

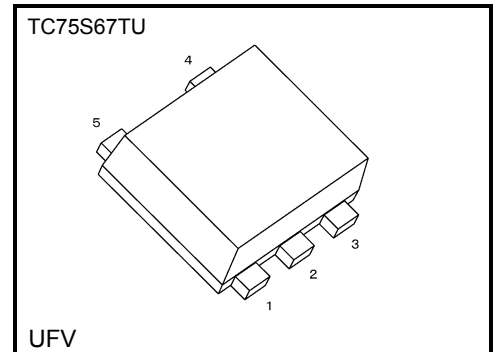
TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

# TC75S67TU

Single Operational Amplifier (Ultra Low Noise Operational Amplifier)

## Features

- Ultra Low Noise.  $V_{NI} = 6 \text{ nV}/\sqrt{\text{Hz}}$  (typ.) @  $V_{DD} = 2.5 \text{ V}$
- Low-current supply.  $430 \text{ }\mu\text{A}$  (typ.) @  $V_{DD} = 2.5 \text{ V}$
- Ultra-compact package.



Weight: 7 mg (typ.)

## Absolute Maximum Ratings (Note) ( $T_a = 25^\circ\text{C}$ )

Characteristics	Symbol	Rating	Unit
Supply voltage	$V_{DD}, V_{SS}$	6	V
Differential input voltage	$DV_{IN}$	$\pm 6$	V
Input voltage	$V_{IN}$	$V_{DD}$ to $V_{SS}$	V
Output current	$I_{OUT}$	$\pm 4$	mA
Power dissipation (Note 1)	$P_D$	450	mW
Operating temperature	$T_{opr}$	-40 to 85	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-55 to 125	$^\circ\text{C}$

Note: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.

Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 1: Mounted on a glass epoxy circuit board of 30 mm × 30 mm. Pad dimension of 35mm<sup>2</sup>

## Operating Ratings (Note) ( $T_a = 25^\circ\text{C}$ )

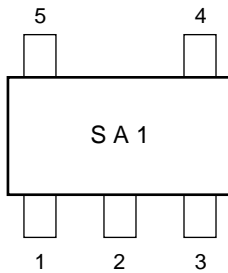
Characteristics	Symbol	Rating	Unit
Supply voltage	$V_{DD}, V_{SS}$	2.2 to 5.5	V

Note: Do not use this product in a voltage follower circuit or outside the range of the common mode input voltage. (For the common mode input voltage, see DC Characteristics on Page 2). Failure to follow this instruction may cause a circuit oscillation.

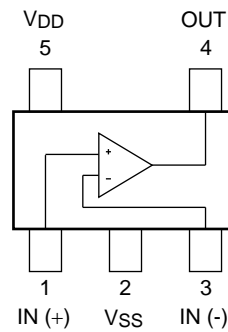
A higher load capacitance will increase the risk of voltage oscillation, even if this product is used within the range of the common mode input voltage. Allow sufficient capacitance value margin when designing your circuit and using this product to prevent a circuit oscillation.

Start of commercial production  
2017-08

## Marking (top view)



## Pin Connection (top view)



## Electrical Characteristics

### DC Characteristics ( $V_{DD} = 2.5\text{ V}$ , $V_{SS} = \text{GND}$ , $T_a = 25^\circ\text{C}$ )

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input offset voltage	$V_{IO}$	1	$R_S = 1\text{ k}\Omega$ , $R_F = 100\text{ k}\Omega$	-	0.5	3	mV
Input offset voltage drift	$V_{IO\text{drift}}$	1	$R_S = 1\text{ k}\Omega$ , $R_F = 100\text{ k}\Omega$	-	2	-	$\mu\text{V}/^\circ\text{C}$
Input offset current	$I_{IO}$	-	-	-	1	-	pA
Input bias current	$I_I$	-	-	-	1	-	pA
Common mode input voltage	$CMV_{IN}$	2	$R_S = 1\text{ k}\Omega$ , $R_F = 100\text{ k}\Omega$	0	-	1.4	V
Voltage gain (open loop)	$G_V$	-	-	80	100	-	dB
Maximum output voltage	$V_{OH}$	3	$R_L \geq 100\text{ k}\Omega$	2.4	-	-	V
	$V_{OL}$	4	$R_L \geq 100\text{ k}\Omega$	-	-	0.1	
Common mode input signal rejection ratio	CMRR	2	$V_{IN} = 0\text{ to }1.4\text{ V}$	70	100	-	dB
Supply voltage rejection ratio	SVRR	1	$V_{DD} = 2.2\text{ to }5.5\text{ V}$	70	100	-	dB
Supply current	$I_{DD}$	5	-	-	430	700	$\mu\text{A}$
Source current	$I_{\text{source}}$	6	-	2000	2500	-	$\mu\text{A}$
Sink current	$I_{\text{sink}}$	7	-	2000	3500	-	$\mu\text{A}$

### AC Characteristics ( $V_{DD} = 2.5\text{ V}$ , $V_{SS} = \text{GND}$ , $T_a = 25^\circ\text{C}$ )

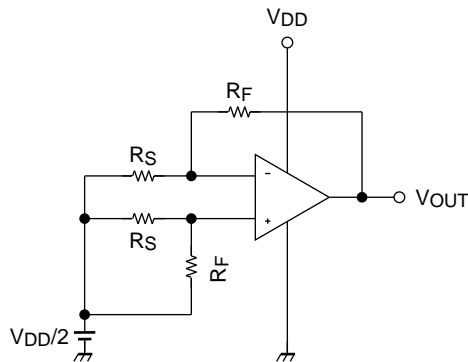
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Equivalent input Noise Voltage	$V_{NI}$	-	$f = 10\text{ Hz}$ , $G_V = 40\text{ dB}$ , $R_S = 100\ \Omega$ , $R_f = 10\text{ k}\Omega$	-	16	40	$\text{nV}/\sqrt{\text{Hz}}$
			$f = 1\text{ kHz}$ , $G_V = 40\text{ dB}$ , $R_S = 100\ \Omega$ , $R_f = 10\text{ k}\Omega$	-	6	10	
Unity Gain Cross Frequency	$f_T$	9	-	3.0	3.5	-	MHz
Phase delay	$\phi_D$	8	$f = 10\text{ kHz}$	-	-10.5	-	degrees
Phase margin	$\phi_m$	9	$G_V = 6\text{ dB}$ ( $A_V = 2$ )	-	55	-	degrees

### AC Characteristics ( $V_{DD} = 1.25\text{ V}$ , $V_{SS} = -1.25\text{ V}$ , $T_a = 25^\circ\text{C}$ )

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Slew Rate	SR	10	$G_V = 12\text{ dB}$ , $V_{IN} = 0.25\text{ V}_{p-p}$	-	1.0	-	$\text{V}/\mu\text{s}$

## Test Circuit

### 1. SVRR, $V_{IO}$



- SVRR
- For each of the two  $V_{DD}$  values, measure the  $V_{OUT}$  value, as indicated below, and calculate the value of SVRR using the equation shown.

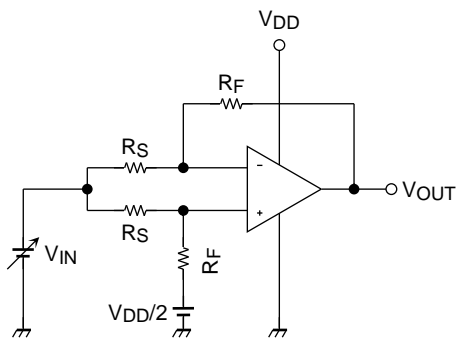
When  $V_{DD} = 2.2\text{ V}$ ,  $V_{DD} = V_{DD1}$  and  $V_{OUT} = V_{OUT1}$   
 When  $V_{DD} = 5.5\text{ V}$ ,  $V_{DD} = V_{DD2}$  and  $V_{OUT} = V_{OUT2}$

$$SVRR = 20 \log \left( \left| \frac{V_{DD1} - V_{DD2}}{\left( V_{OUT1} - \frac{V_{DD1}}{2} \right) \left( V_{OUT2} - \frac{V_{DD2}}{2} \right)} \right| \times \frac{R_F + R_S}{R_S} \right)$$

- $V_{IO}$   
 Measure the value of  $V_{OUT}$  and calculate the value of  $V_{IO}$  using the following equation.

$$V_{IO} = \left( V_{OUT} - \frac{V_{DD}}{2} \right) \times \left( \frac{R_S}{R_F + R_S} \right)$$

### 2. CMRR, $CMV_{IN}$



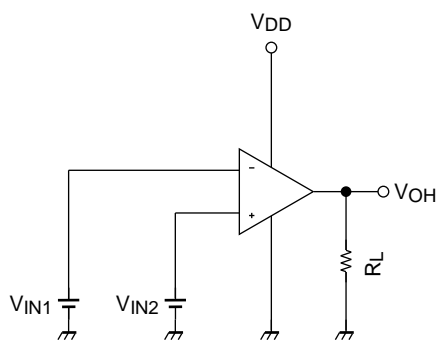
- CMRR  
 Measure the  $V_{OUT}$  value, as indicated below, and calculate the value of the CMRR using the equation shown.

When  $V_{IN} = 0\text{ V}$ ,  $V_{IN} = V_{IN1}$  and  $V_{OUT} = V_{OUT1}$   
 When  $V_{IN} = 1.4\text{ V}$ ,  $V_{IN} = V_{IN2}$  and  $V_{OUT} = V_{OUT2}$

$$CMRR = 20 \log \left( \left| \frac{V_{IN1} - V_{IN2}}{V_{OUT1} - V_{OUT2}} \right| \times \frac{R_F + R_S}{R_S} \right)$$

- $CMV_{IN}$   
 Input range within which the CMRR specification guarantees  $V_{OUT}$  value (as varied by the  $V_{IN}$  value).

### 3. $V_{OH}$

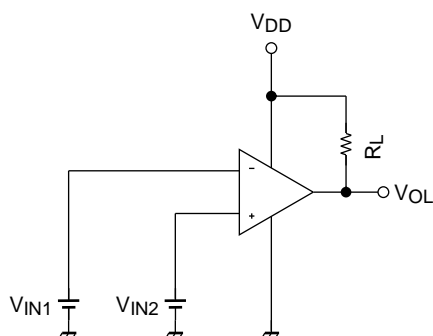


- $V_{OH}$

$$V_{IN1} = \frac{V_{DD}}{2} - 0.1\text{ V}$$

$$V_{IN2} = \frac{V_{DD}}{2}$$

### 4. $V_{OL}$

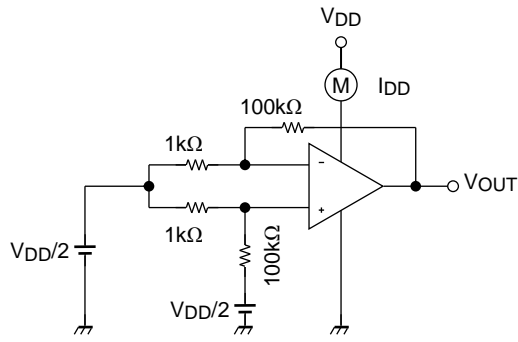


- $V_{OL}$

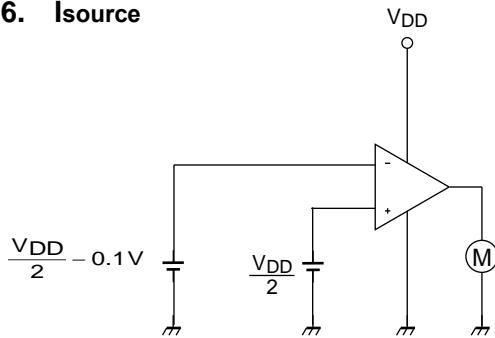
$$V_{IN1} = \frac{V_{DD}}{2}$$

$$V_{IN2} = \frac{V_{DD}}{2} - 0.1\text{ V}$$

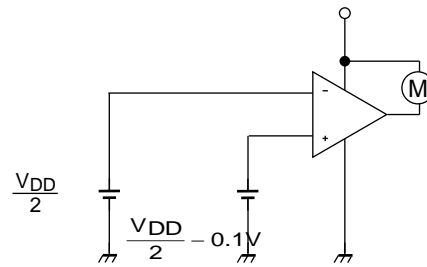
## 5. I<sub>DD</sub>



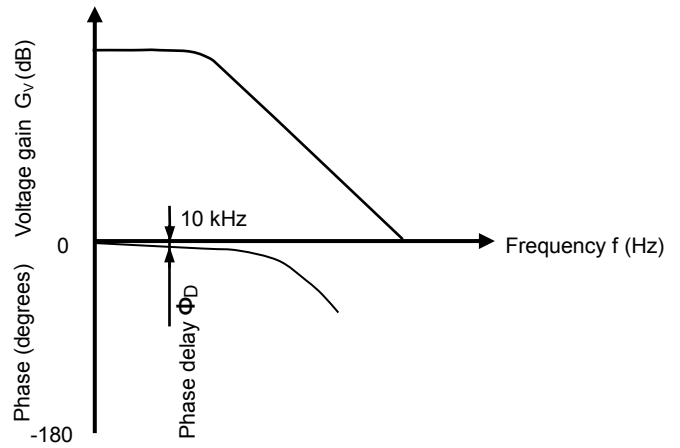
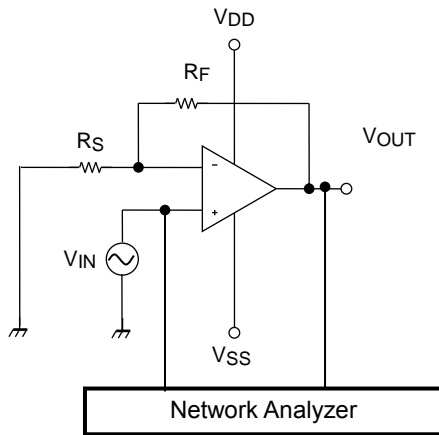
## 6. I<sub>source</sub>



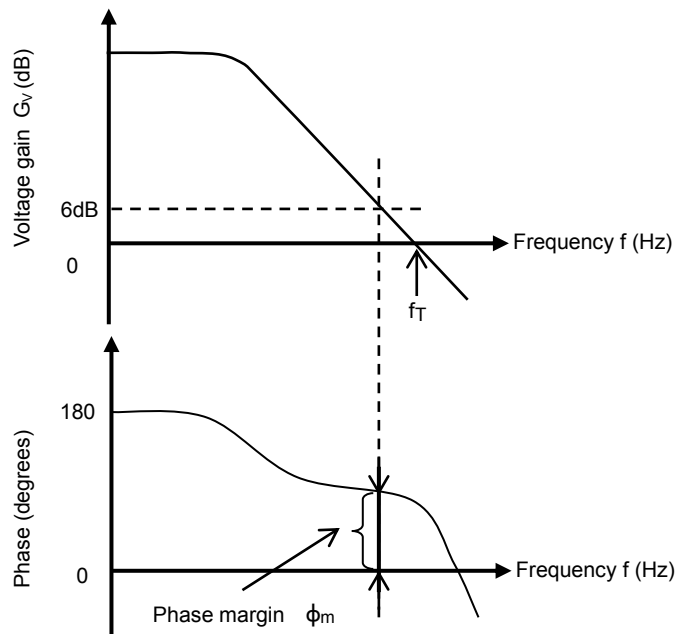
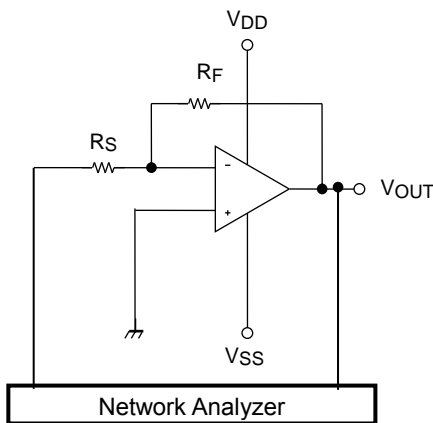
## 7. I<sub>sink</sub>



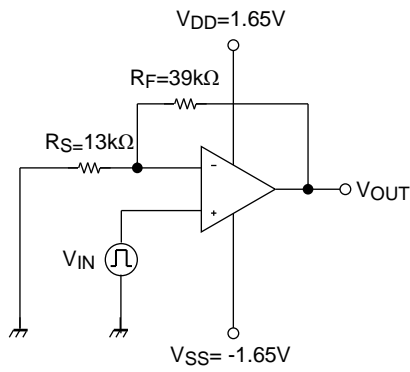
8.  $\phi_D$



9.  $f_T$ ,  $\phi_m$



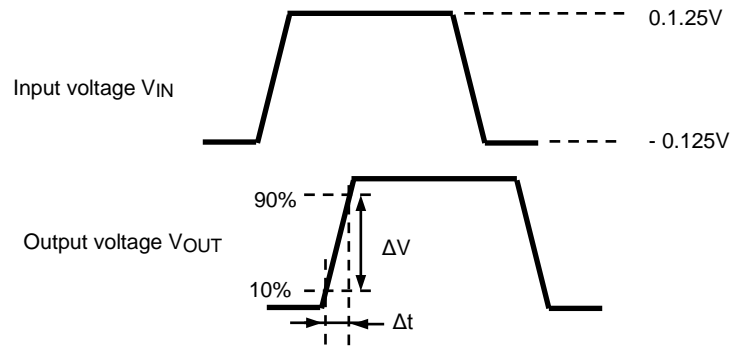
10. SR

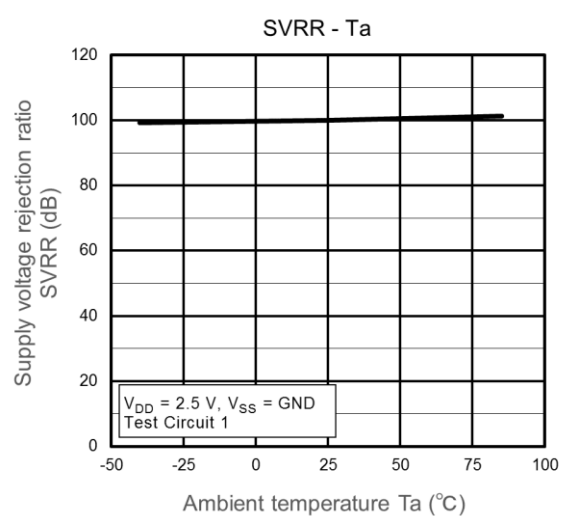
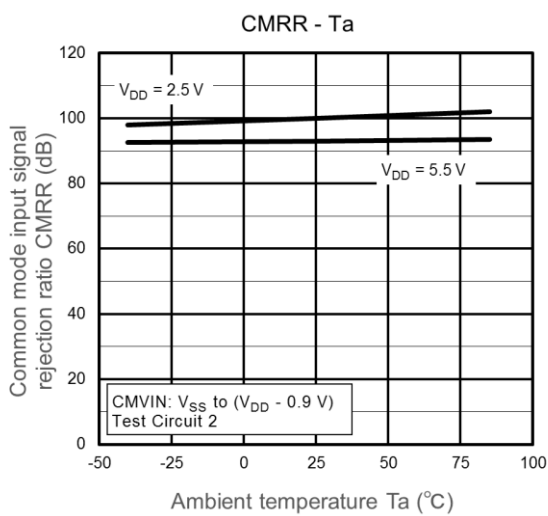
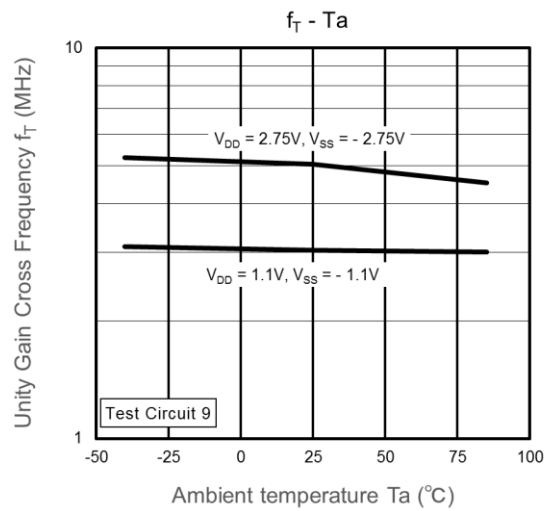
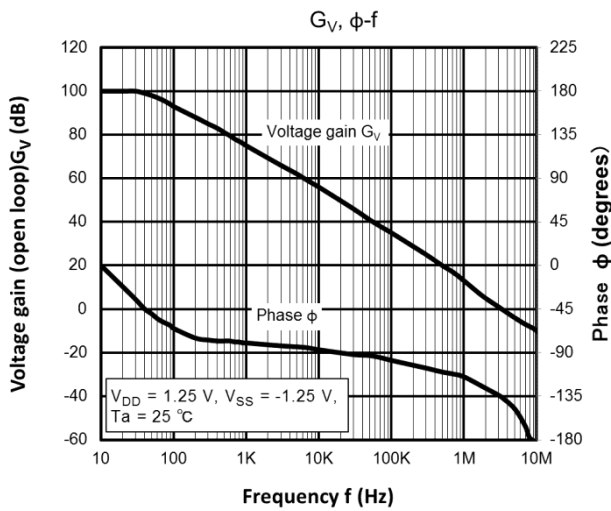
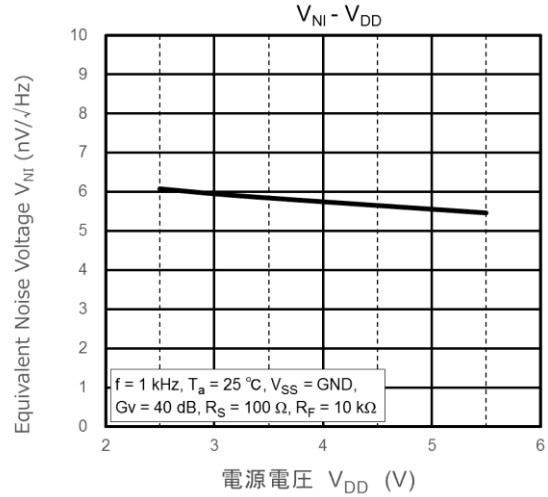
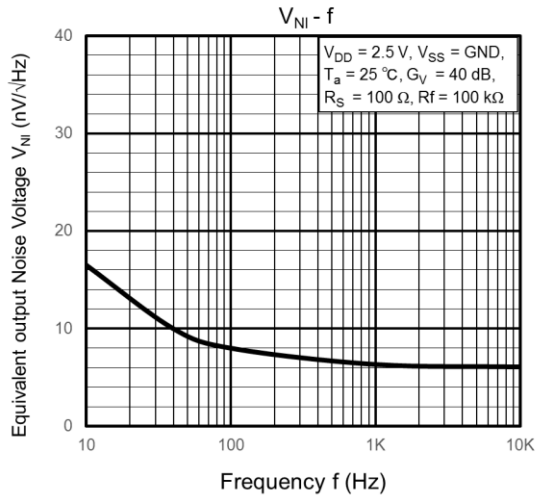


- SR

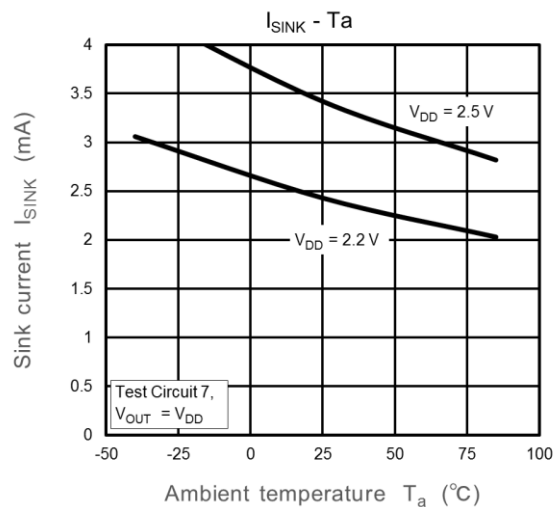
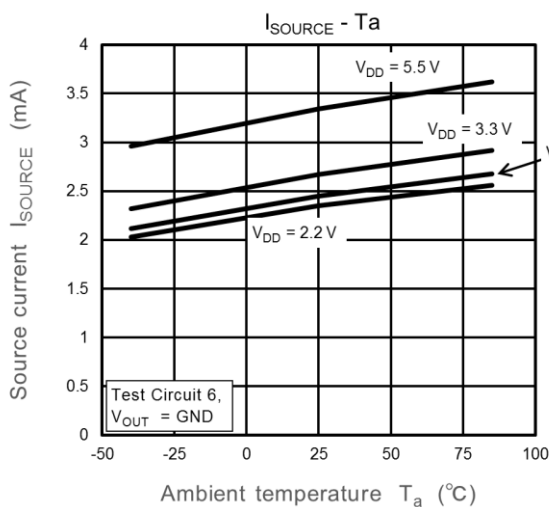
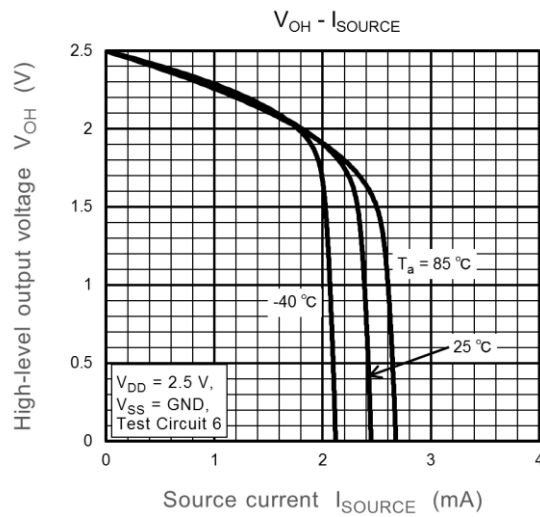
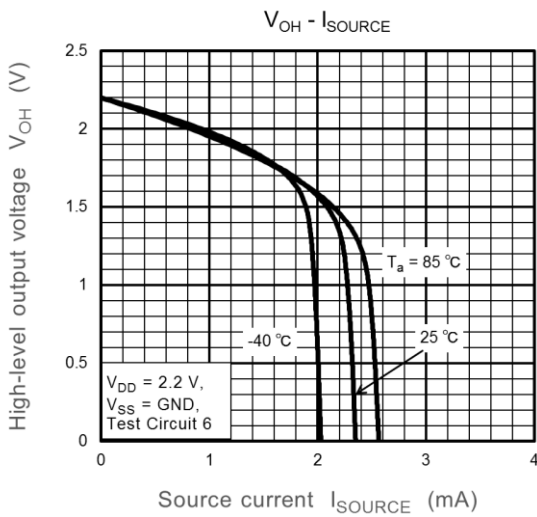
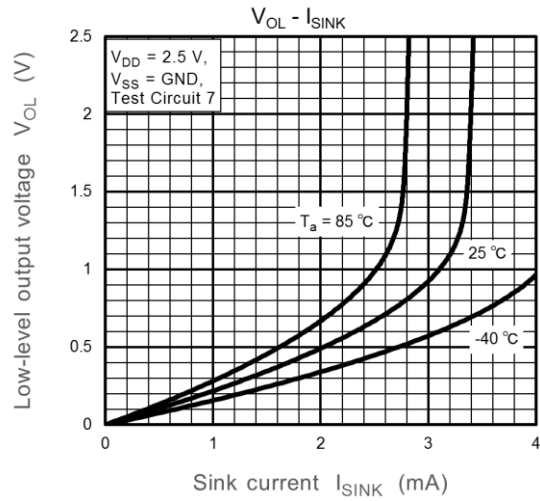
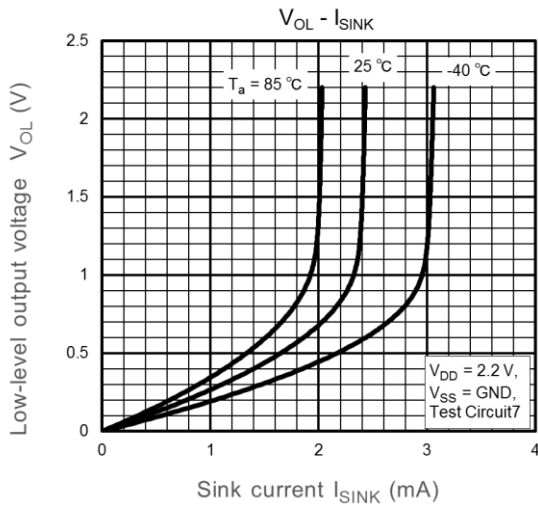
$$G_V = 1 + \frac{R_F}{R_S} = 12 \text{ dB}$$

$$SR = \frac{\Delta t}{\Delta V}$$



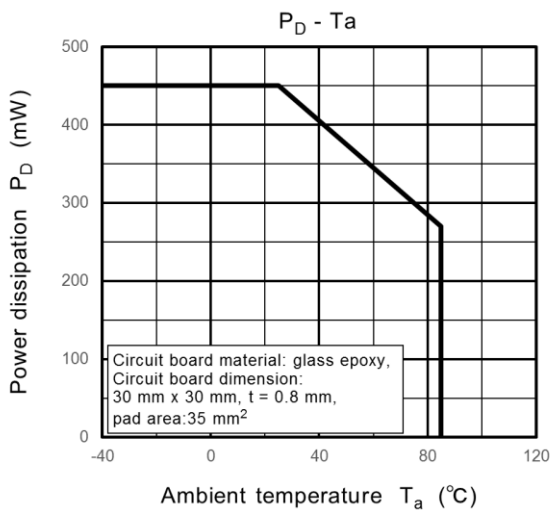
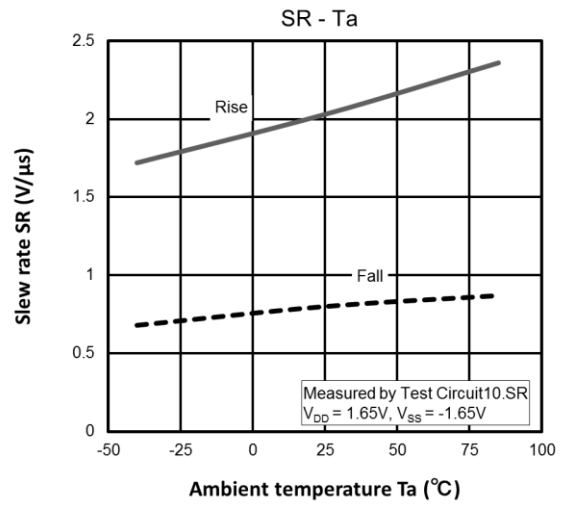
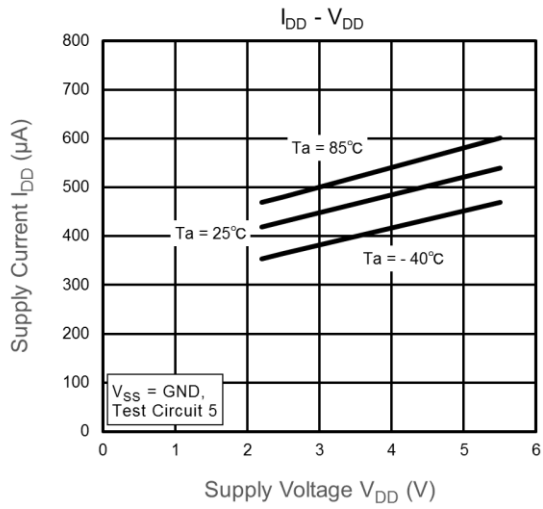


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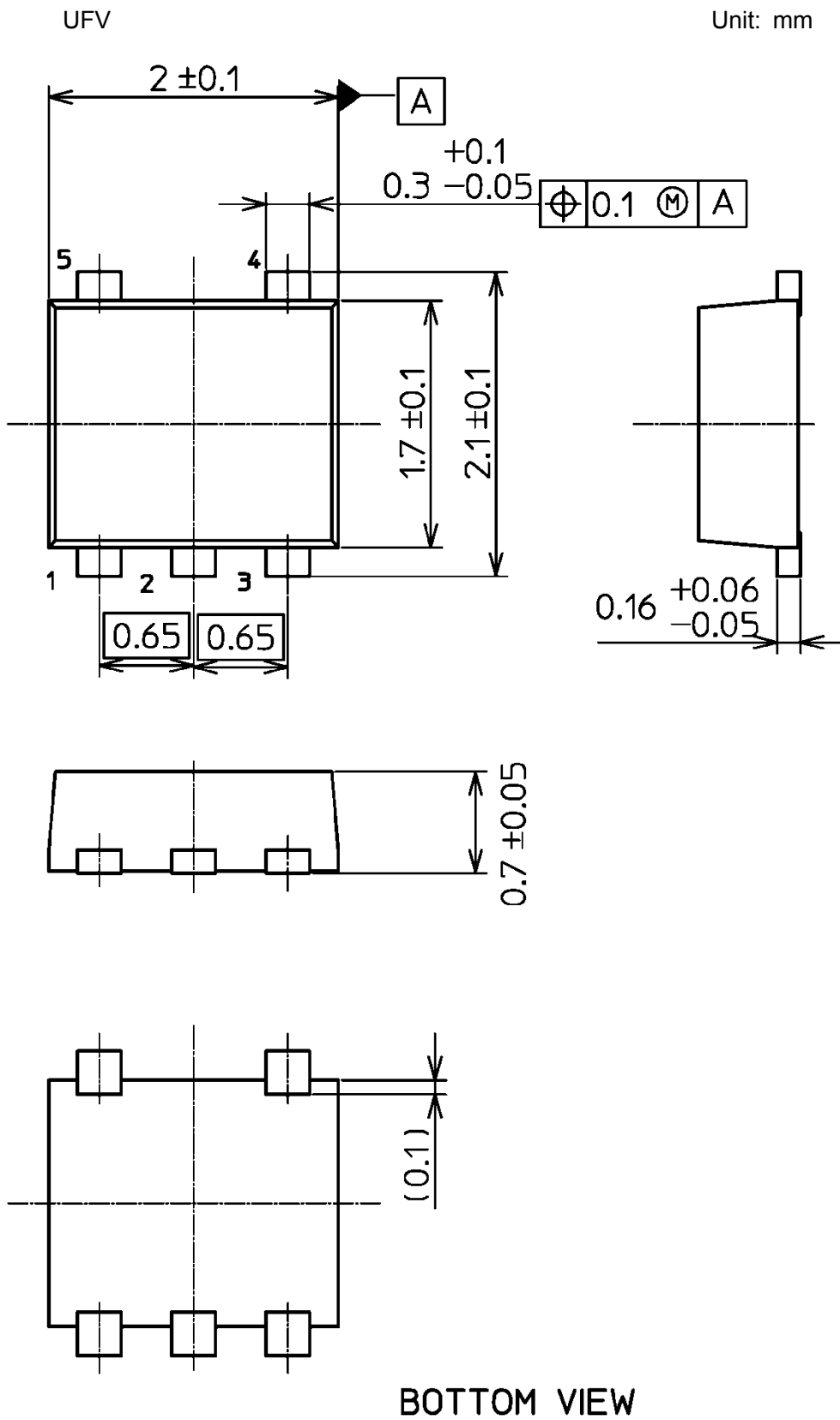
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The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

## Package Dimensions



Weight: 7 mg (typ.)

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