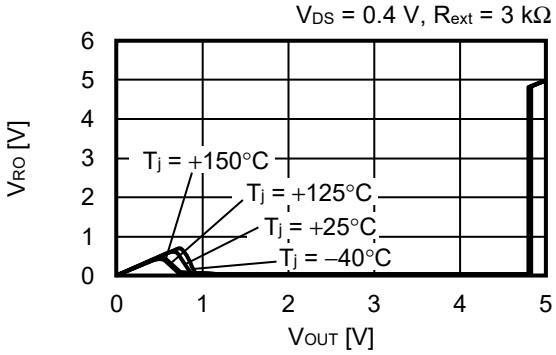


2. 5 RO pin voltage vs. Output voltage

2. 5. 1 $-V_{DET}$ = 2.6 V



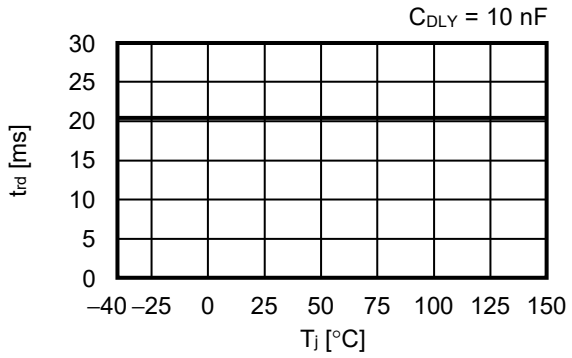
2. 5. 2 $-V_{DET}$ = 4.7 V



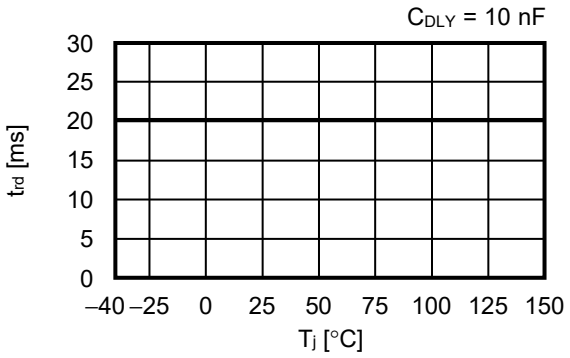
Remark I_{RO}: Nch transistor output current
V_{RO}: Nch transistor output voltage
V_{DS}: Drain-to-source voltage of Nch transistor

2. 6 Release delay time vs. Junction temperature

2. 6. 1 $-V_{DET}$ = 2.6 V

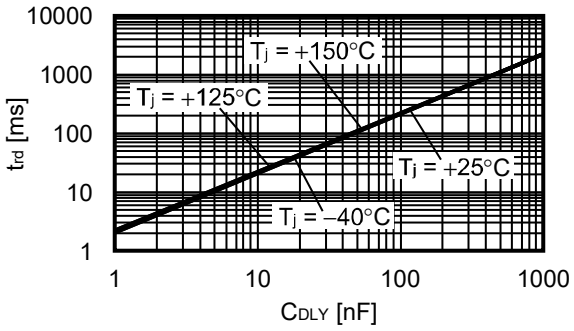


2. 6. 2 $-V_{DET}$ = 4.7 V

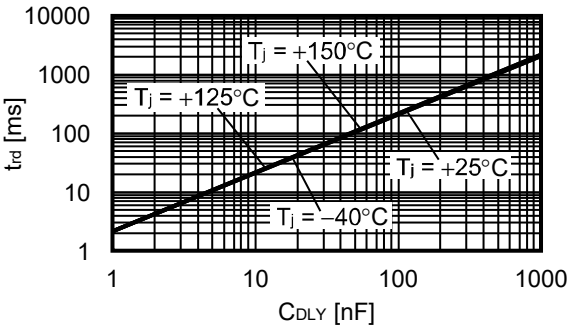


2. 7 Release delay time vs. Release delay time adjustment capacitance

2. 7. 1 $-V_{DET}$ = 2.6 V

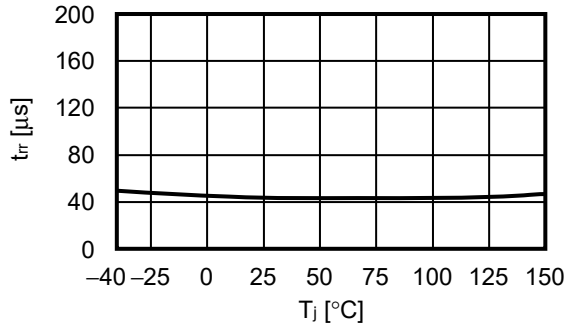


2. 7. 2 $-V_{DET}$ = 4.7 V

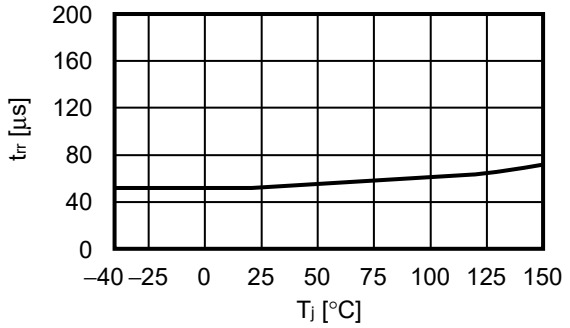


2. 8 Reset reaction time vs. Junction temperature

2. 8. 1 $-V_{DET}$ = 2.6 V



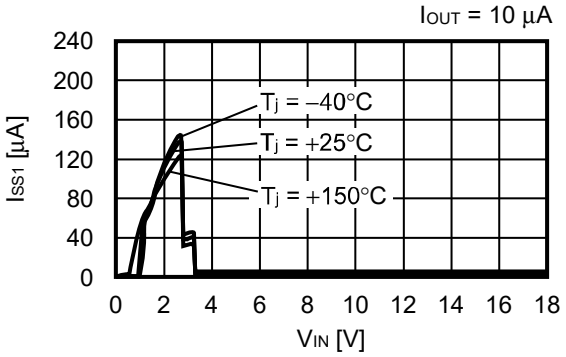
2. 8. 2 $-V_{DET}$ = 4.7 V



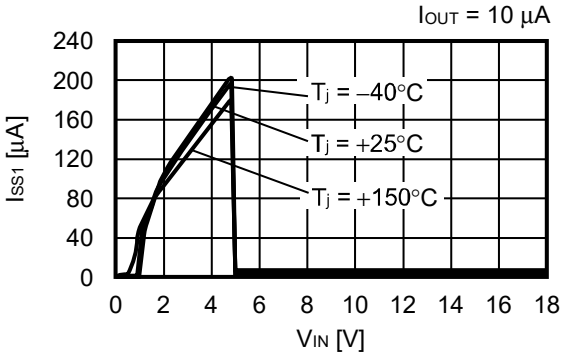
3. Overall

3. 1 Current consumption during operation vs. Input voltage

3. 1. 1 V_{OUT} = 3.3 V, $-V_{DET}$ = 2.6 V

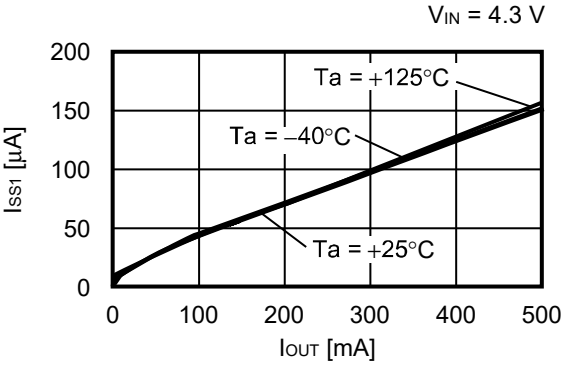


3. 1. 2 V_{OUT} = 5.0 V, $-V_{DET}$ = 4.7 V

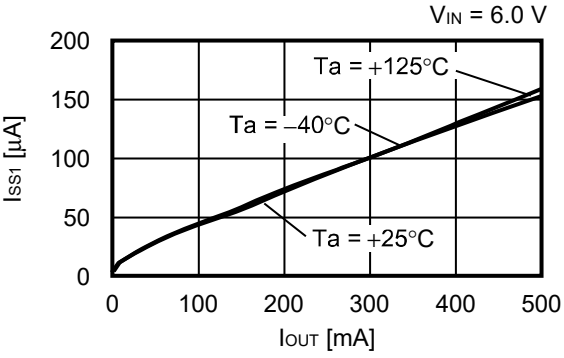


3. 2 Current consumption during operation vs. Output current

3. 2. 1 V_{OUT} = 3.3 V, $-V_{DET}$ = 2.6 V

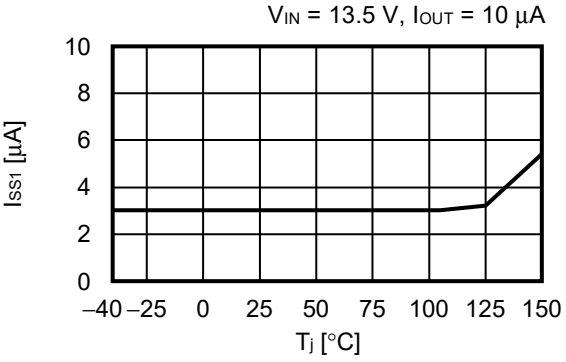


3. 2. 2 V_{OUT} = 5.0 V, $-V_{DET}$ = 4.7 V

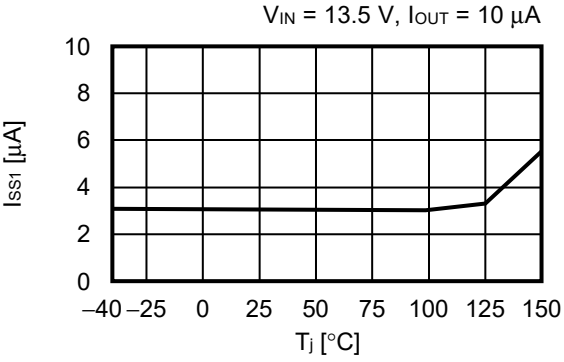


3. 3 Current consumption during operation vs. Junction temperature

3. 3. 1 V_{OUT} = 3.3 V, $-V_{DET}$ = 2.6 V



3. 3. 2 V_{OUT} = 5.0 V, $-V_{DET}$ = 4.7 V

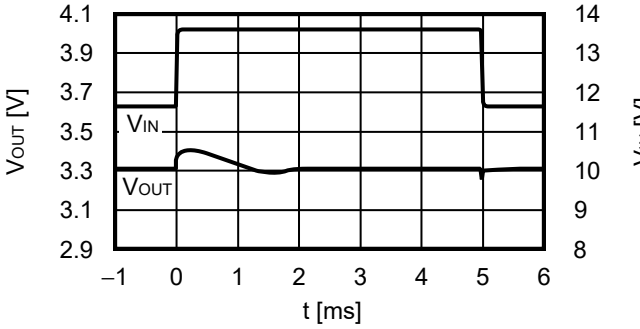


■ Reference Data

1. Characteristics of input transient response (Ta = +25°C)

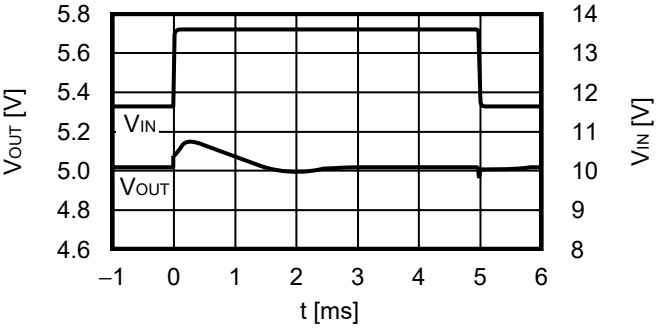
1. 1 V_{OUT} = 3.3 V

I_{OUT} = 0.1 mA, C_L = 1.0 µF, V_{IN} = 11.5 V ↔ 13.5 V, t_r = t_f = 5.0 µs



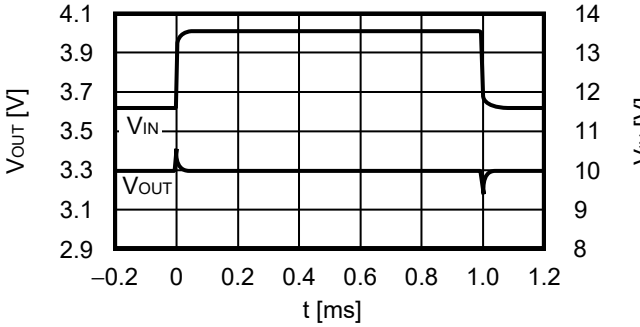
1. 2 V_{OUT} = 5.0 V

I_{OUT} = 0.1 mA, C_L = 1.0 µF, V_{IN} = 11.5 V ↔ 13.5 V, t_r = t_f = 5.0 µs



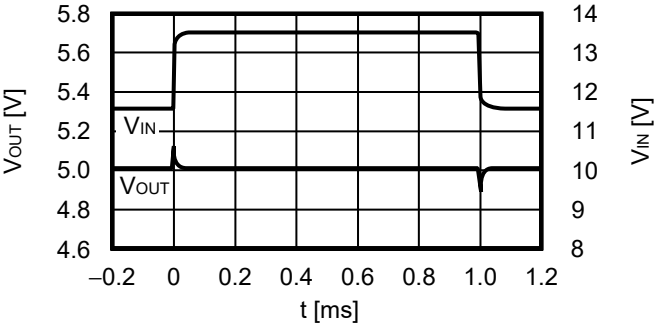
1. 3 V_{OUT} = 3.3 V

I_{OUT} = 250 mA, C_L = 1.0 µF, V_{IN} = 11.5 V ↔ 13.5 V, t_r = t_f = 5.0 µs



1. 4 V_{OUT} = 5.0 V

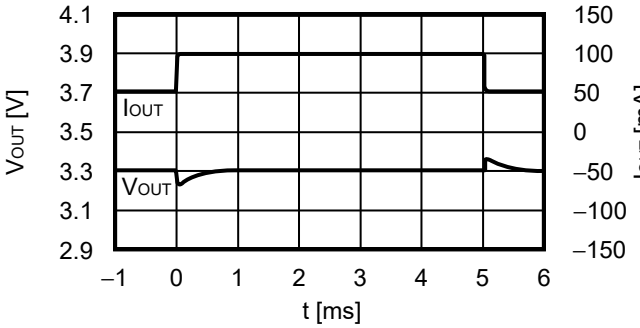
I_{OUT} = 250 mA, C_L = 1.0 µF, V_{IN} = 11.5 V ↔ 13.5 V, t_r = t_f = 5.0 µs



2. Characteristics of load transient response (Ta = +25°C)

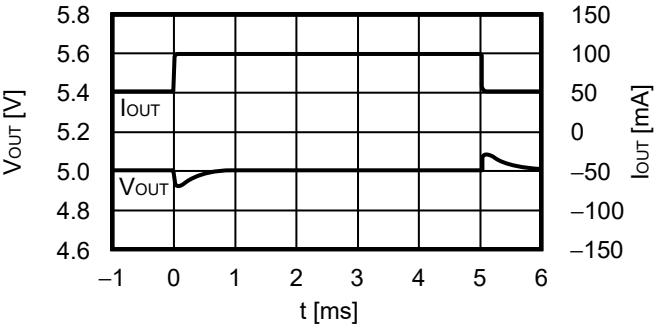
2. 1 V_{OUT} = 3.3 V

V_{IN} = 4.3 V, C_L = 1.0 µF, I_{OUT} = 50 mA ↔ 100 mA, t_r = t_f = 1.0 µs



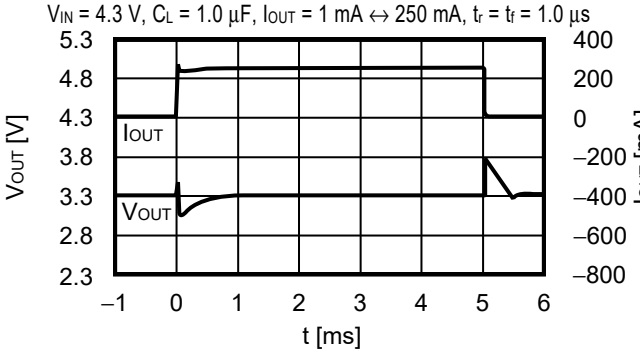
2. 2 V_{OUT} = 5.0 V

V_{IN} = 6.0 V, C_L = 1.0 µF, I_{OUT} = 50 mA ↔ 100 mA, t_r = t_f = 1.0 µs



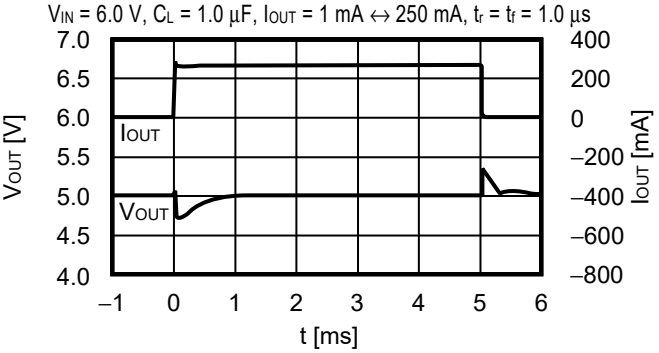
2. 3 V_{OUT} = 3.3 V

V_{IN} = 4.3 V, C_L = 1.0 µF, I_{OUT} = 1 mA ↔ 250 mA, t_r = t_f = 1.0 µs



2. 4 V_{OUT} = 5.0 V

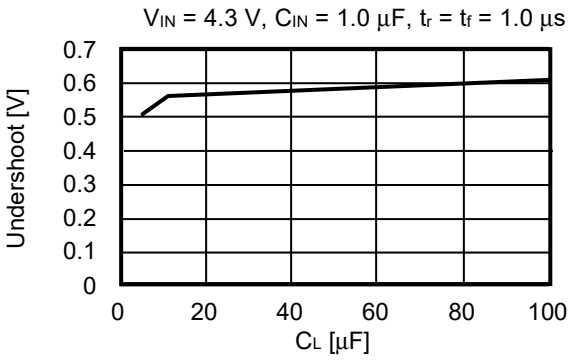
V_{IN} = 6.0 V, C_L = 1.0 µF, I_{OUT} = 1 mA ↔ 250 mA, t_r = t_f = 1.0 µs



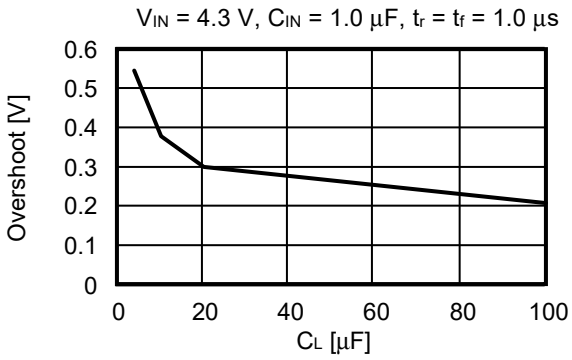
3. Load transient response characteristics dependent on capacitance (Ta = +25°C)

3. 1 V_{OUT} = 3.3 V

3. 1. 1 I_{OUT} = 1.0 mA → 500 mA

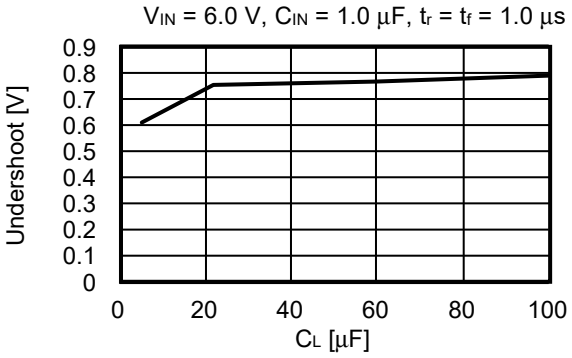


3. 1. 2 I_{OUT} = 500 mA → 1.0 mA

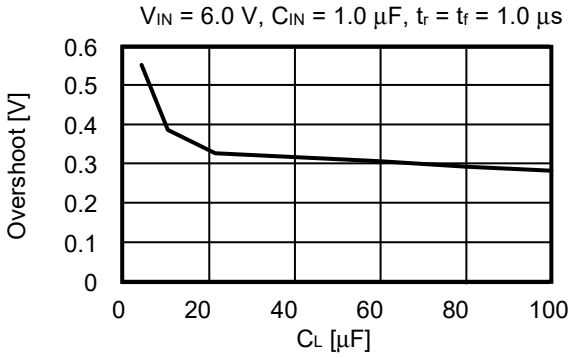


3. 2 V_{OUT} = 5.0 V

3. 2. 1 I_{OUT} = 1.0 mA → 500 mA

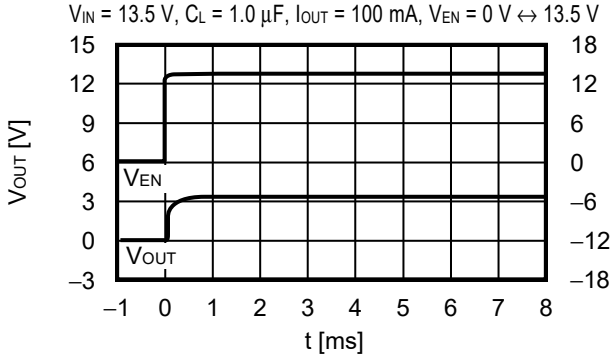


3. 2. 2 I_{OUT} = 500 mA → 1.0 mA

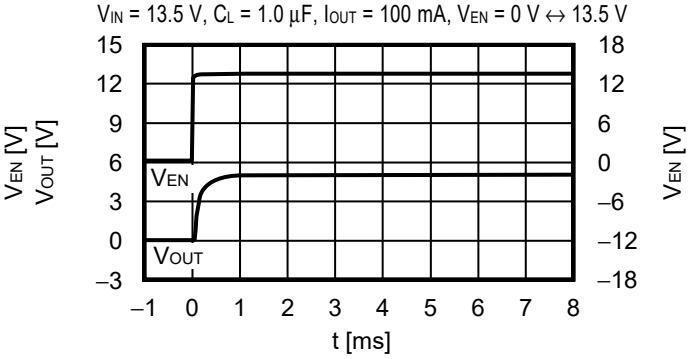


4. Characteristics of EN pin transient response (Ta = +25°C)

4. 1 V_{OUT} = 3.3 V



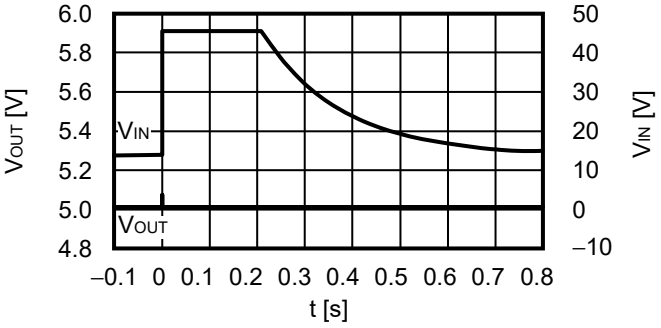
4. 2 V_{OUT} = 5.0 V



5. Load dump characteristics (Ta = +25°C)

5. 1 V_{OUT} = 5.0 V

I_{OUT} = 0.1 mA, V_{IN} = 14.0 V ↔ 45.0 V, C_{IN} = C_L = 1.0 µF



6. Example of equivalent series resistance vs. Output current characteristics (Ta = –40°C to +125°C)

C_{IN} = C_L = 1.0 µF, C_{DLY} = 10 nF

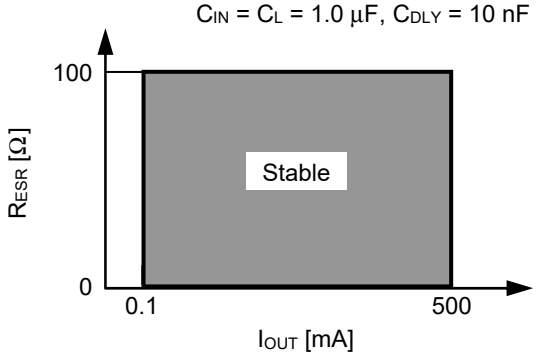
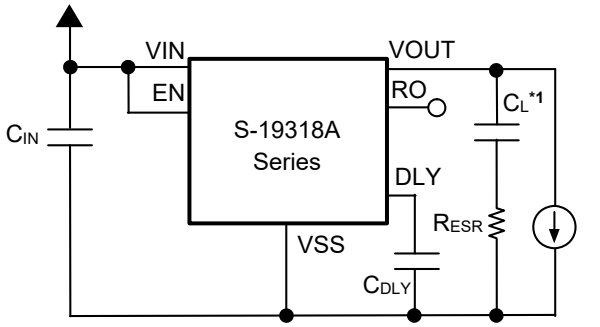


Figure 19

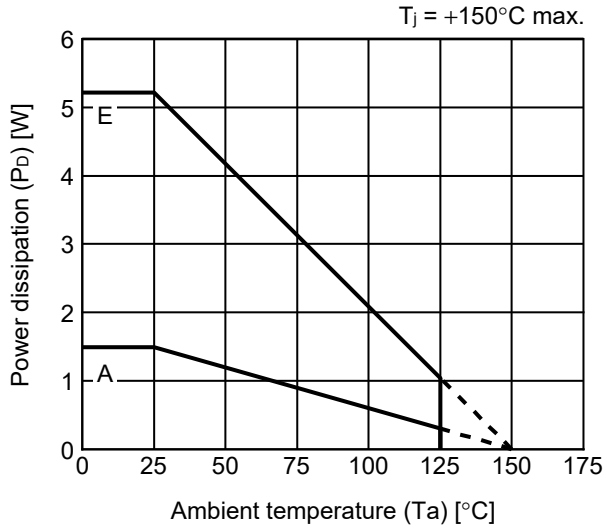


***1.** C_L: TDK Corporation CGA5L3X8R1H105K (1.0 µF)

Figure 20

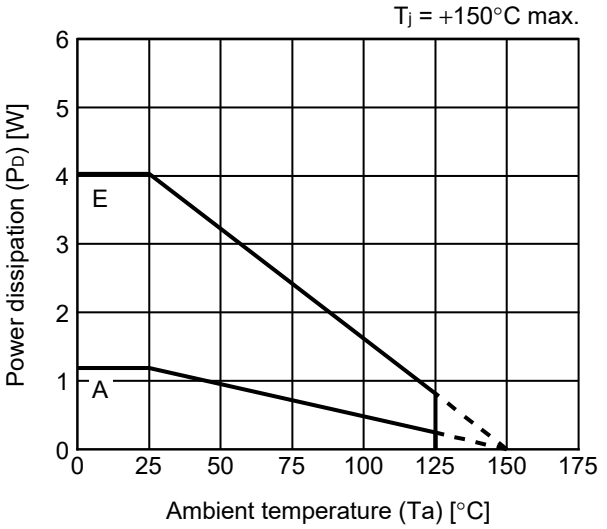
■ Power Dissipation

TO-252-9S



Board	Power Dissipation (P_D)*1
A	1.49 W
B	–
C	–
D	–
E	5.21 W

HSOP-8A



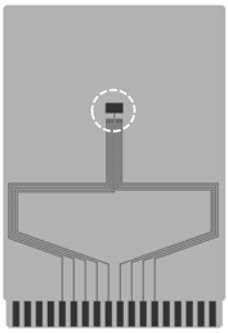
Board	Power Dissipation (P_D)*1
A	1.19 W
B	–
C	–
D	–
E	4.03 W

***1.** Measurement values when this IC is mounted on each board

TO-252-9S Test Board

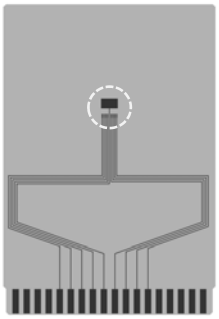
(1) Board A

IC Mount Area



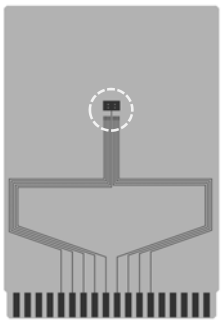
Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		2
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	-
	3	-
	4	74.2 x 74.2 x t0.070
Thermal via		-

(2) Board B



Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		-

(3) Board C



Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		Number: 4 Diameter: 0.3 mm

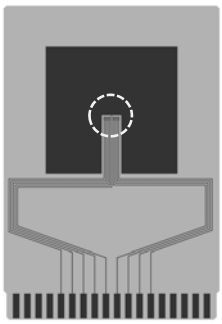
enlarged view

No. TO252-9S-A-Board-SD-1.0

TO-252-9S Test Board

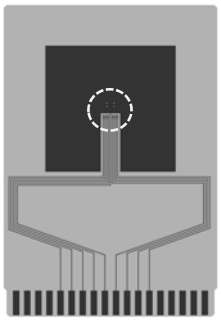
(4) Board D

IC Mount Area



Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Pattern for heat radiation: 2000mm^2 t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		-

(5) Board E



Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Pattern for heat radiation: 2000mm^2 t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		Number: 4 Diameter: 0.3 mm

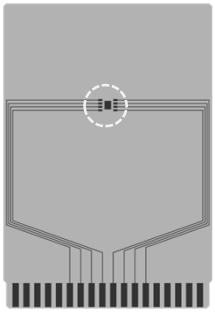
enlarged view

No. TO252-9S-A-Board-SD-1.0

HSOP-8A Test Board

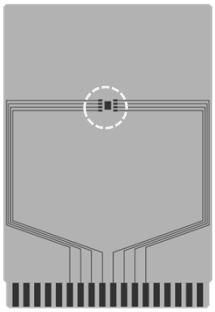
(1) Board A

IC Mount Area



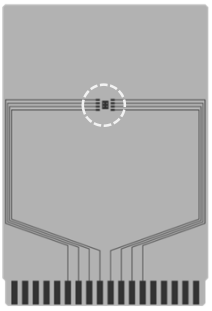
Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		2
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	-
	3	-
	4	74.2 x 74.2 x t0.070
Thermal via		-

(2) Board B

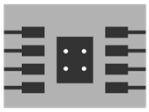


Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		-

(3) Board C



Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		Number: 4 Diameter: 0.3 mm



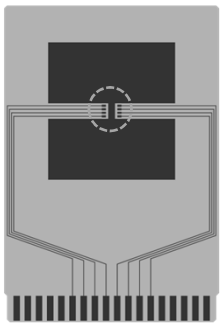
enlarged view

No. HSOP8A-A-Board-SD-1.0

HSOP-8A Test Board

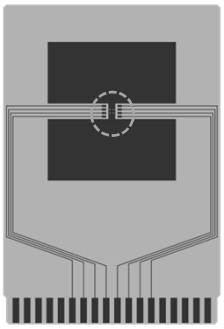
(4) Board D

IC Mount Area

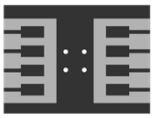


Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Pattern for heat radiation: 2000mm2 t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		-

(5) Board E

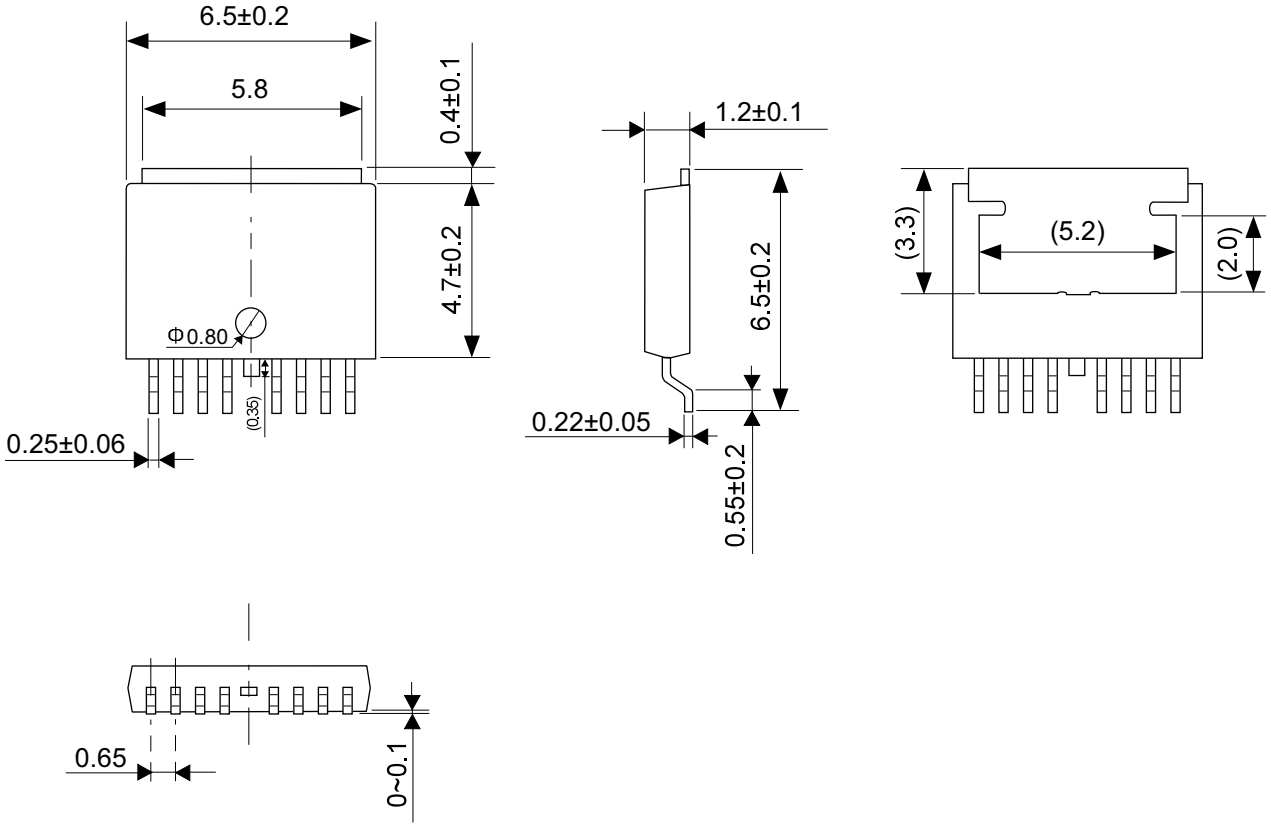


Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Pattern for heat radiation: 2000mm^2 t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		Number: 4 Diameter: 0.3 mm



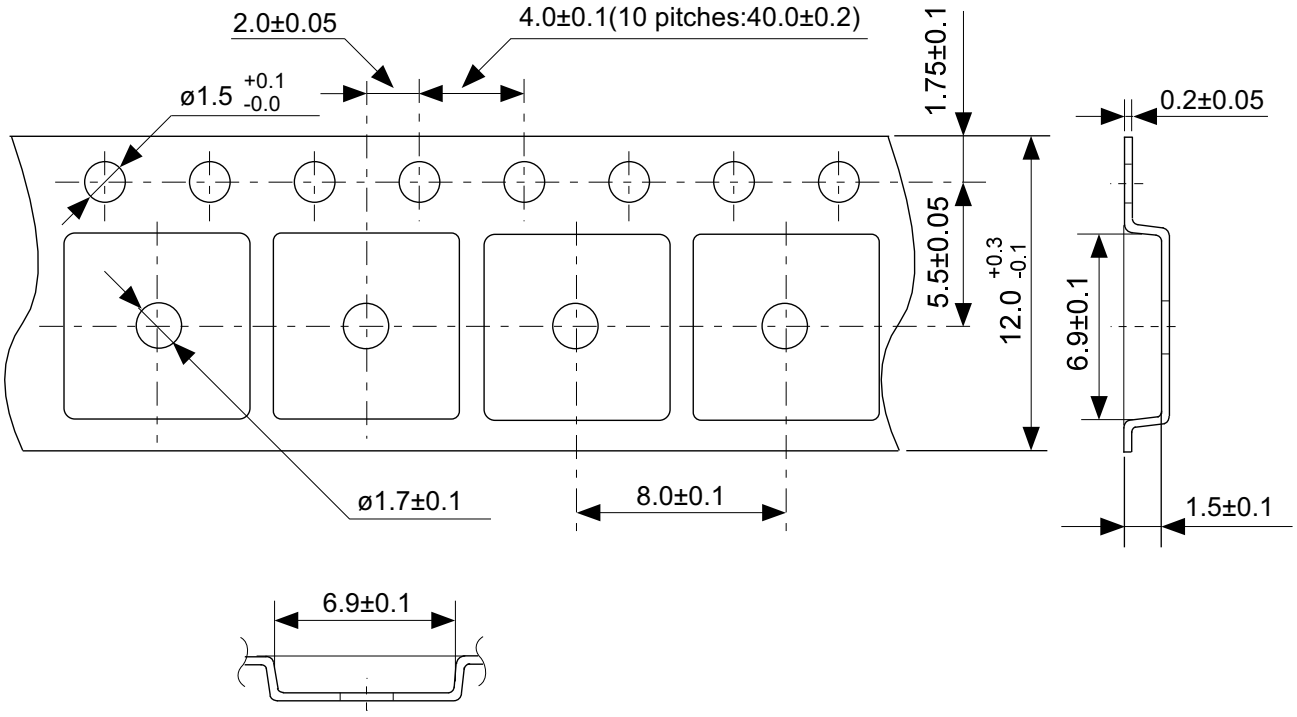
enlarged view

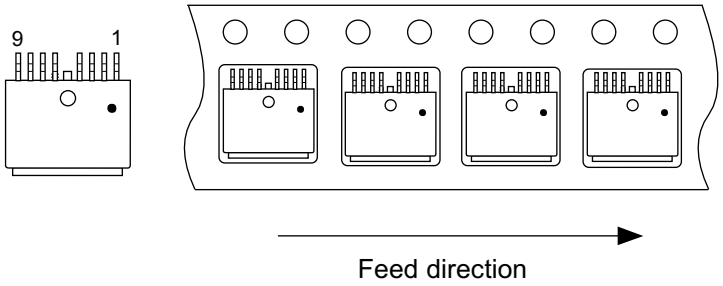
No. HSOP8A-A-Board-SD-1.0



No. VA009-A-P-SD-2.0

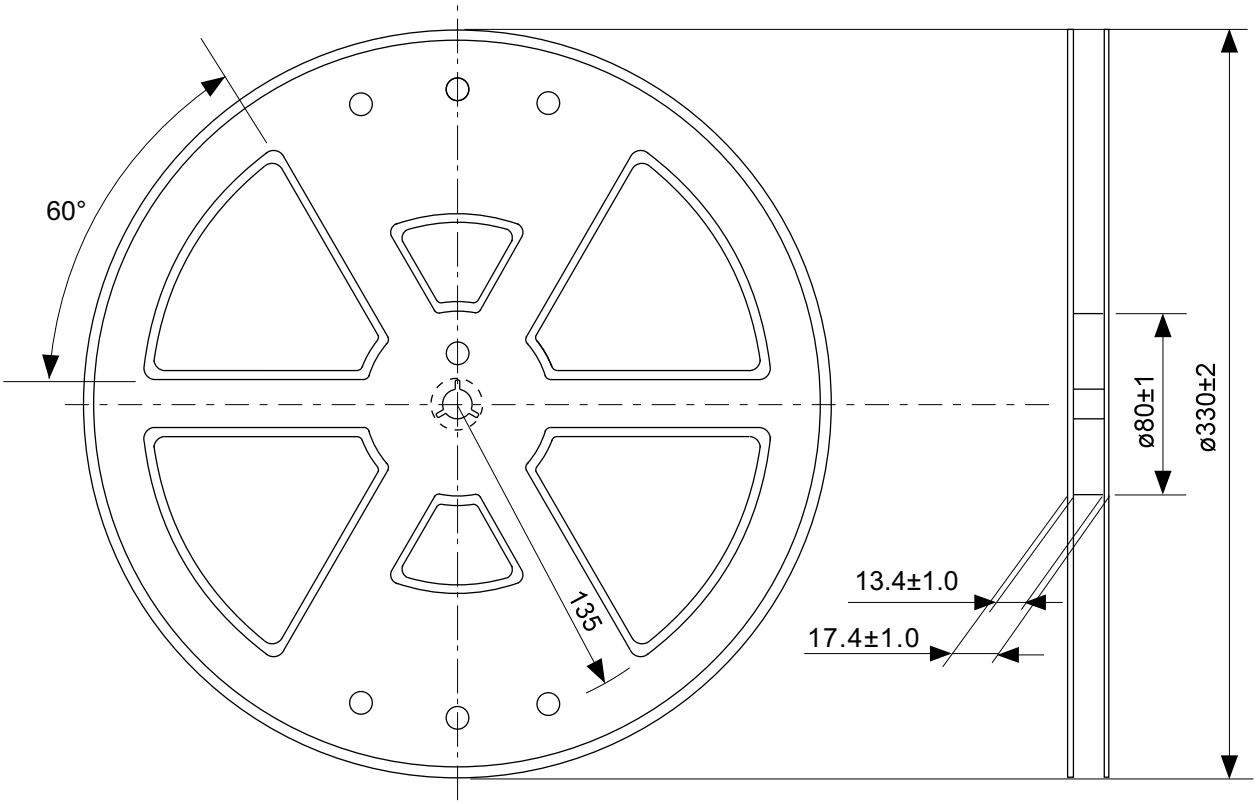
TITLE	TO252-9S-A-PKG Dimensions
No.	VA009-A-P-SD-2.0
ANGLE	
UNIT	mm
ABLIC Inc.	



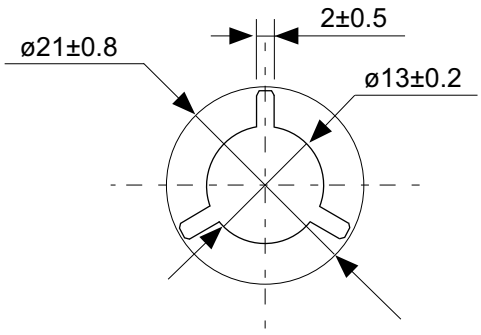


No. VA009-A-C-SD-1.0

TITLE	TO252-9S-A-Carrier Tape
No.	VA009-A-C-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	

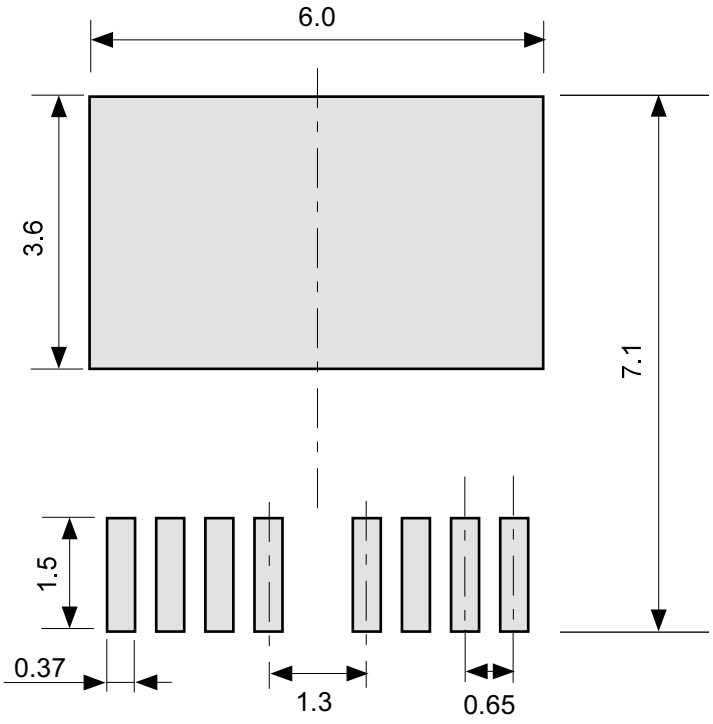


Enlarged drawing in the central part



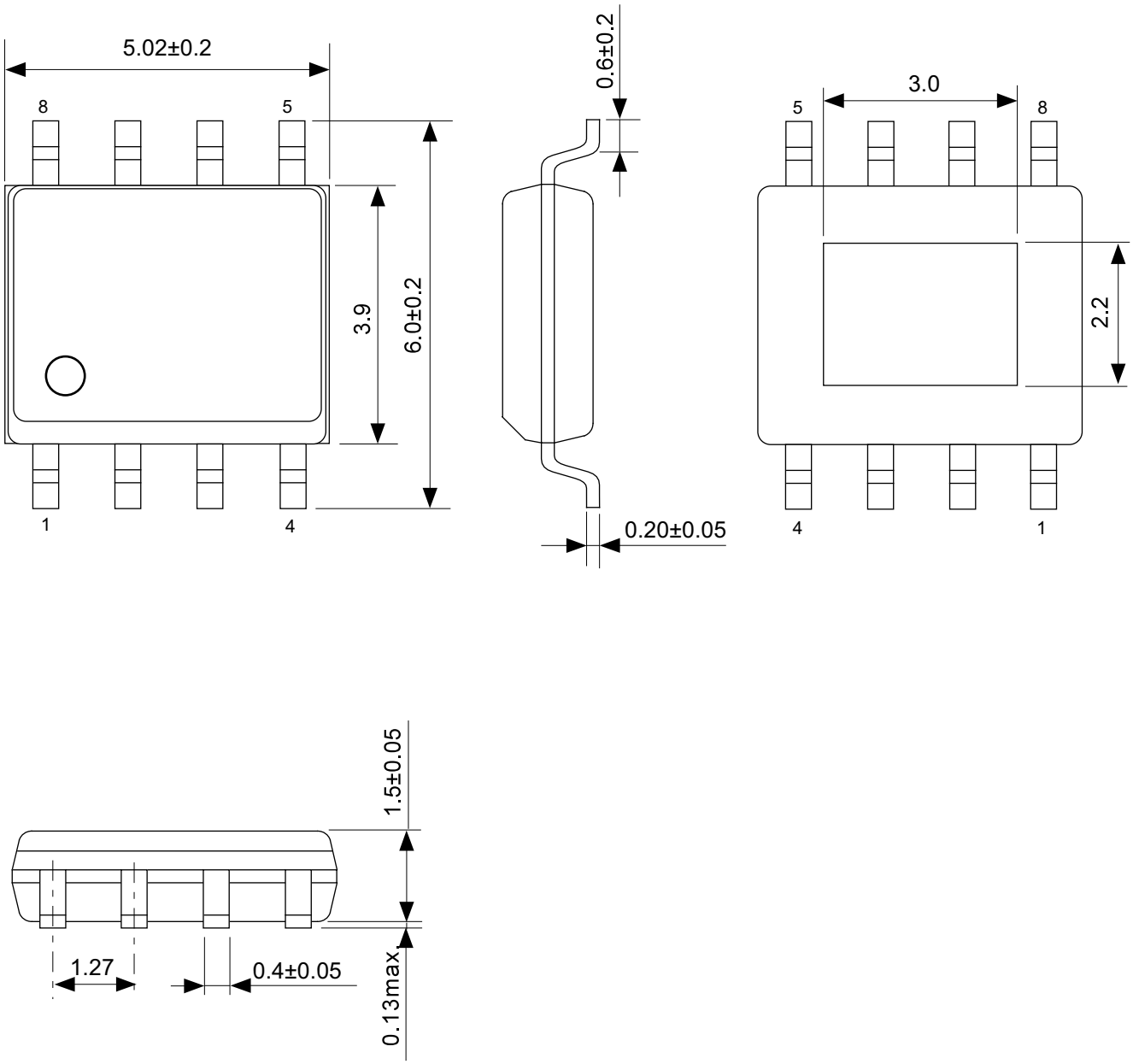
No. VA009-A-R-SD-1.1

TITLE	TO252-9S-A-Reel		
No.	VA009-A-R-SD-1.1		
ANGLE		QTY.	4,000
UNIT	mm		
ABLIC Inc.			



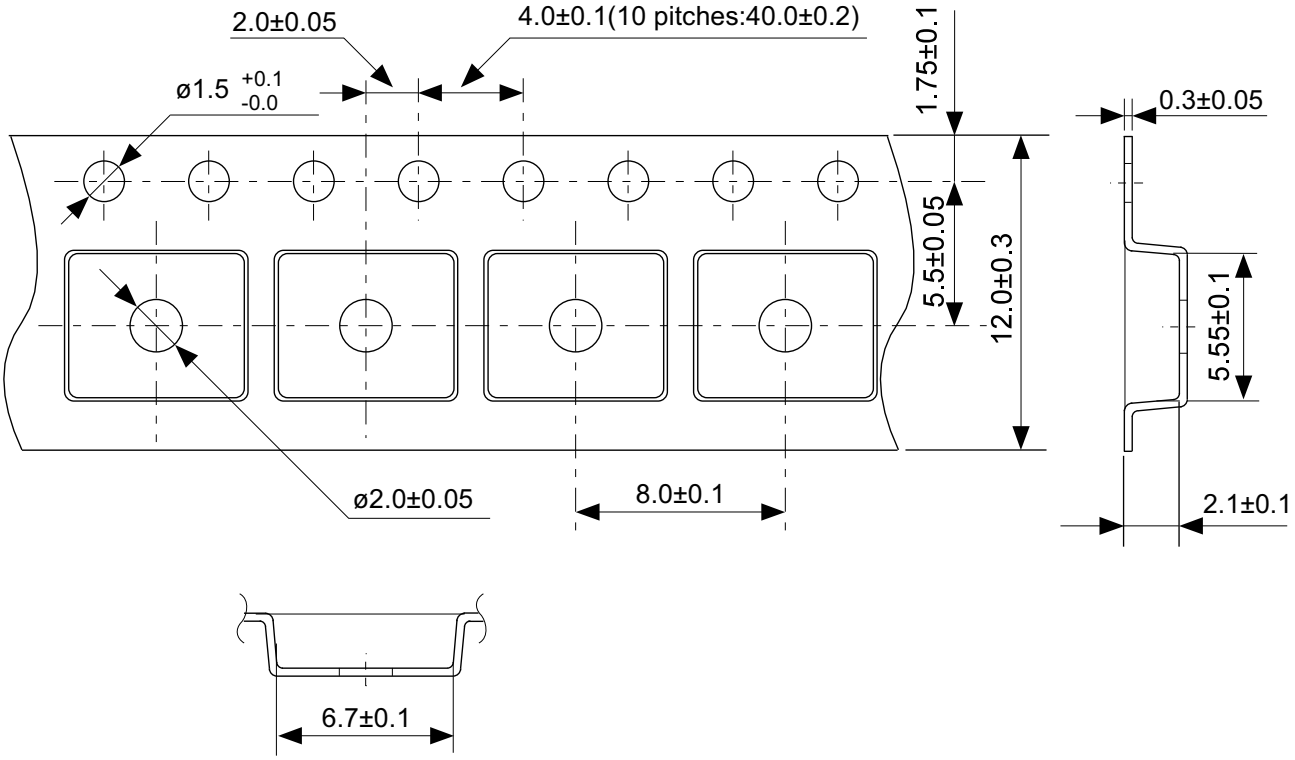
No. VA009-A-L-SD-1.0

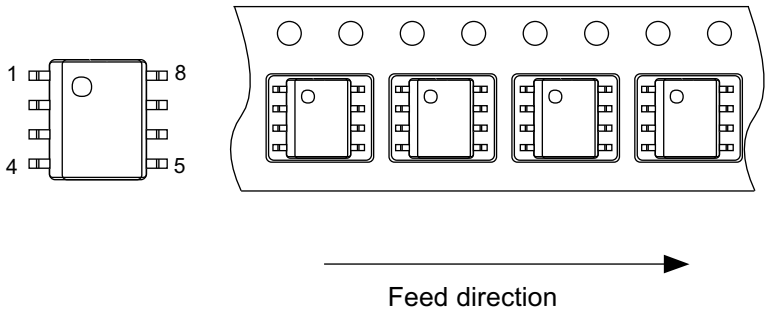
TITLE	TO252-9S-A -Land Recommendation
No.	VA009-A-L-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	



No. FH008-A-P-SD-2.0

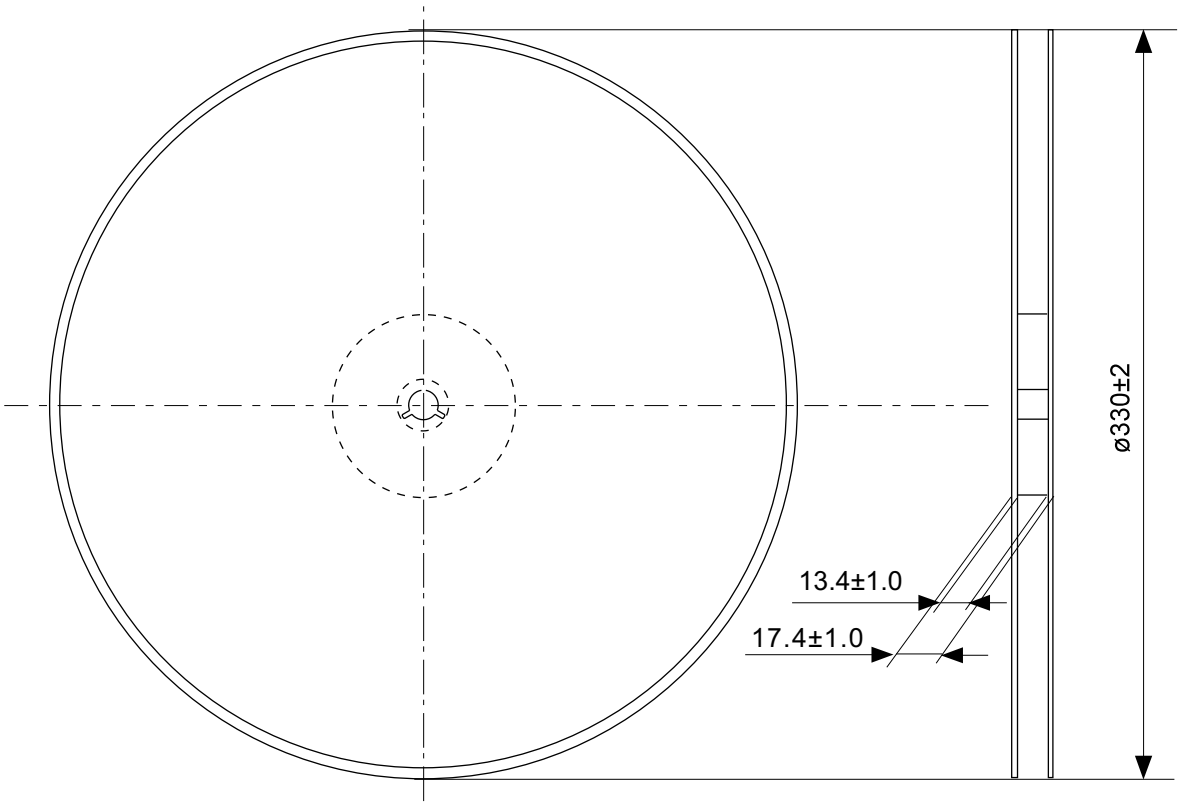
TITLE	HSOP8A-A-PKG Dimensions
No.	FH008-A-P-SD-2.0
ANGLE	
UNIT	mm
ABLIC Inc.	



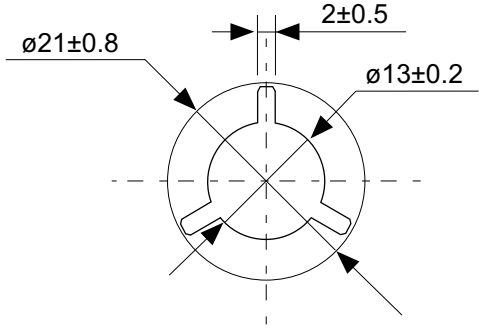


No. FH008-A-C-SD-1.0

TITLE	HSOP8A-A-Carrier Tape
No.	FH008-A-C-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	

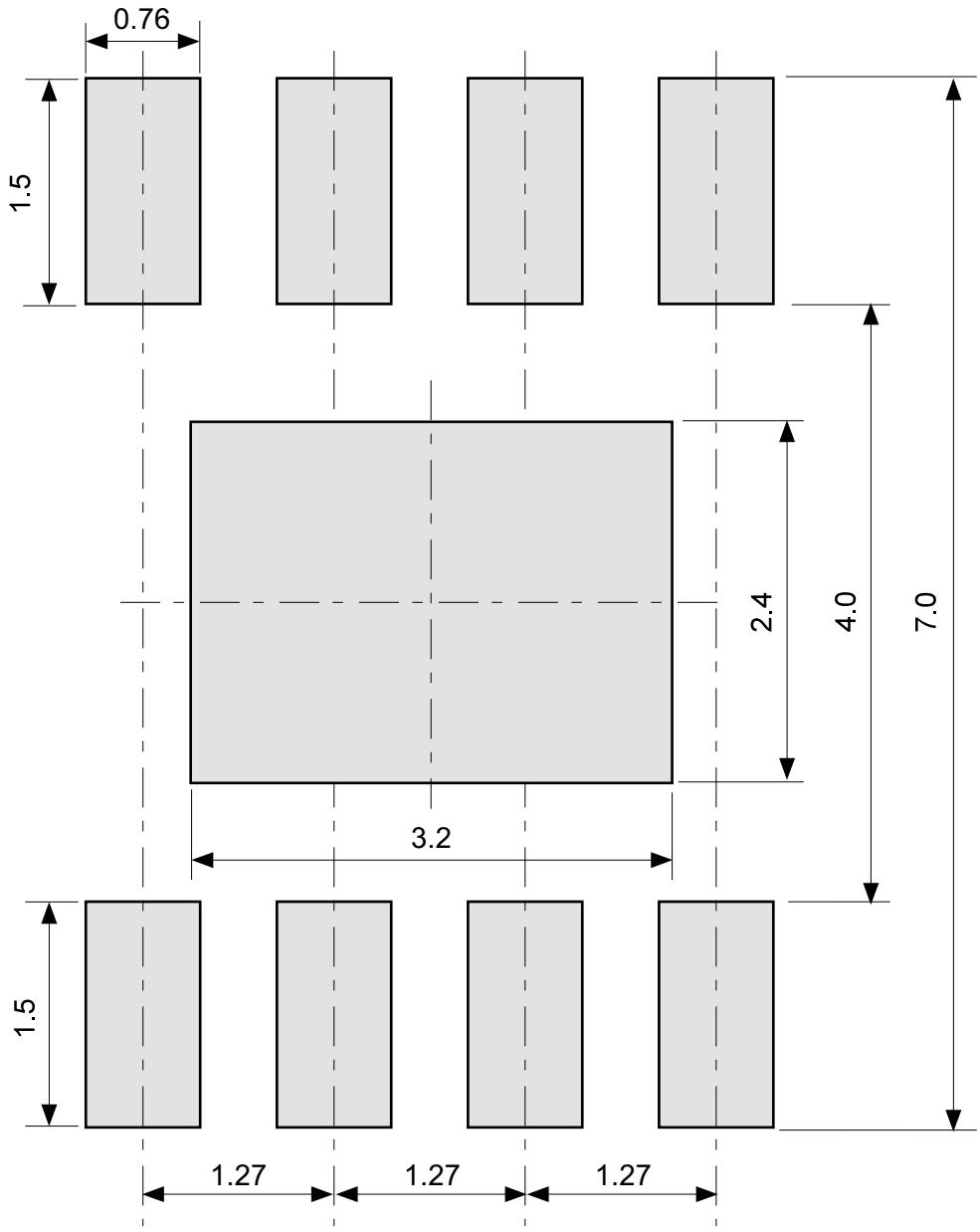


Enlarged drawing in the central part



No. FH008-A-R-SD-1.1

TITLE	HSOP8A-A-Reel		
No.	FH008-A-R-SD-1.1		
ANGLE		QTY.	4,000
UNIT	mm		
ABLIC Inc.			



No. FH008-A-L-SD-1.0

TITLE	HSOP8A-A -Land Recommendation
No.	FH008-A-L-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	

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