

TCR3DMxxA series

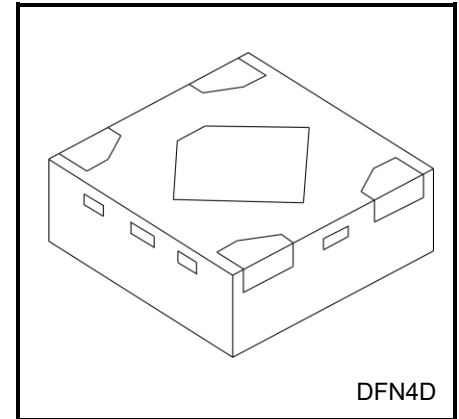
300 mA CMOS Low Drop-Out Regulator with inrush current protection circuit

1. Description

The TCR3DMxxA series are CMOS general-purpose single-output voltage regulators with an on/off control input, featuring low dropout voltage, low output noise voltage, fast load transient response and low inrush current.

These voltage regulators are available in fixed output voltages between 1.0 V and 4.5 V and capable of driving up to 300 mA. They feature Overcurrent protection, Thermal shutdown, Inrush current protection circuit and Auto-discharge.

The TCR3DMxxA series is offered in the ultra small plastic mold package DFN4D (1.0 mm x 1.0 mm; t 0.37 mm (typ.)) and has a low dropout voltage of 216 mV (2.5 V output, $I_{OUT} = 300$ mA) with low output noise voltage of 38 μ Vrms (2.5 V output). As small ceramic input and output capacitors 1.0 μ F can be used with the TCR3DMxxA series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones.



DFN4D

Weight: 1.1 mg (typ.)

2. Applications

Power IC developed for portable applications

3. Features

- Ultra small package DFN4D (1.0 mm x 1.0 mm; t 0.37 mm (typ.))
- Wide range output voltage line up ($V_{OUT} = 1.0$ to 4.5 V)
- Low dropout voltage
 - $V_{DO} = 175$ mV (typ.) at 3.3 V output, $I_{OUT} = 300$ mA
 - $V_{DO} = 216$ mV (typ.) at 2.5 V output, $I_{OUT} = 300$ mA
 - $V_{DO} = 297$ mV (typ.) at 1.8 V output, $I_{OUT} = 300$ mA
- Low output noise voltage ($V_{NO} = 38$ μ Vrms (typ.) at 10Hz $\leq f \leq$ 100kHz)
- High ripple rejection ratio (72 dB (typ.) at 2.5 V output, $I_{OUT} = 10$ mA, $f = 1$ kHz)
- Fast load transient response (± 80 mV (typ.) at 2.5 V output, $I_{OUT} = 1$ mA \leftrightarrow 300 mA)
- Overcurrent protection
- Thermal shutdown
- Inrush current protection circuit
- Auto-discharge
- Pull down connection between CONTROL and GND
- Ceramic capacitors can be used ($C_{IN} = 1.0$ μ F, $C_{OUT} = 1.0$ μ F)

Start of commercial production
2023-11

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

| Characteristics | Symbol | Rating | Unit |
|---------------------------|-----------|---------------------------------|------------------|
| Input voltage | V_{IN} | -0.3 to 6.0 | V |
| Control voltage | V_{CT} | -0.3 to 6.0 | V |
| Output voltage | V_{OUT} | -0.3 to $V_{IN} + 0.3 \leq 6.0$ | V |
| Power dissipation | P_D | 420 (Note1) | mW |
| Junction temperature | T_j | 150 | $^\circ\text{C}$ |
| Storage temperature range | T_{stg} | -55 to 150 | $^\circ\text{C}$ |

Note: 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).

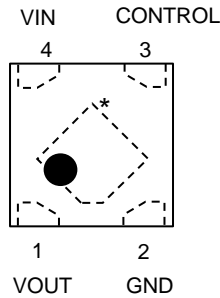
Note1: Rating at mounting on a board

Glass epoxy(FR4) board dimension: 40 mm x 40 mm x 1.6mm, both sides of board.

Metal pattern ratio: a surface approximately 50%, the reverse side approximately 50 %

Through hole hall: diameter 0.5 mm x 24 pcs

5. Pin Assignment (Top view)



*Center electrode should be connected to GND or Open

6. Operating Ranges

| Characteristics | Symbol | Rating | Unit |
|-----------------------|-----------|---------------------|------------------|
| Input voltage | V_{IN} | 1.5 to 5.5 (Note 2) | V |
| Control voltage | V_{CT} | 0 to 5.5 | V |
| Output voltage | V_{OUT} | 1.0 to 4.5 | V |
| Output current | I_{OUT} | DC 300 | mA |
| Operation Temperature | T_{opr} | -40 to 85 | $^\circ\text{C}$ |
| Output Capacitance | C_{OUT} | ≥ 1.0 | μF |
| Input Capacitance | C_{IN} | ≥ 1.0 | μF |

Note 2: Please refer to Dropout Voltage and use it within Absolute Maximum Ratings Junction temperature and Operation Temperature Ranges.

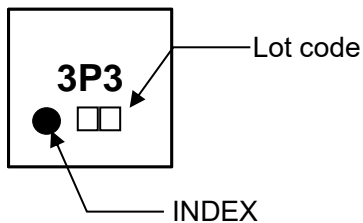
7. List of Products Number, Output voltage and Marking

| Product No. | Output voltage (V) | Marking | Product No. | Output voltage (V) | Marking |
|--------------|--------------------|---------|--------------|--------------------|---------|
| TCR3DM10A | 1.0 | 1P0 | TCR3DM26A* | 2.6 | 2P6 |
| TCR3DM105A | 1.05 | 1PA | TCR3DM27A* | 2.7 | 2P7 |
| TCR3DM11A | 1.1 | 1P1 | TCR3DM28A | 2.8 | 2P8 |
| TCR3DM115A* | 1.15 | 1PB | TCR3DM285A* | 2.85 | 2PD |
| TCR3DM12A | 1.2 | 1P2 | TCR3DM29A* | 2.9 | 2P9 |
| TCR3DM13A* | 1.3 | 1P3 | TCR3DM2925A* | 2.925 | 2PH |
| TCR3DM135A* | 1.35 | 1PD | TCR3DM30A* | 3.0 | 3P0 |
| TCR3DM14A* | 1.4 | 1P4 | TCR3DM31A* | 3.1 | 3P1 |
| TCR3DM15A | 1.5 | 1P5 | TCR3DM32A* | 3.2 | 3P2 |
| TCR3DM16A* | 1.6 | 1P6 | TCR3DM33A | 3.3 | 3P3 |
| TCR3DM175A* | 1.75 | 1PE | TCR3DM35A* | 3.5 | 3P5 |
| TCR3DM18A | 1.8 | 1P8 | TCR3DM36A* | 3.6 | 3P6 |
| TCR3DM1825A* | 1.825 | 1PF | TCR3DM41A* | 4.1 | 4P1 |
| TCR3DM185A* | 1.85 | 1PG | TCR3DM42A* | 4.2 | 4P2 |
| TCR3DM19A* | 1.9 | 1P9 | TCR3DM45A | 4.5 | 4P5 |
| TCR3DM25A | 2.5 | 2P5 | — | — | — |

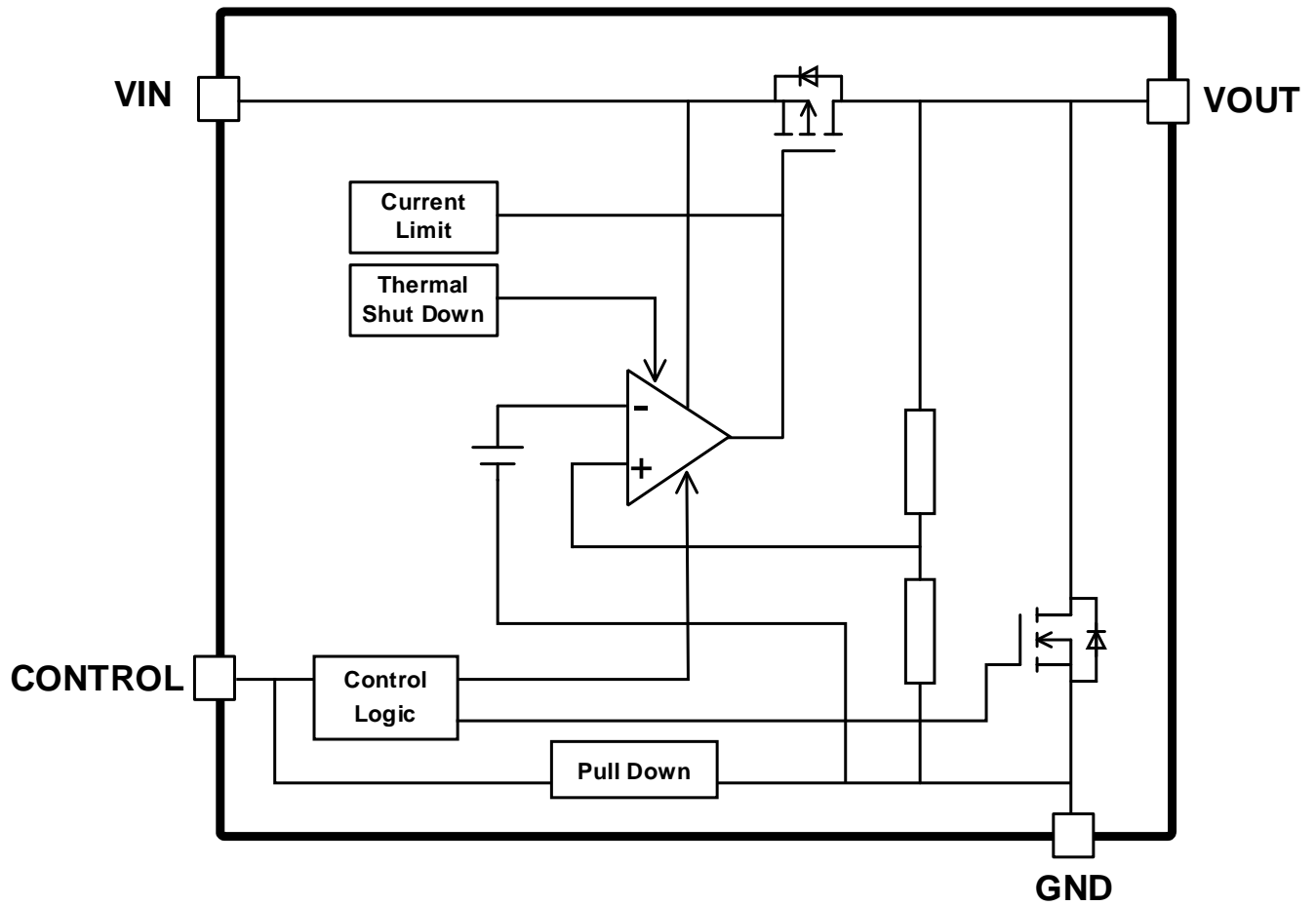
* Please contact your local Toshiba representative if you are interested in products with * sign.

Top Marking (Top view)

Example: TCR3DM33A (3.3 V output)



8. Block Diagram



9. Electrical Characteristics

(Unless otherwise specified, $V_{IN} = V_{OUT} + 1.0\text{ V}$, $C_{IN} = 1.0\ \mu\text{F}$, $C_{OUT} = 1.0\ \mu\text{F}$)

| Characteristics | Symbol | Test Condition | $T_j = 25\text{ }^\circ\text{C}$ | | | $T_j = -40\text{ to }85\text{ }^\circ\text{C}$ (Note 8) | | Unit | |
|-------------------------------|------------------|--|----------------------------------|------|-----|--|-----|---------------------|----|
| | | | Min | Typ. | Max | Min | Max | | |
| Output voltage accuracy | V_{OUT} | $I_{OUT} = 50\text{ mA}$ $V_{IN} = V_{OUT} + 1.0\text{ V}$ (Note 3) | $V_{OUT} < 1.8\text{ V}$ | -18 | — | +18 | — | — | mV |
| | | | $1.8\text{ V} \leq V_{OUT}$ | -1.0 | — | +1.0 | — | — | % |
| Line regulation | Reg·line | $V_{OUT} + 0.5\text{ V} \leq V_{IN} \leq 5.5\text{ V}$ $I_{OUT} = 1\text{ mA}$ | — | 1 | — | — | — | mV | |
| Load regulation | Reg·load | $1\text{ mA} \leq I_{OUT} \leq 300\text{ mA}$ | — | 18 | — | — | 52 | mV | |
| Quiescent current | $I_{B(ON)}$ | $I_{OUT} = 0\text{ mA}$ $V_{IN} = 5.5\text{ V}$ (Note 5) | — | 86 | — | — | 159 | μA | |
| Stand-by current | $I_{B(OFF)}$ | $V_{CT} = 0\text{ V}$, $V_{IN} = 5.5\text{ V}$ (Note 5) | — | 0.1 | — | — | 1 | μA | |
| Control pull down current | I_{CT} | — | — | 0.1 | — | — | 0.2 | μA | |
| Drop-out voltage (Note 9) | V_{DO} | $I_{OUT} = 300\text{ mA}$ | $V_{OUT} = 1.8\text{ V}$ | — | 297 | 335 | — | 389 | mV |
| | | | $V_{OUT} = 2.5\text{ V}$ | — | 216 | 262 | — | 296 | mV |
| | | | $V_{OUT} = 3.3\text{ V}$ | — | 175 | 206 | — | 242 | mV |
| | | | $V_{OUT} = 4.5\text{ V}$ | — | 148 | 179 | — | 231 | mV |
| Output noise voltage | V_{NO} | $I_{OUT} = 10\text{ mA}$ $10\text{ Hz} \leq f \leq 100\text{ kHz}$, $T_a = 25\text{ }^\circ\text{C}$ (Note 4) | — | 38 | — | — | — | μV_{rms} | |
| Ripple rejection ratio | R.R. | $V_{IN} = 3.5\text{ V}$ $V_{OUT} = 2.5\text{ V}$ $I_{OUT} = 10\text{ mA}$, $V_{IN}\text{ Ripple} = 500\text{ mV}_{p-p}$, $T_a = 25\text{ }^\circ\text{C}$ (Note 4) | $f = 100\text{ Hz}$ | — | 75 | — | — | — | dB |
| | | | $f = 1\text{ kHz}$ | — | 72 | — | — | — | |
| | | | $f = 10\text{ kHz}$ | — | 54 | — | — | — | |
| | | | $f = 100\text{ kHz}$ | — | 48 | — | — | — | |
| | | | $f = 1\text{ MHz}$ | — | 55 | — | — | — | |
| Load transient response | ΔV_{OUT} | $I_{OUT} = 1\text{ mA} \rightarrow 300\text{ mA}$ (Note 4) (Note 6) | — | -80 | — | — | — | mV | |
| | | $I_{OUT} = 300\text{ mA} \rightarrow 1\text{ mA}$ (Note 4) (Note 6) | — | +80 | — | — | — | | |
| Output current limit | I_{CL} | $V_{OUT} = V_{OUT(NOM)} * 90\%$ (Note 7) | — | — | — | 320 | 650 | mA | |
| Thermal shutdown threshold | T_{SDH} | T_j rising | — | 160 | — | — | — | $^\circ\text{C}$ | |
| | T_{SDL} | T_j falling | — | 130 | — | — | — | $^\circ\text{C}$ | |
| Control pin threshold voltage | V_{CTH} | Control pin input voltage "HIGH" | — | — | — | 0.8 | 5.5 | V | |
| | V_{CTL} | Control pin input voltage "LOW" | — | — | — | 0 | 0.4 | V | |
| Discharge on resistance | RSD | (Note 4) | — | 45 | — | — | — | Ω | |

Note 3: stable state with fixed I_{OUT} condition

Note 4: $V_{OUT} = 2.5\text{ V}$

Note 5: except Control pull down current (I_{CT})

Note 6: $t_r = t_f = 1.0\ \mu\text{s}$ (Defined when 10 % to 90 % is 0.8 μs)

Note 7: Pulse measurement

Note 8: This parameter is warranted by design.

Note 9: $V_{DO} = V_{IN1} - (V_{OUT1} \times 0.97)$

V_{OUT1} is the output voltage when $V_{IN} = V_{OUT} + 1.0\text{ V}$.

V_{IN1} is the input voltage at which the output voltage becomes 97 % of V_{OUT1} after gradually decreasing the input voltage.

10. Drop-out voltage table

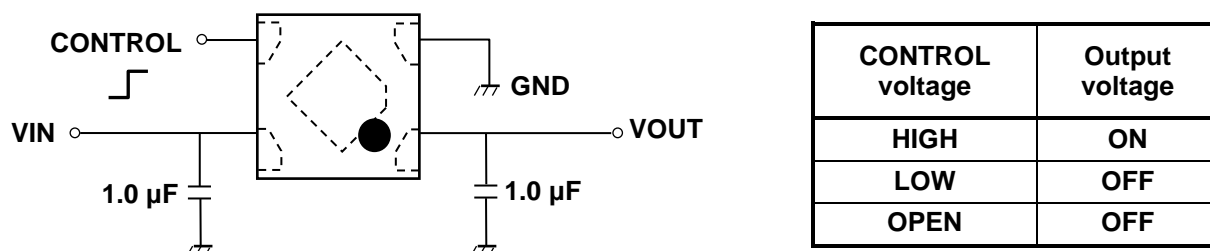
($I_{OUT} = 300 \text{ mA}$, $C_{IN} = 1.0 \mu\text{F}$, $C_{OUT} = 1.0 \mu\text{F}$)

| Output voltages | Symbol | $T_j = 25 \text{ }^\circ\text{C}$ | | | $T_j = -40 \text{ to } 85 \text{ }^\circ\text{C}$ (Note 10) | | Unit |
|---|----------|-----------------------------------|------|-----|--|-----|------|
| | | Min | Typ. | Max | Min | Max | |
| 1.0 V, 1.05 V | VIN-VOUT | — | 642 | 738 | — | 790 | mV |
| 1.1 V, 1.15 V | | — | 566 | 666 | — | 716 | |
| 1.2 V | | — | 500 | 592 | — | 644 | |
| 1.3 V | | — | 456 | 535 | — | 590 | |
| 1.35V, 1.4 V | | — | 434 | 506 | — | 563 | |
| $1.5 \text{ V} \leq V_{OUT} < 1.8 \text{ V}$ | | — | 367 | 419 | — | 481 | |
| $1.8 \text{ V} \leq V_{OUT} < 1.9 \text{ V}$ | | — | 297 | 335 | — | 389 | |
| $1.9 \text{ V} \leq V_{OUT} < 2.5 \text{ V}$ | | — | 277 | 309 | — | 365 | |
| $2.5 \text{ V} \leq V_{OUT} < 2.8 \text{ V}$ | | — | 216 | 262 | — | 296 | |
| $2.8 \text{ V} \leq V_{OUT} < 3.2 \text{ V}$ | | — | 196 | 233 | — | 268 | |
| $3.2 \text{ V} \leq V_{OUT} < 3.6 \text{ V}$ | | — | 179 | 211 | — | 247 | |
| $3.6 \text{ V} \leq V_{OUT} \leq 4.5 \text{ V}$ | | — | 168 | 199 | — | 240 | |

Note 10: This parameter is guaranteed by design.

11. Application Note

11.1. Recommended Application Circuit



The figure above shows the recommended configuration for using a Low-Dropout regulator. Insert a capacitor at VOUT and VIN pins for stable input/output operation. (Ceramic capacitors can be used).

11.2. Power Dissipation

Board-mounted power dissipation ratings for TCR3DMxxA series are available in the Absolute Maximum Ratings table. Power dissipation is measured on the board condition shown below.

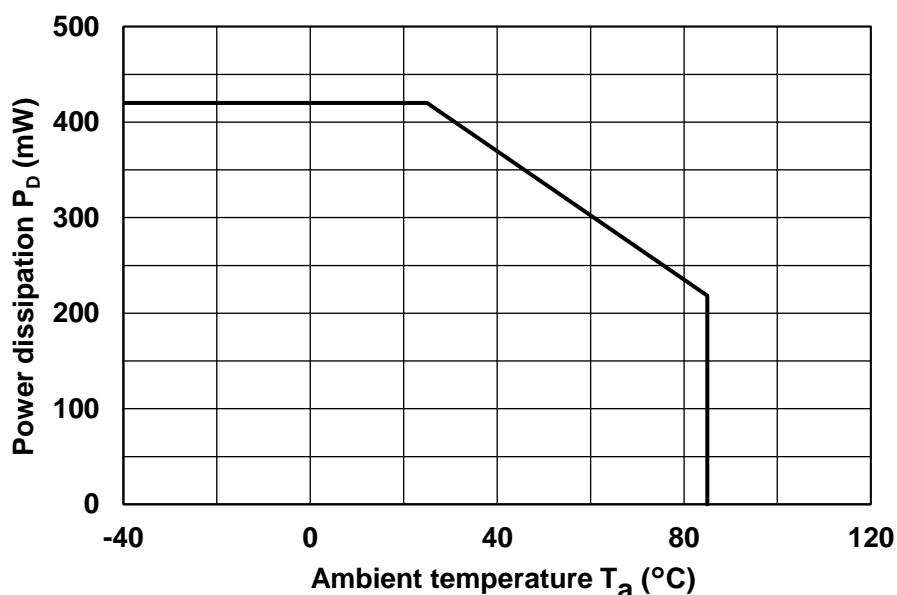
[The Board Condition]

Board material: Glass epoxy(FR4)

Board dimension: 40 mm x 40 mm (both sides of board), t = 1.6 mm

Metal pattern ratio: a surface approximately 50%, the reverse side approximately 50 %

Through hole: diameter 0.5 mm x 24 pcs



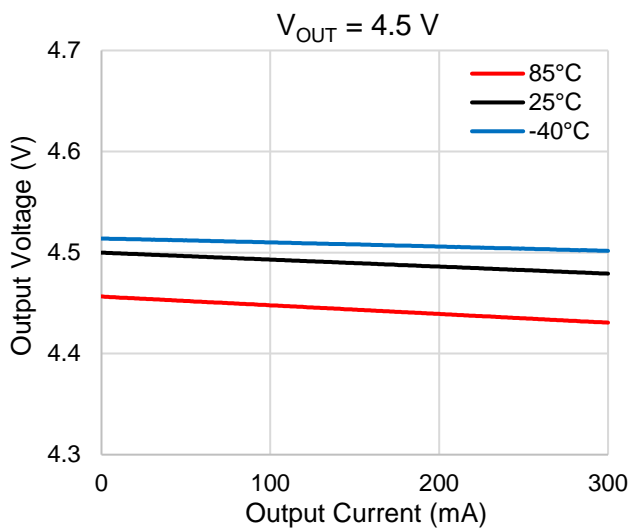
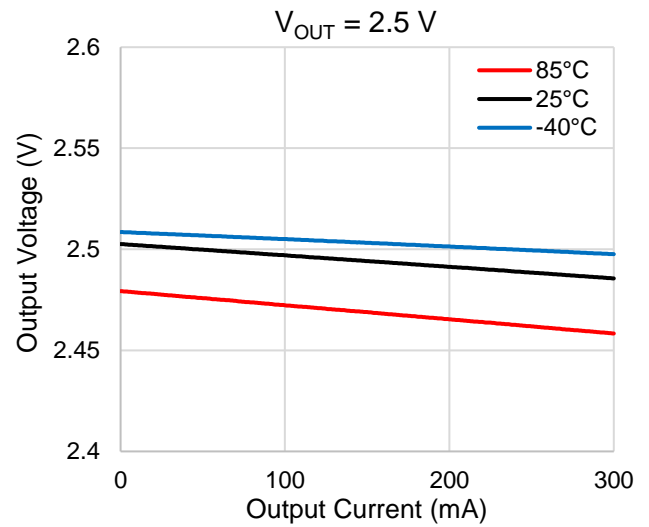
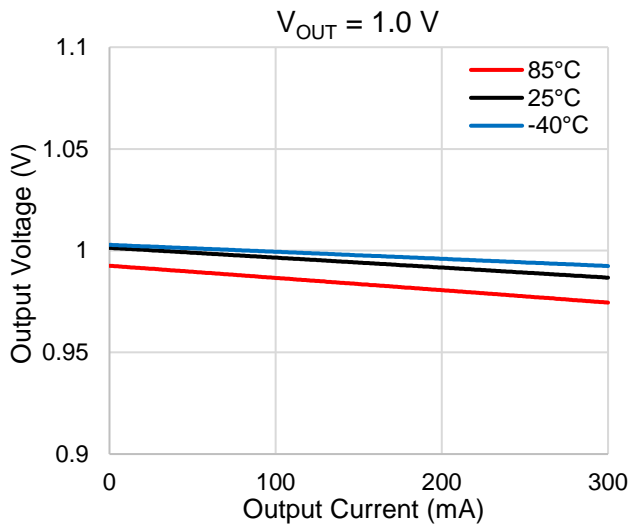
11.3. Attention in Use

- **Output Capacitors**
Ceramic capacitors can be used for these devices. However, because of the type of the capacitors, there might be unexpected thermal features. Please consider application condition for selecting capacitors. And Toshiba recommend ceramic capacitor.
- **Mounting**
The long distance between IC and output capacitor might affect phase assurance by impedance in wire and inductor. For stable power supply, output capacitor need to mount near IC as much as possible. Also VIN and GND pattern need to be large and make the wire impedance small as possible.
- **Permissible Loss**
Please have enough design patterns for expected maximum permissible loss. And under consideration of surrounding temperature, input voltage, and output current etc., we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70 to 80 %.
- **Over current Protection and Thermal shut down function**
Over current protection and Thermal shut down function are designed in these products, but these are not designed to constantly ensure the suppression of the device within operation limits. Depending on the condition during actual usage, it could affect the electrical characteristic specification and reliability. Also note that if output pins and GND pins are not completely shorted out, these products might be break down. When using these products, please read through and understand the concept of dissipation for absolute maximum ratings from the above mention or our 'Semiconductor Reliability Handbook'. Then use these products under absolute maximum ratings in any condition. Furthermore, Toshiba recommend inserting failsafe system into the design.

12. Representation Typical Characteristics (Note)

12.1. Output Voltage vs. Output Current

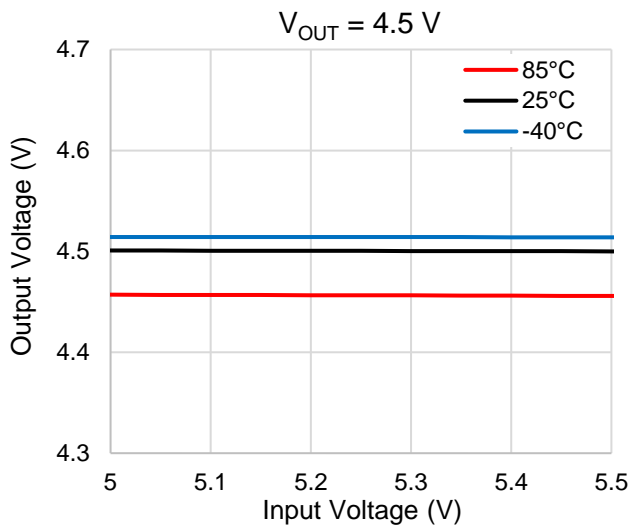
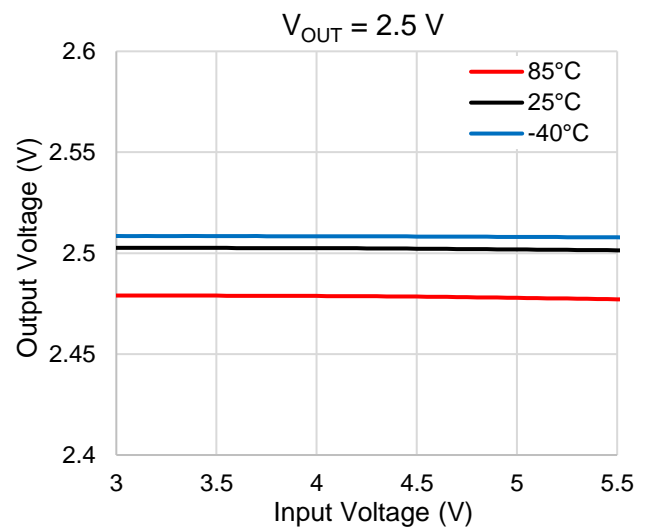
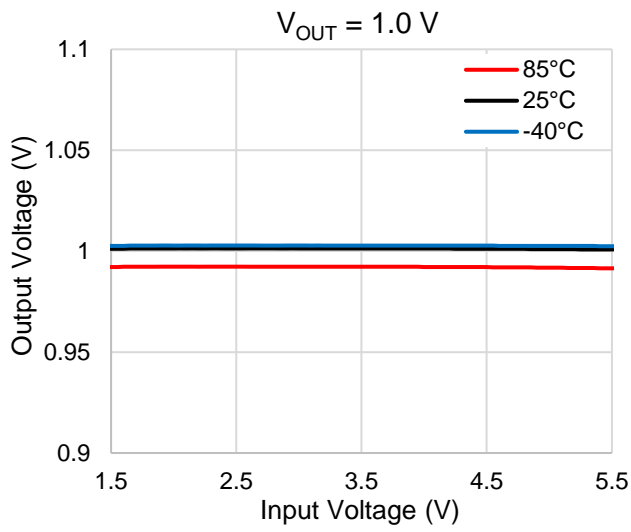
($V_{IN} = V_{OUT} + 1.0\text{ V}$)



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

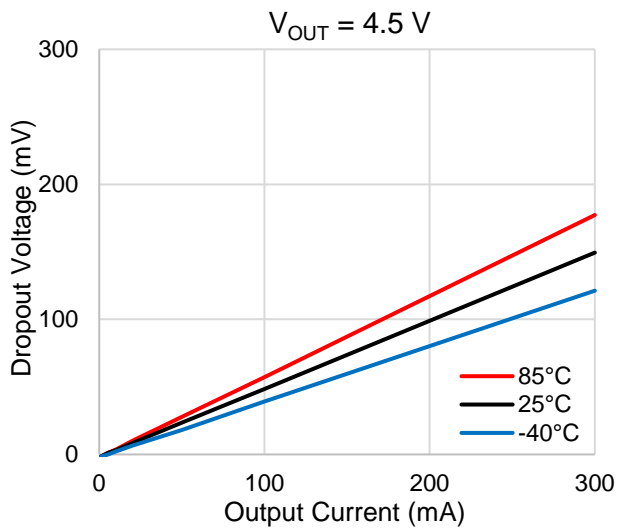
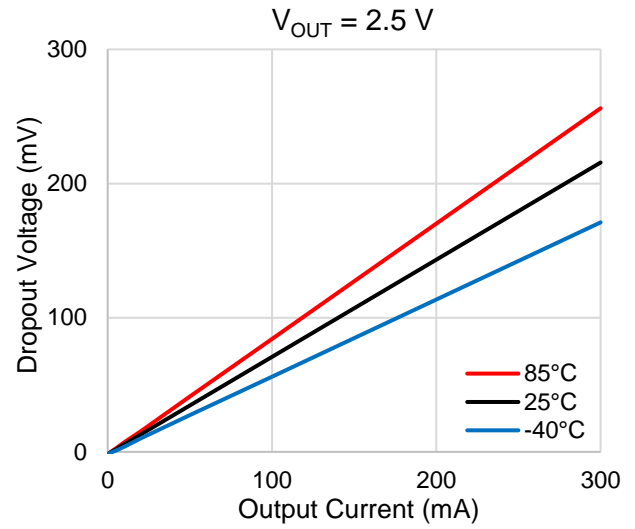
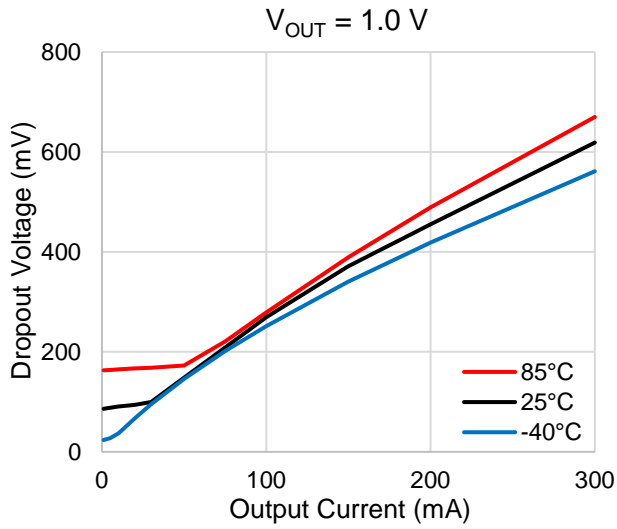
12.2. Output Voltage vs. Input Voltage

($I_{OUT} = 1 \text{ mA}$)



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

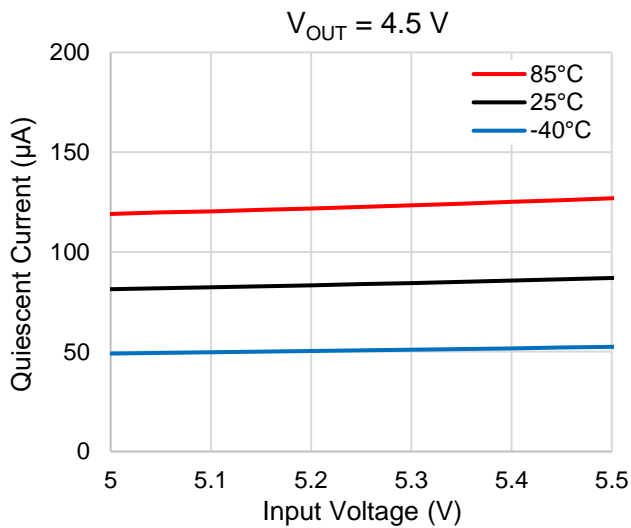
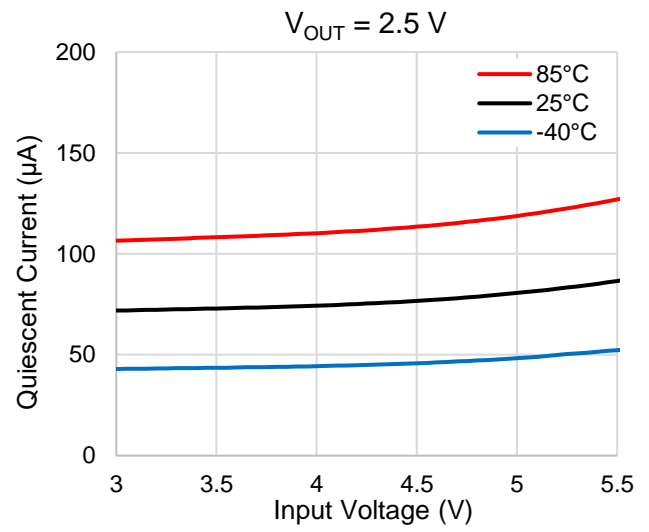
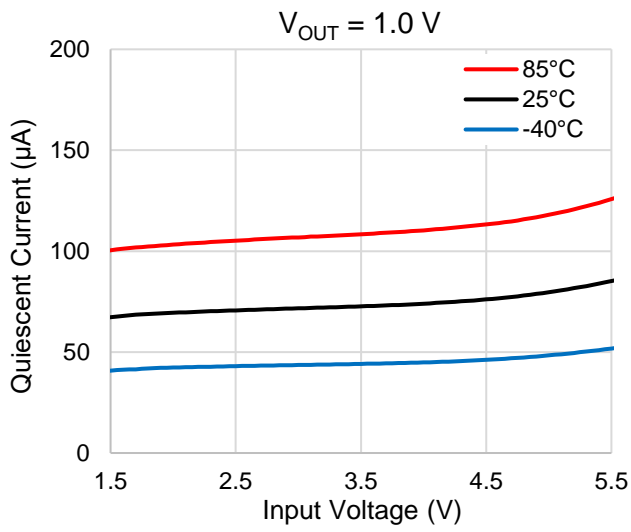
12.3. Dropout Voltage vs. Output Current



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

12.4. Quiescent Current vs. Input Voltage

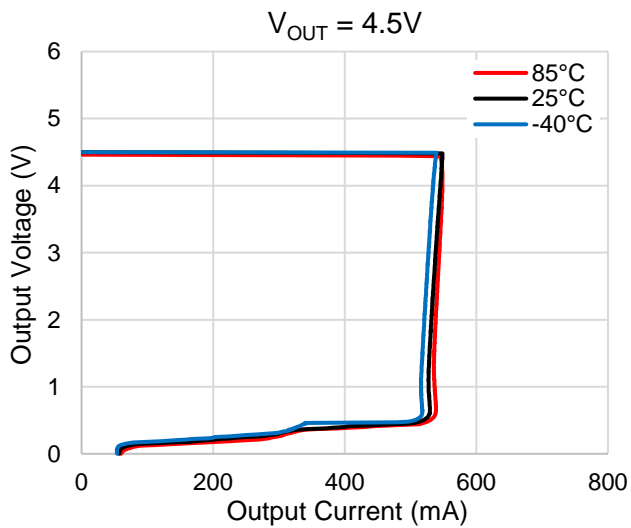
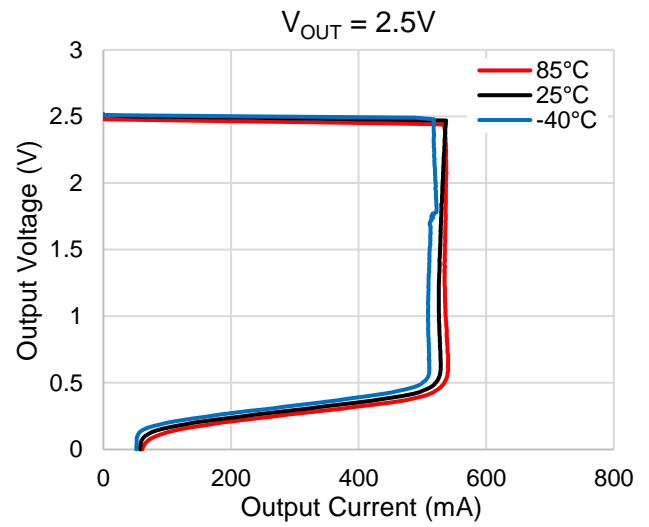
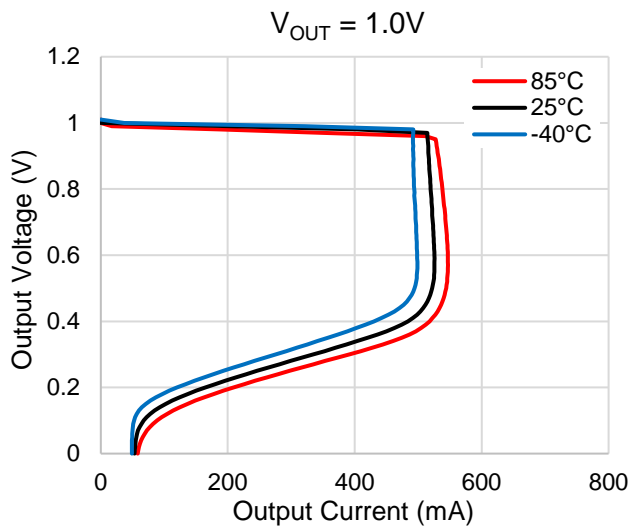
($I_{OUT} = 0 \text{ mA}$)



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

12.5. Output Current Limit

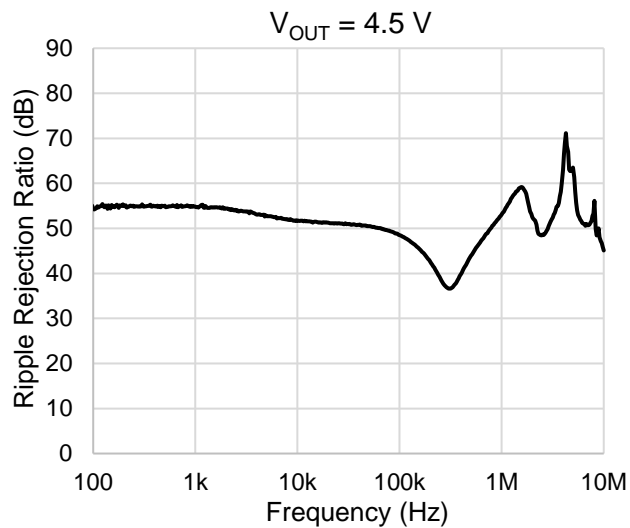
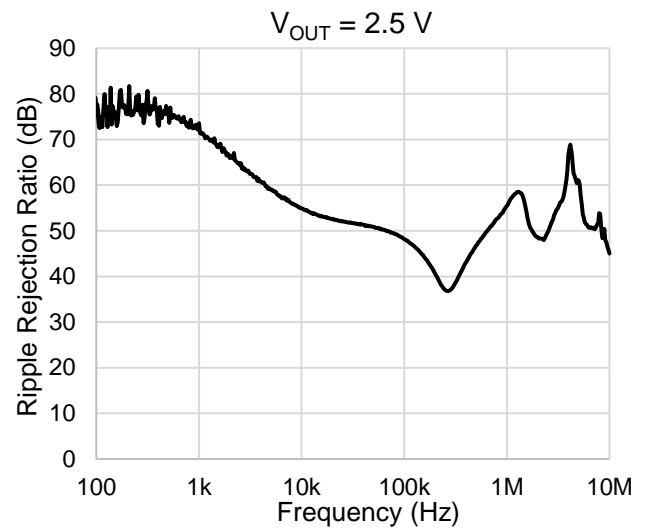
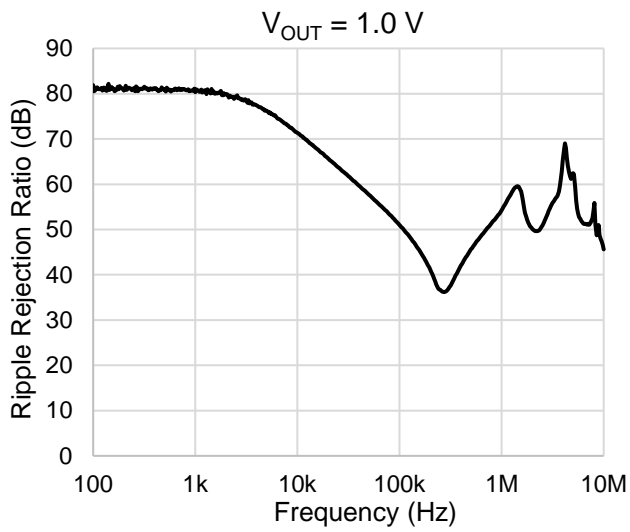
($V_{IN} = V_{OUT} + 1.0\text{ V}$)



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

12.6. Ripple rejection Ratio vs. Frequency

(C_{IN} = none, C_{OUT} = 1.0 μ F, V_{IN} = V_{OUT} + 1.0 V, V_{IN} Ripple = 500 mV_{p-p}, I_{OUT} = 10 mA, T_a = 25°C)



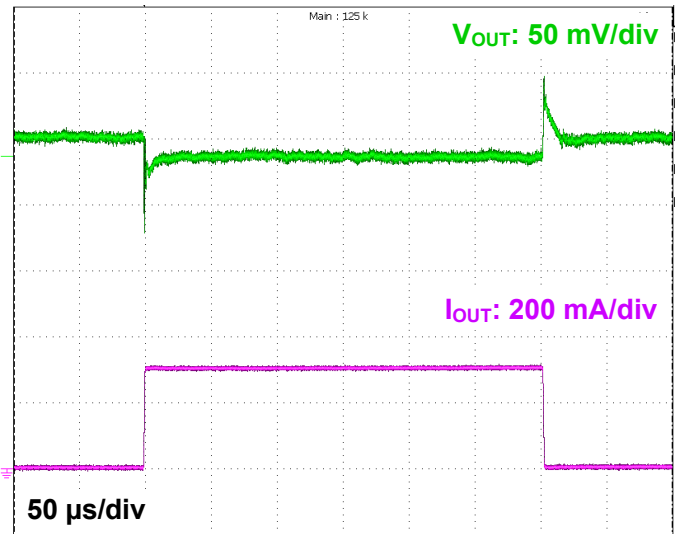
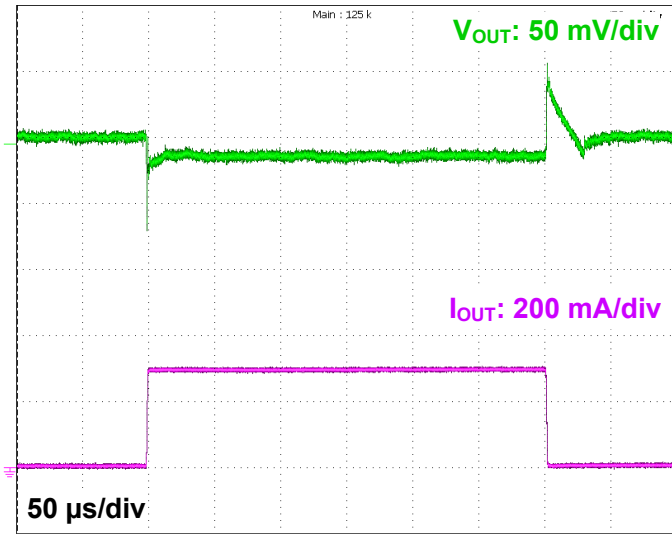
Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

12.7. Load Transient Response

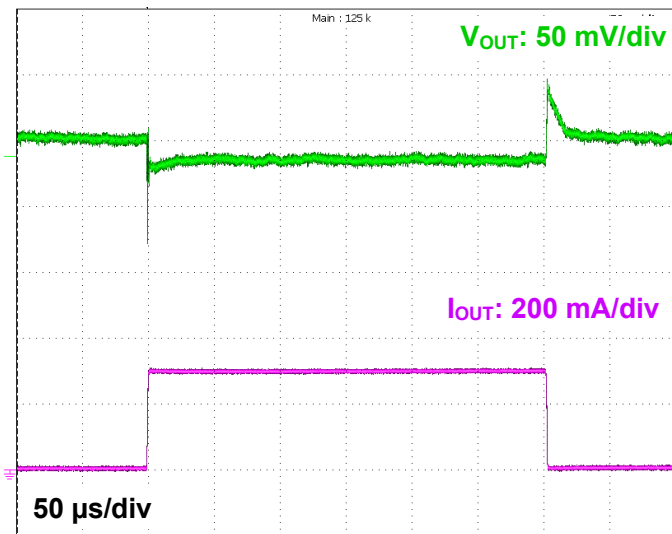
($C_{IN} = 1.0 \mu F$, $C_{OUT} = 1.0 \mu F$, $V_{IN} = V_{OUT} + 1.0 V$, $I_{OUT} = 1 mA \Leftrightarrow 300 mA$, $t_r = 1.0 \mu s$, $t_f = 1.0 \mu s$, $T_a = 25^\circ C$)

$V_{OUT} = 1.0 V$

$V_{OUT} = 2.5 V$



$V_{OUT} = 4.5 V$



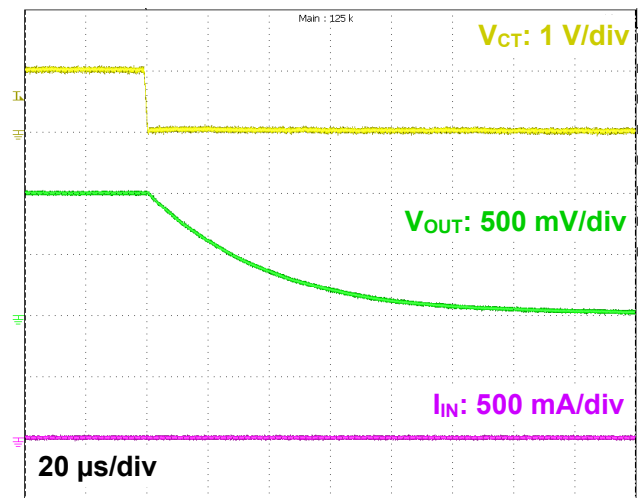
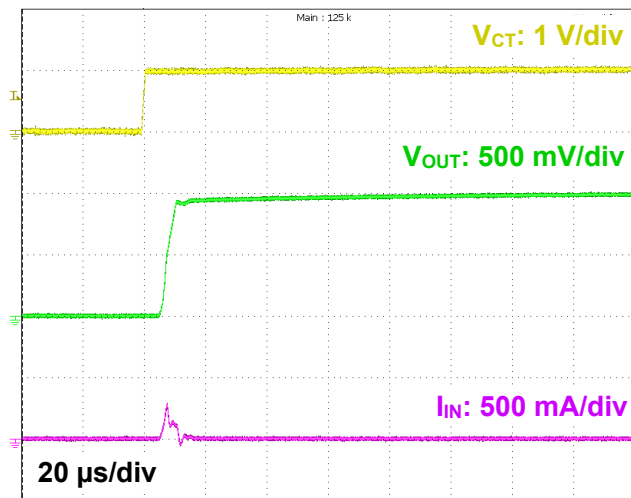
Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

12.8. t_{ON} / t_{OFF} Response

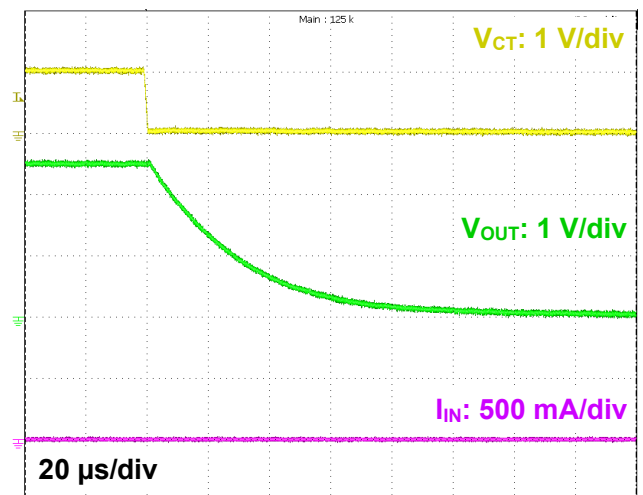
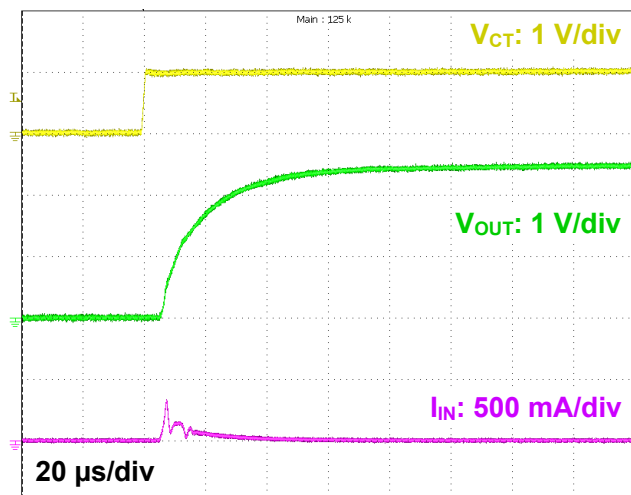
($C_{IN} = 1.0 \mu F$, $C_{OUT} = 1.0 \mu F$, $V_{IN} = V_{OUT} + 1.0 V$, $V_{CT} = 0 V \leftrightarrow 1.0 V$, $T_a = 25^\circ C$)

- $I_{OUT} = 0 mA$

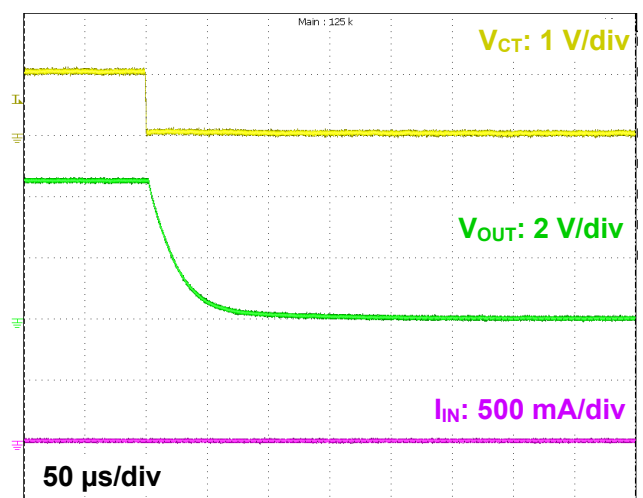
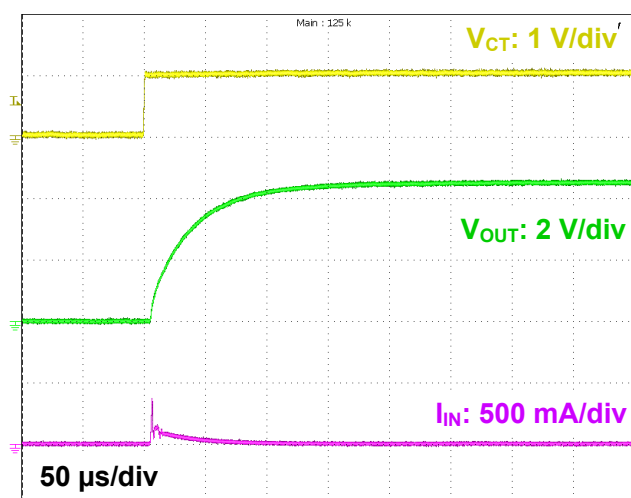
$V_{OUT} = 1.0 V$



$V_{OUT} = 2.5 V$



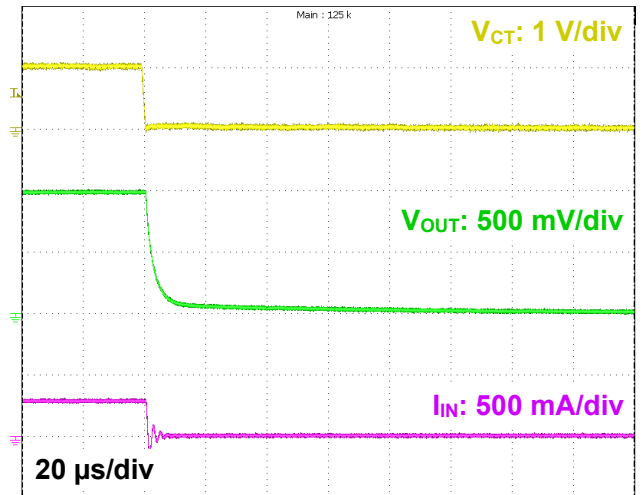
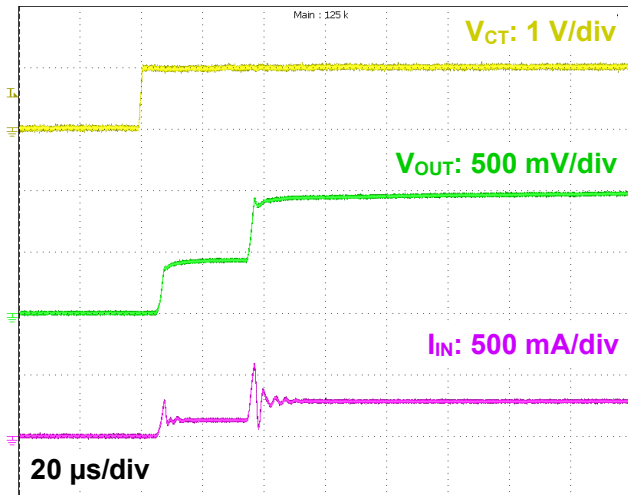
$V_{OUT} = 4.5 V$



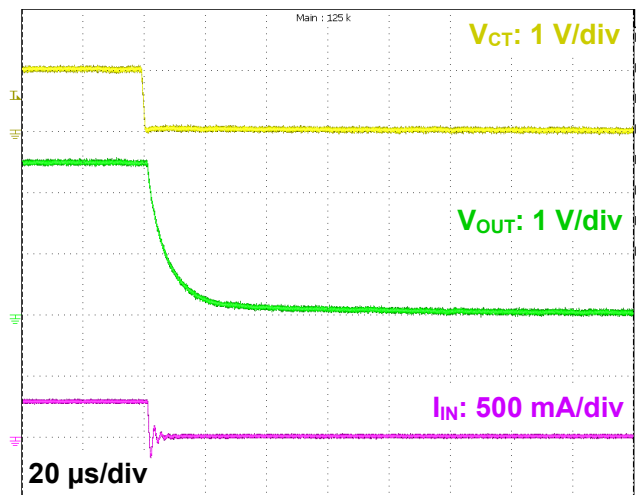
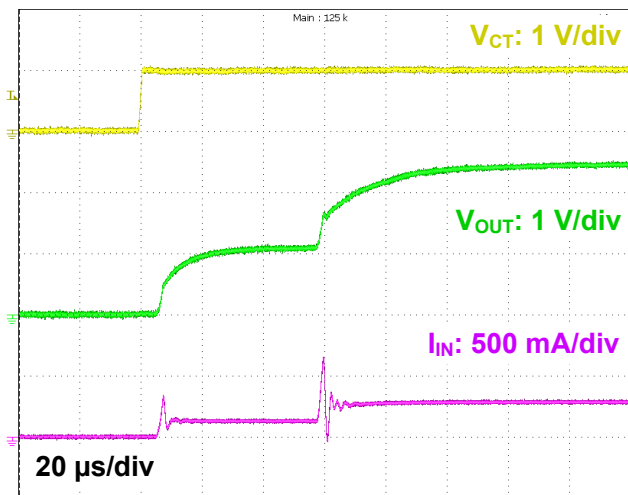
Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

● $I_{OUT} = 300 \text{ mA}$

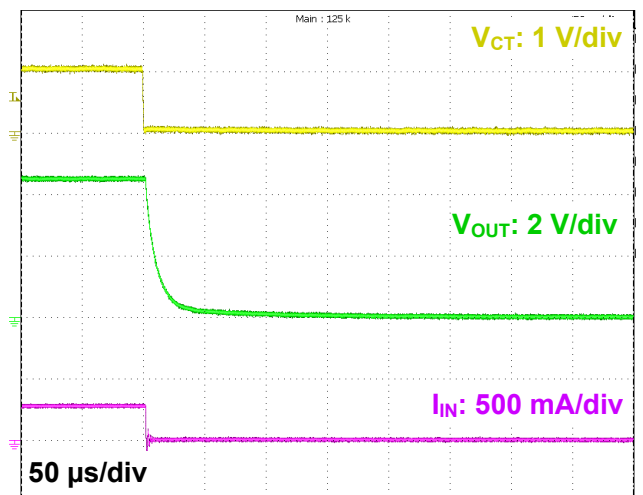
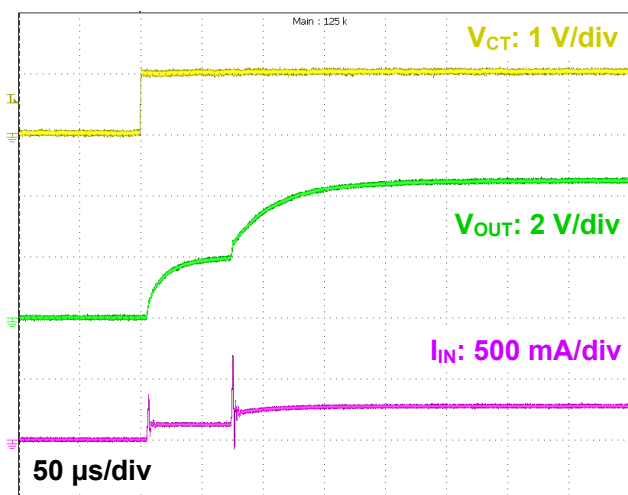
$V_{OUT} = 1.0 \text{ V}$



$V_{OUT} = 2.5 \text{ V}$



$V_{OUT} = 4.5 \text{ V}$

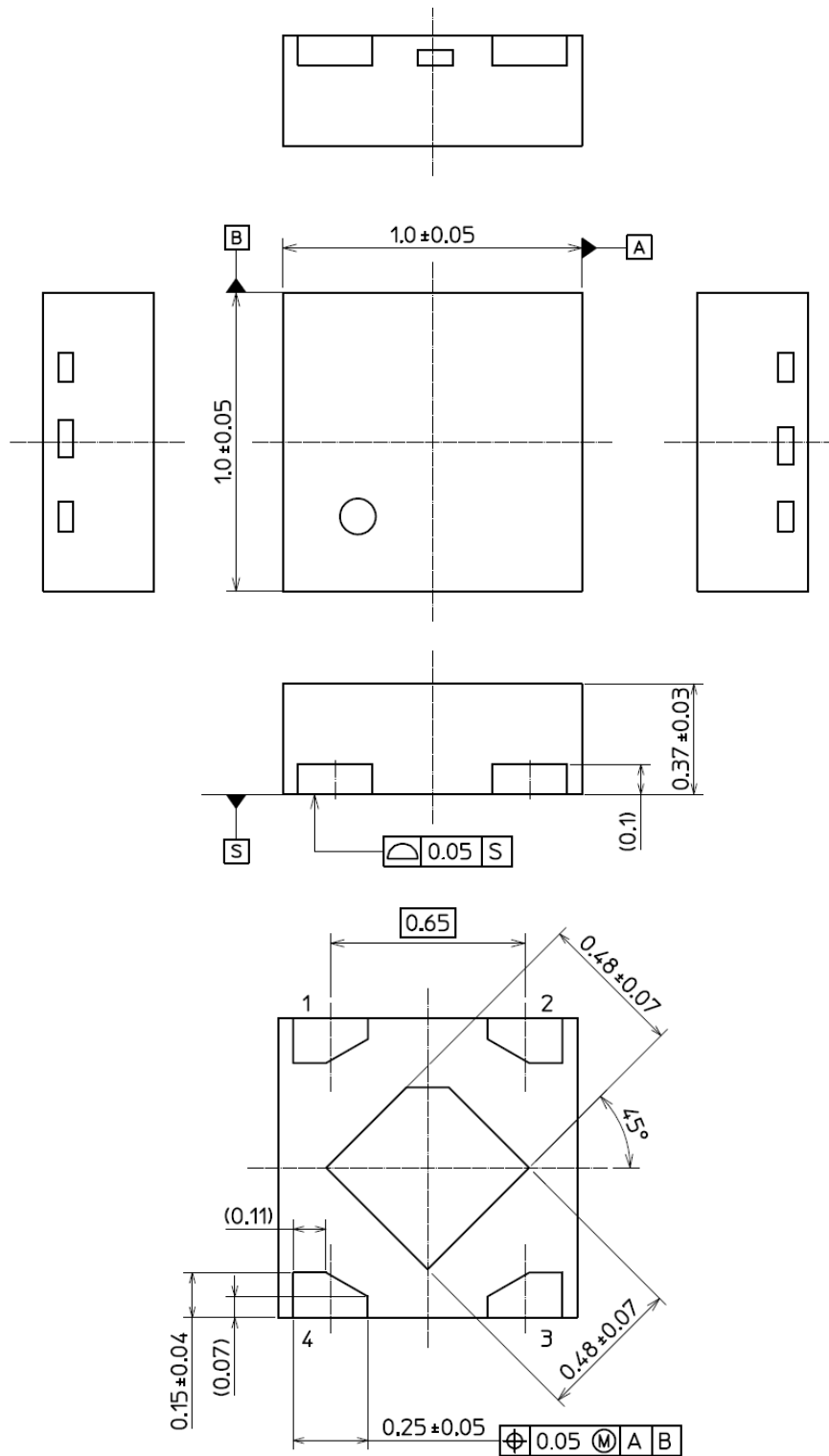


Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

13. Package Information

DFN4D

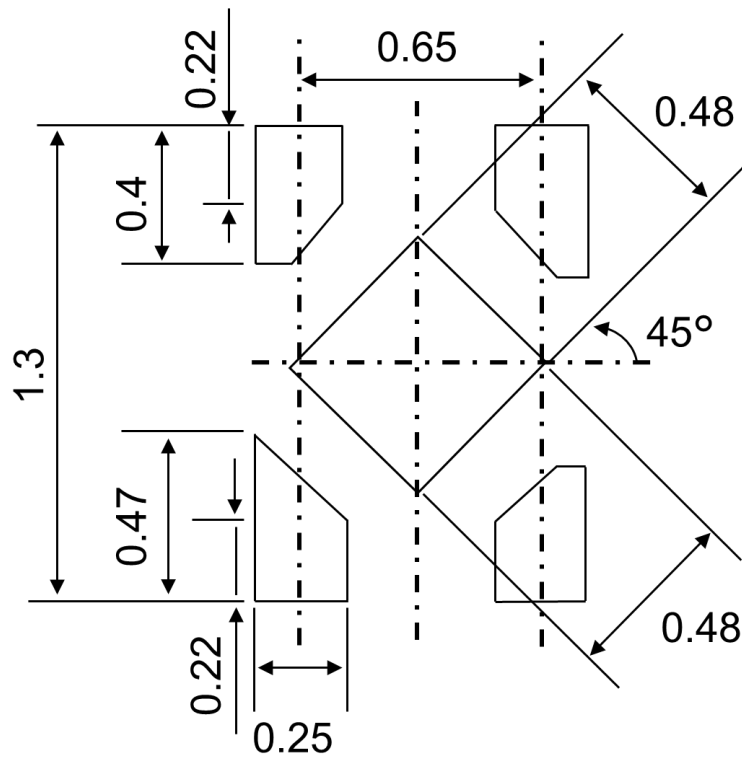
Unit: mm



Weight: 1.1 mg (typ.)

14. Land Pattern Dimensions (for reference only)

Unit: mm



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