TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

# TCR5BM series

500 mA CMOS Ultra Low Dropout Regulator

## 1. Description

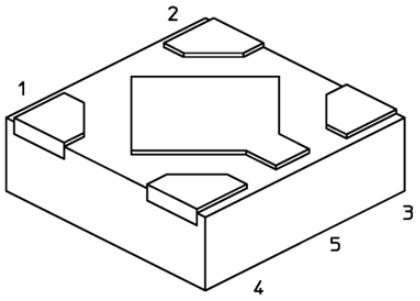
The TCR5BM series are CMOS single-output voltage regulators with an on/off control input, featuring ultra low dropout voltage, high PSRR, low inrush current and fast load transient response.

A differentiating feature is the use of a secondary bias rail as a reference voltage that allows ultra low dropout of 100 mV (Typ.) at $I_{OUT}$ = 500 mA (1.1 V output, $V_{BIAS}$ = 3.3 V).

These voltage regulators are available in fixed output voltages between 0.8 V and 3.6 V, and capable of driving up to 500 mA. Other features include overcurrent protection, thermal shutdown, and Auto-discharge.

The TCR5BM series are offered in the ultra small plastic mold package DFN5B (1.2 mm x 1.2 mm; t 0.38 mm).

As small ceramic input and output capacitors can be used with the TCR5BM series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones.




BOTTOM VIEW ILLUSTRATION

DFN5B

Weight : 1.4 mg (Typ.)

## 2. Application

Power IC developed for portable applications

## 3. Features

- Low dropout voltage
  $V_{DO}$ = 100 mV (Typ.) at 1.1 V output, $V_{BIAS}$ = 3.3 V, $I_{OUT}$ = 500 mA
- Low stand-by current ($I_{BIAS(OFF)}$ = 1 μA (Max))
- Low quiescent bias current ($I_{BIAS(ON)}$ = 19 μA (Typ.) at $V_{BIAS}$ = 5.3 V, $I_{OUT}$ = 0 mA)
- Wide range output voltage line up $V_{OUT}$ = 0.8 to 3.6 V
- Overcurrent protection
- Thermal shutdown
- Inrush current reduction
- Under voltage lockout (TCR5BMxxA products)
- Auto-discharge
- Pull down connection between CONTROL and GND
- Ultra small package DFN5B (1.2 mm x 1.2 mm ; t 0.38 mm)

Start of commercial production
2018-08

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## 4. Absolute Maximum Ratings (Ta = 25 °C)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Bias voltage | $V_{BIAS}$ | -0.3 to 6.0 | V |
| 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 ≤ 6.0 | V |
| Power dissipation | $P_D$ | 600 (Note 1) | mW |
| Junction temperature | $T_j$ | -40 to 150 | °C |
| Storage temperature range | $T_{stg}$ | −55 to 150 | °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).

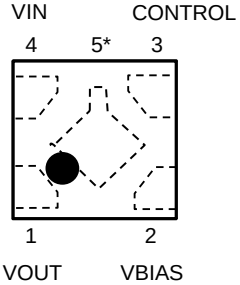
Note 1: Rating at mounting on a board
(Glass epoxy board dimension : 40 mm x 40 mm (4layer), t = 1.8 mm
Metal pattern ratio : approximately 70 % each layer)

## 5. Operating Ranges

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Bias voltage | $V_{BIAS}$ | ($V_{OUT}$ + 1.4 ≥ 2.5) to 5.5 | V |
| Input voltage | $V_{IN}$ | $V_{OUT}$ + $V_{DO}$ to $V_{BIAS}$ | V |
| Control voltage | $V_{CT}$ | 0 to $V_{BIAS}$ | V |
| Output voltage | $V_{OUT}$ | 0.8 to 3.6 | V |
| Output current | $I_{OUT}$ | 0 to 0.5 (Note 2) | A |
| Operation Temperature | $T_{opr}$ | −40 to 85 | °C |
| COUT | $C_{OUT}$ | ≥ 2.2 μF | — |
| CIN | $C_{IN}$ | ≥ 1.0 μF | — |
| CBIAS | $C_{BIAS}$ | ≥ 0.1 μF | — |

Note 2: Do not operate at or near the maximum ratings of operating ranges for extended periods of time. Exposure to such conditions may adversely impact product reliability and results in failures not covered by warranty.
Maximum operating ranges output current specification defined as lifetime average junction temperature of +45 °C where max rated DC current = lifetime average current to avoid electro migration.

## 6. Pin Assignment (top view)




*Center electrode is GND

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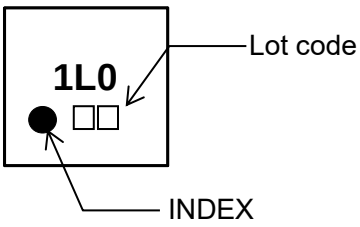
## 7. List of Products Number, Output voltage and Marking

| Product No. | $V_{OUT}$(V) (Typ.) | Marking | Product No. | $V_{OUT}$(V) (Typ.) | Marking |
|---|---|---|---|---|---|
| TCR5BM08A | 0.8 | 0N8 | TCR5BM19A* | 1.9 | 1N9 |
| TCR5BM085A | 0.85 | 0NJ | TCR5BM20A* | 2.0 | 2N0 |
| TCR5BM09A | 0.9 | 0N9 | TCR5BM21A | 2.1 | 2N1 |
| TCR5BM095A | 0.95 | 0NK | TCR5BM22A | 2.2 | 2N2 |
| TCR5BM10 | 1.0 | 1L0 | TCR5BM23A | 2.3 | 2N3 |
| TCR5BM10A | 1.0 | 1N0 | TCR5BM24A | 2.4 | 2N4 |
| TCR5BM105 | 1.05 | 1LA | TCR5BM25A | 2.5 | 2N5 |
| TCR5BM105A | 1.05 | 1NA | TCR5BM26A | 2.6 | 2N6 |
| TCR5BM11 | 1.1 | 1L1 | TCR5BM27A | 2.7 | 2N7 |
| TCR5BM11A | 1.1 | 1N1 | TCR5BM28A | 2.8 | 2N8 |
| TCR5BM115A | 1.15 | 1NB | TCR5BM285A* | 2.85 | 2NJ |
| TCR5BM12 | 1.2 | 1L2 | TCR5BM29A* | 2.9 | 2N9 |
| TCR5BM12A | 1.2 | 1N2 | TCR5BM295A | 2.95 | 2NK |
| TCR5BM125A | 1.25 | 1NC | TCR5BM30A | 3.0 | 3N0 |
| TCR5BM13A | 1.3 | 1N3 | TCR5BM31A | 3.1 | 3N1 |
| TCR5BM14A* | 1.4 | 1N4 | TCR5BM32A | 3.2 | 3N2 |
| TCR5BM15A* | 1.5 | 1N5 | TCR5BM33A | 3.3 | 3N3 |
| TCR5BM16A* | 1.6 | 1N6 | TCR5BM34A* | 3.4 | 3N4 |
| TCR5BM17A* | 1.7 | 1N7 | TCR5BM35A* | 3.5 | 3N5 |
| TCR5BM18A | 1.8 | 1N8 | TCR5BM36A | 3.6 | 3N6 |

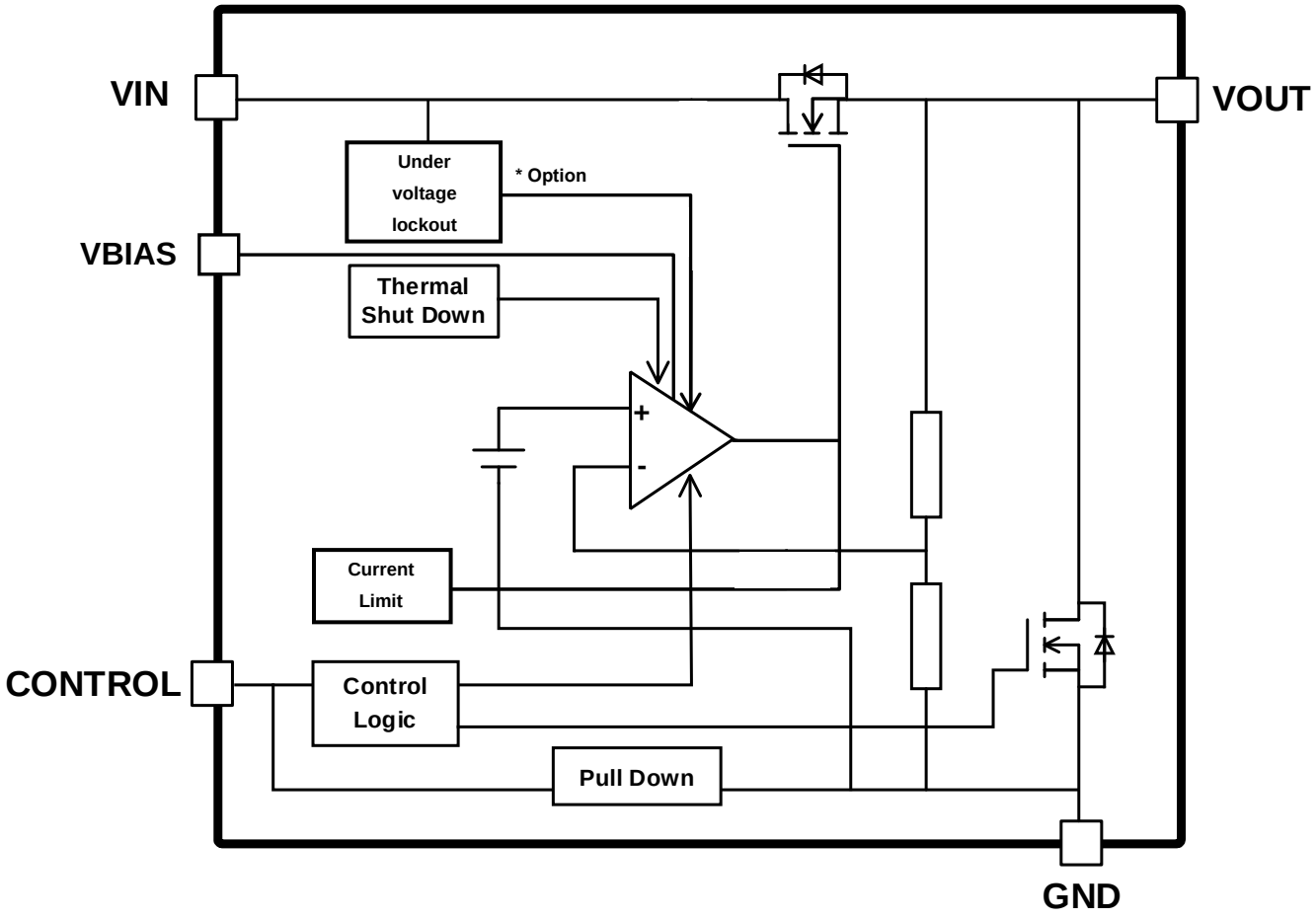
* Please contact your local Toshiba representative if you are interested in products with * sign
TCR5BMxxA products have under voltage lockout function.

### Top Marking (top view)

Example: TCR5BM10 (1.0 V output)



## 8. Block Diagram




* Under voltage lockout is applied TCR5BMxxA products.

## 9. Electrical Characteristics

**(Unless otherwise specified, $V_{BIAS}$ = 3.3 V or $V_{OUT}$ + 1.7 V whichever is greater, $V_{IN}$ = $V_{OUT}$ + 0.5 V, $C_{IN}$ = 1.0 µF, $C_{OUT}$ = 2.2 µF, $C_{BIAS}$ = 0.1 µF)**

| Characteristics | Symbol | Test Condition | | $T_j$ = 25 °C | | | $T_j$ = -40 to 85 °C (Note 8) | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ. | Max | Min | Max | |
| Output voltage accuracy | $V_{OUT}$ | $I_{OUT}$ = 50 mA (Note 3) | $V_{OUT}$ < 1.8 V | -18 | — | +18 | — | — | mV |
| | | | 1.8 V ≤ $V_{OUT}$ | -1.0 | — | +1.0 | — | — | % |
| Line regulation | Reg·line | $V_{OUT}$ + 0.5 V ≤ $V_{IN}$ ≤ 5.5 V, $I_{OUT}$ = 1 mA | | — | 0.1 | — | — | — | mV |
| Load regulation | Reg·load | 1 mA ≤ $I_{OUT}$ ≤ 500 mA (Note 5) | | — | 7 | — | — | — | mV |
| Quiescent current (Note 4) | $I_{BIAS\ (ON)}$ | $I_{OUT}$ = 0 mA, $V_{BIAS}$ current | | — | 19 | — | — | 36 | µA |
| | $I_{IN\ (ON)}$ | $I_{OUT}$ = 0 mA, $V_{IN}$ current | | — | 3 | — | — | 6 | |
| Stand-by current | $I_{BIAS\ (OFF)}$ | $V_{CT}$ = 0 V, $V_{BIAS}$ current | | — | 0.1 | — | — | 1.0 | µA |
| | $I_{IN\ (OFF)}$ | $V_{CT}$ = 0 V, $V_{IN}$ current | | — | — | 0.5 | — | — | µA |
| Control pull down current | $I_{CT}$ | — | | — | 0.1 | — | — | — | µA |
| Dropout voltage | $V_{DO}$ | $I_{OUT}$ = 500 mA, $V_{BIAS}$ = 3.3 V $V_{OUT}$ = 1.1 V (Note 6) | | — | 100 | — | — | 140 | mV |
| Under voltage lockout (Note 9) | $V_{UVLO}$ | $V_{IN}$ voltage | | — | 0.6 | — | — | 0.75 | V |
| Temperature coefficient | $T_{CVO}$ | −40°C ≤ $T_{opr}$ ≤ 85°C | | — | 70 | — | — | — | ppm/°C |
| Output noise voltage | $V_{NO}$ | $V_{BIAS}$ = 3.3 V, $V_{IN}$ = $V_{OUT}$ + 0.5 V $I_{OUT}$ = 10 mA, 10 Hz ≤ f ≤ 100 kHz (Note 7) | | — | 40 | — | — | — | $\mu V_{rms}$ |
| Ripple rejection ratio | R.R. | $V_{BIAS}$ = 3.3 V, $V_{IN}$ = $V_{OUT}$ + 1 V $I_{OUT}$ = 10 mA, f = 1 kHz $V_{IN\ Ripple}$ = 200 $mV_{p-p}$ (Note 7) | | — | 98 | — | — | — | dB |
| Load transient response | $\Delta V_{OUT}$ | $I_{OUT}$ = 1 mA to 500 mA (Note 5) | | — | -60 | — | — | — | mV |
| | | $I_{OUT}$ = 500 mA to 1 mA (Note 5) | | — | +60 | — | — | — | |
| Control voltage (ON) | $V_{CT\ (ON)}$ | — | | 0.9 | — | $V_{BIAS}$ | 1.0 | $V_{BIAS}$ | V |
| Control voltage (OFF) | $V_{CT\ (OFF)}$ | — | | 0 | — | 0.4 | 0 | 0.4 | V |
| Current limit | $I_{CL}$ | — | | — | 900 | — | 550 | — | mA |
| Output discharge on resistance | $R_{SD}$ | — | | — | 10 | — | — | — | Ω |

Note 3: Stable state with fixed $I_{OUT}$ condition
Note 4: Except Control pull down current
Note 5: The 1.0 V output product
Note 6: $V_{DO}$ = $V_{IN1}$ - ($V_{OUT1}$ x 0.97)
$V_{OUT1}$ is the output voltage when $V_{IN}$ = $V_{OUT}$ + 0.5 V.
$V_{IN1}$ is the input voltage at which the output voltage becomes 97% of $V_{OUT1}$ after gradually decreasing the input voltage.
Note 7: The 0.8 V output product
Note 8: This parameter is warranted by design.
Note 9: Under voltage lockout is applied TCR5BMxxA products.

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## 10. Dropout voltage

**($C_{IN}$ = 1.0 µF, $C_{OUT}$ = 2.2 µF, $C_{BIAS}$ = 0.1 µF, $T_j$ = 25 °C)**

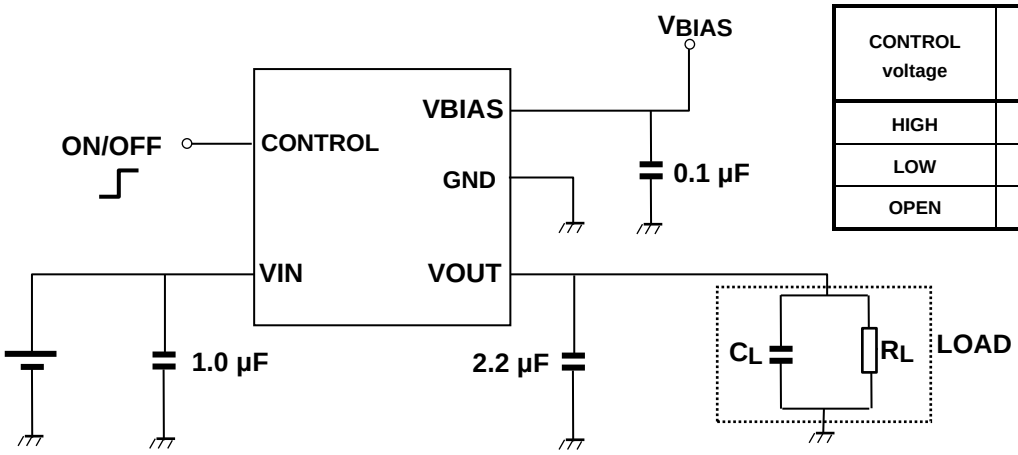
| Output voltages | $V_{BIAS}$ input voltage | $I_{OUT}$ = 500 mA | | | Unit |
|---|---|---|---|---|---|
| | | Min | Typ. | Max (Note 10) | |
| 0.8 V, 0.85 V | 3.3 V | — | 90 | 125 | mV |
| 0.9 V, 0.95 V | 3.3 V | — | 95 | 130 | mV |
| 1.0 V | 3.3 V | — | 95 | 135 | mV |
| 1.05 V, 1.1 V | 3.3 V | — | 100 | 140 | mV |
| 1.15 V | 3.3 V | — | 100 | 145 | mV |
| 1.2 V | 3.3 V | — | 105 | 150 | mV |
| 1.25 V | 3.3 V | — | 110 | 155 | mV |
| 1.3 V | 3.3 V | — | 110 | 160 | mV |
| 1.4 V | 3.3 V | — | 120 | 170 | mV |
| 1.5 V | 3.3 V | — | 125 | 190 | mV |
| 1.6 V | 3.3 V | — | 140 | 215 | mV |
| 1.7 V ≤ $V_{OUT}$ ≤ 1.9 V | $V_{OUT}$ + 1.7 V | — | 135 | 210 | mV |
| 2.0 V, 2.1 V | $V_{OUT}$ + 1.7 V | — | 135 | 205 | mV |
| 2.2 V ≤ $V_{OUT}$ ≤ 2.7 V | $V_{OUT}$ + 1.7 V | — | 135 | 200 | mV |
| 2.8 V ≤ $V_{OUT}$ ≤ 3.6 V | $V_{OUT}$ + 1.7 V | — | 130 | 195 | mV |

Note 10: $T_j$ = -40 to 85 °C This parameter is warranted by design

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# 11. Application Note

## 11.1. Example of Application Circuit



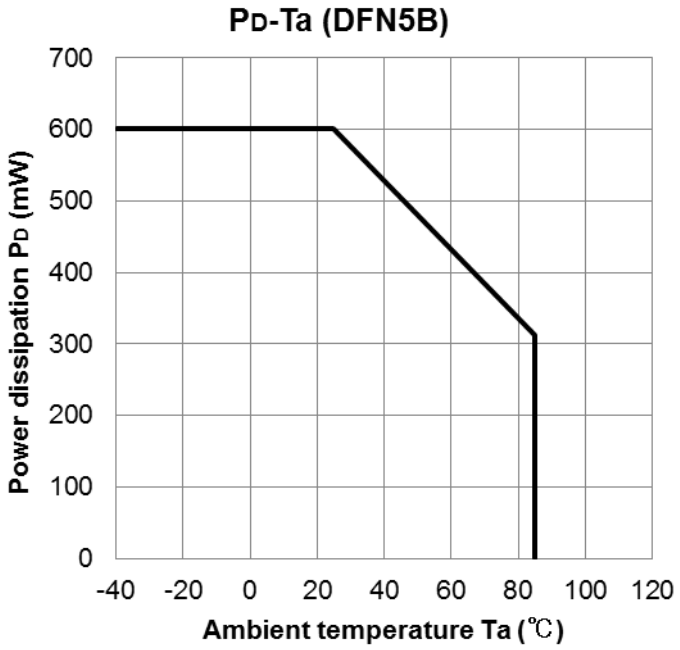

| CONTROL voltage | Output voltage |
|---|---|
| HIGH | ON |
| LOW | OFF |
| OPEN | OFF |

The figure above shows the Example of configuration for using a Low dropout regulator. Insert a capacitor at $V_{IN}$, $V_{OUT}$ and $V_{BIAS}$ pins for stable input/output operation. (Ceramic capacitors can be used).

## 11.2. Power Dissipation

Board-mounted power dissipation ratings for TCR5BM series are available in the Absolute Maximum Ratings table. Power dissipation is measured on the board condition shown in below.

[The Board Condition]
Board material: Glass epoxy (FR4)
Board dimension: 40 mm x 40 mm (4layer), t = 1.8 mm
Metal pattern ratio: approximately 70 % each layer



## 11.3. Attention in Use

- Capacitors(Output, Input, and Bias Capacitor)
  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. For stable operation, please use over 1.0 μF input capacitor, 0.1 μF bias capacitor and 2.2 μF output ceramic capacitor.

- Recommending for Control Pin Operation
  This device is optimized to operate the best performance when turn on and off with control pin. Especially the rush current and bias current can be suppressed by using control pin after applying $V_{IN}$ and $V_{BIAS}$.
  TCR5BMxxA products have $V_{IN}$ under voltage lockout function, bias current is suppressed at low $V_{IN}$ even when $V_{BIAS}$ and $V_{CT}$ are applied.

- Mounting
  The long distance between IC and output capacitor might affect phase compensation by impedance in wire and inductor. For stable power supply, output capacitor need to mount near IC as much as possible. Also $V_{IN}$ and GND pattern need to be large and make the wire impedance small as possible.

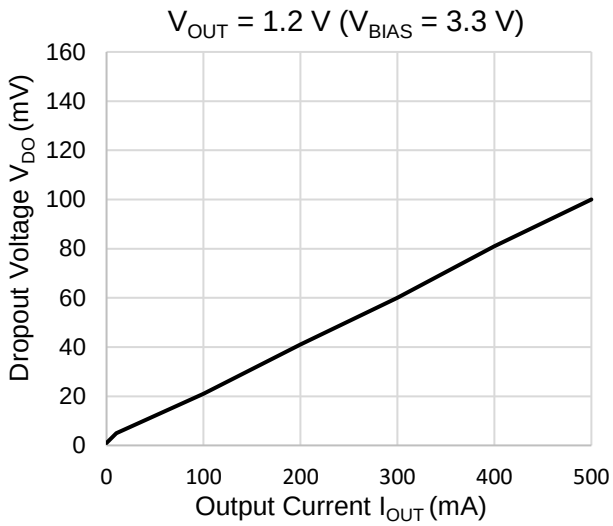
- Permissible Loss
  Please have enough design patterns for expected maximum permissible loss. And under consideration of ambient temperature, input voltage, and output current etc, we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70 to 80 percent.

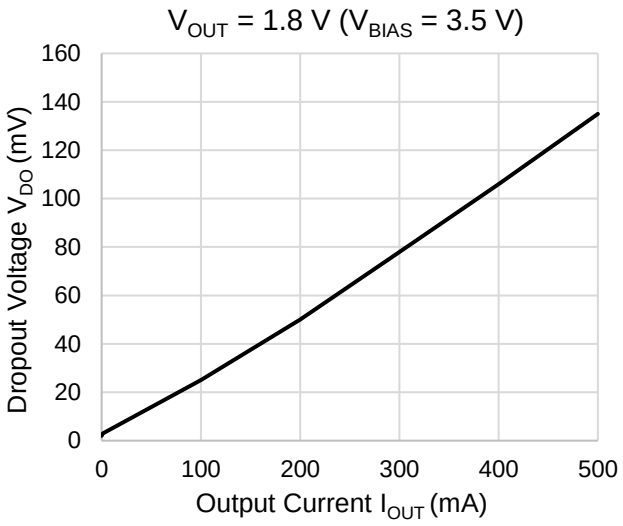
- Overcurrent Protection and Thermal shutdown
  Overcurrent protection and Thermal shutdown are designed in these products, but these are not designed to constantly ensure the suppression of the device within operation limits. Depending on the condition during actual usage, it could affect the electrical characteristic specification and reliability. Also note that if output pins and GND pins are not completely shorted out, these products might 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 recommends inserting failsafe system into the design.

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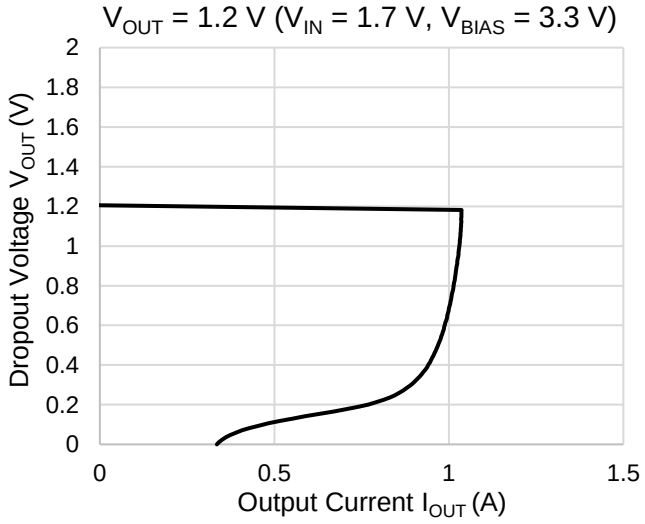
# 12. Representative Typical Characteristics

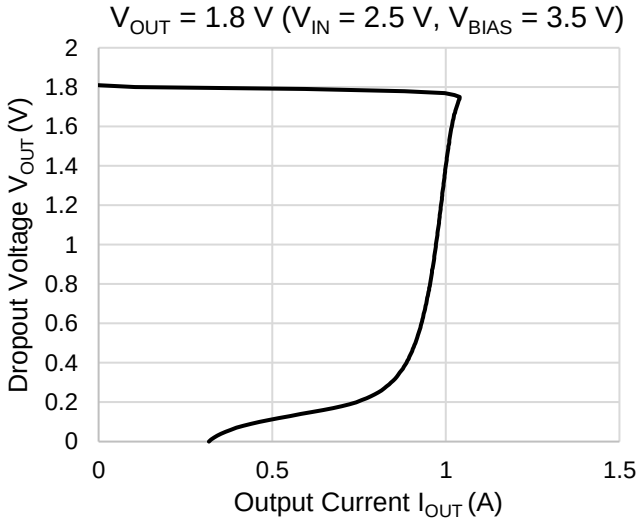
## 12.1. Dropout Voltage vs. Output Current (Ta = 25 °C)




## 12.2. Output Current Limit (Ta = 25 °C)

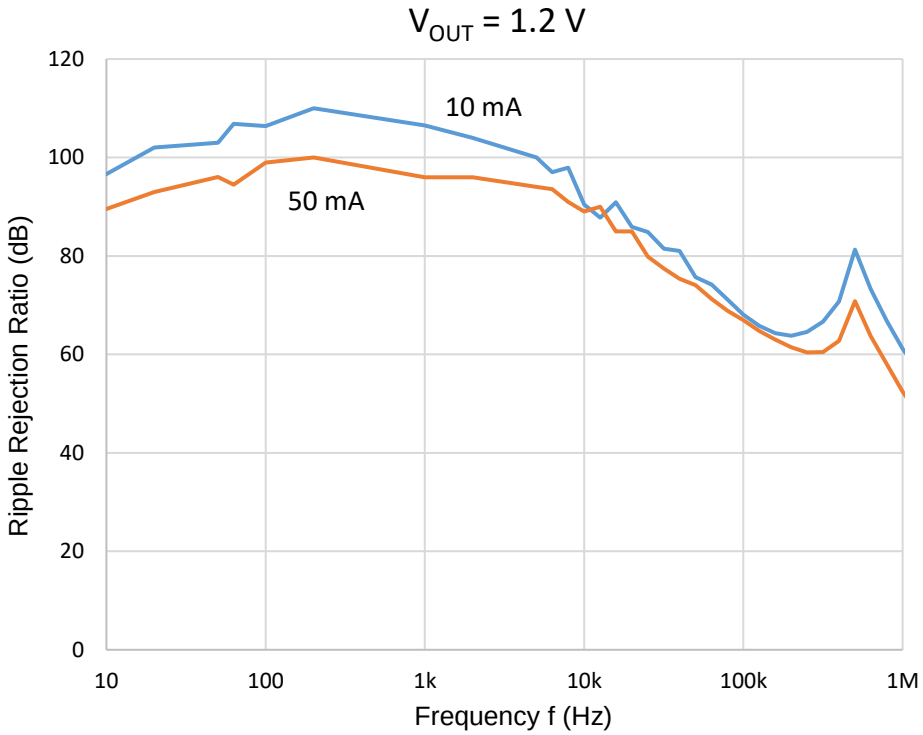



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## 12.3. Ripple rejection Ratio vs. Frequency

**($C_{IN}$ = none, $C_{OUT}$ = 2.2 µF, $V_{IN}$ = 2.2 V, $V_{BIAS}$ = 3.3 V, $V_{IN\ Ripple}$ = 200 $mV_{p-p}$, Ta = 25 °C)**

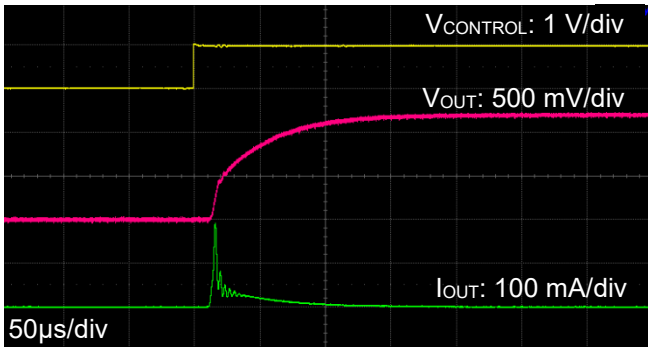


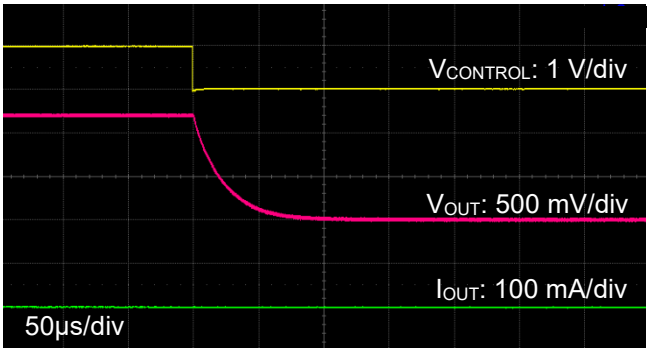
## 12.4. $t_{ON}$ / $t_{OFF}$ Response

**($C_{IN}$ = 1.0 µF, $C_{OUT}$ = 2.2 µF, $V_{CONTROL}$ = 0 V ⇔ 1 V, Ta = 25 °C)**

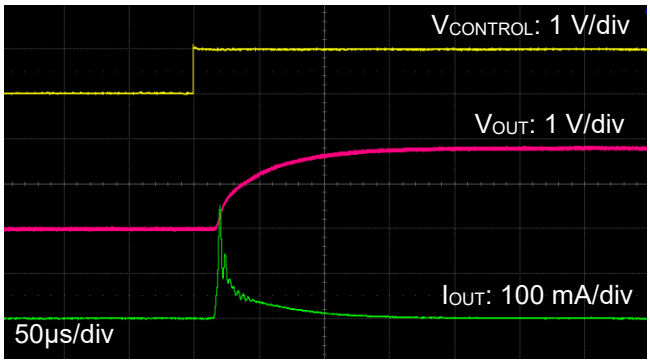
- **$I_{OUT}$ = 0 mA**

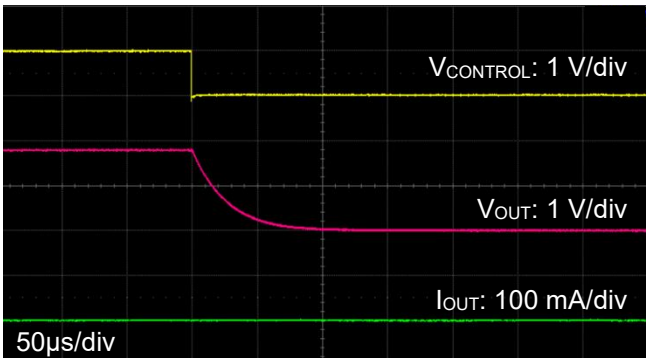
$V_{OUT}$ = 1.2 V ($V_{IN}$ = 1.7 V, $V_{BIAS}$ = 3.3 V)



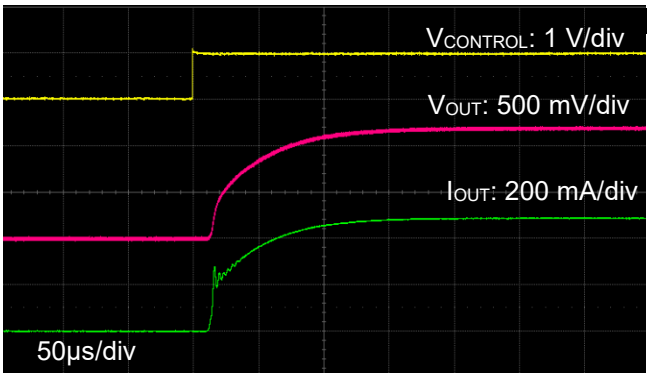

$V_{OUT}$ = 1.8 V ($V_{IN}$ = 2.5 V, $V_{BIAS}$ = 3.5 V)

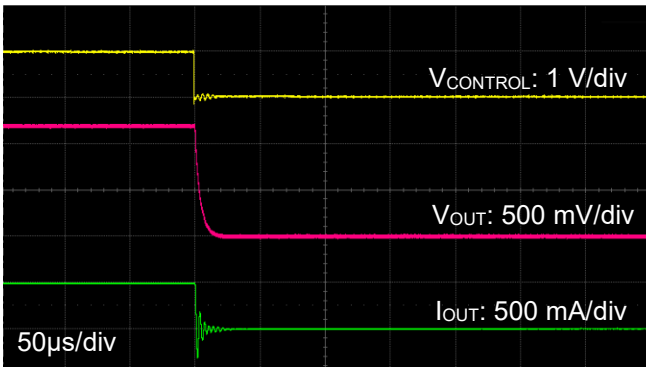


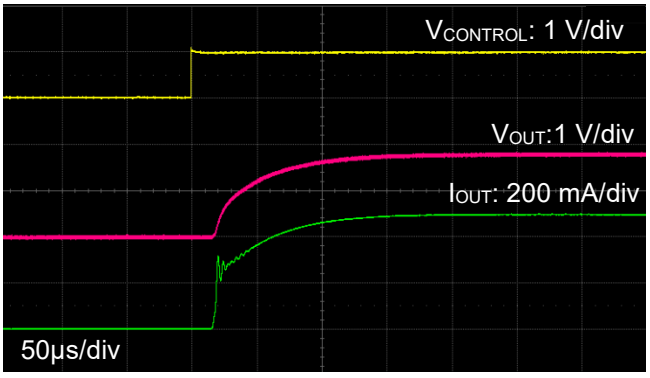
- **$I_{OUT}$ = 500 mA**

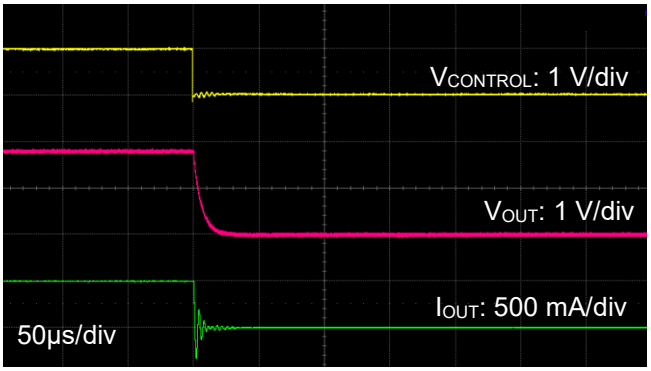
$V_{OUT}$ = 1.2 V ($V_{IN}$ = 1.7 V, $V_{BIAS}$ = 3.3 V)




$V_{OUT}$ = 1.8 V ($V_{IN}$ = 2.5 V, $V_{BIAS}$ = 3.5 V)



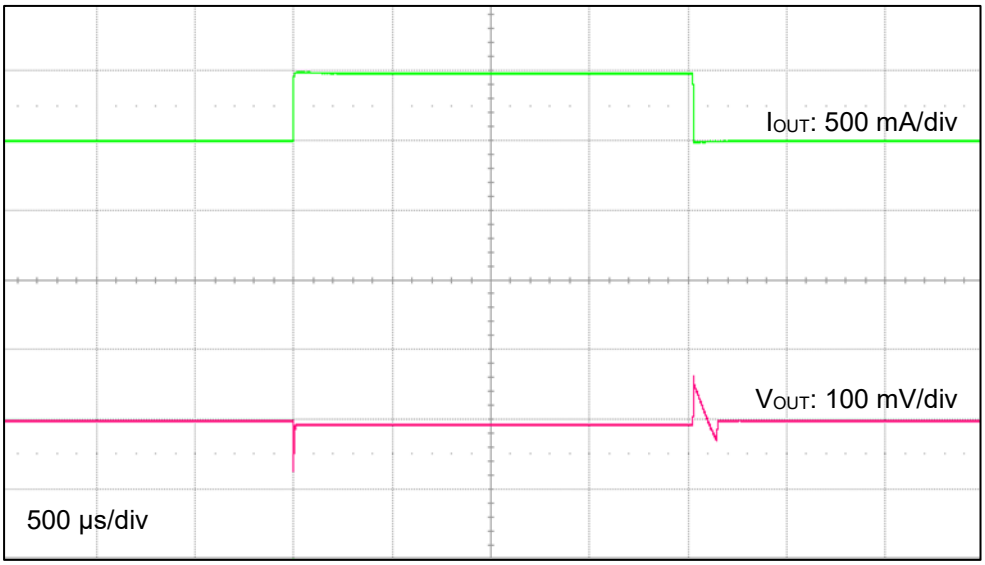




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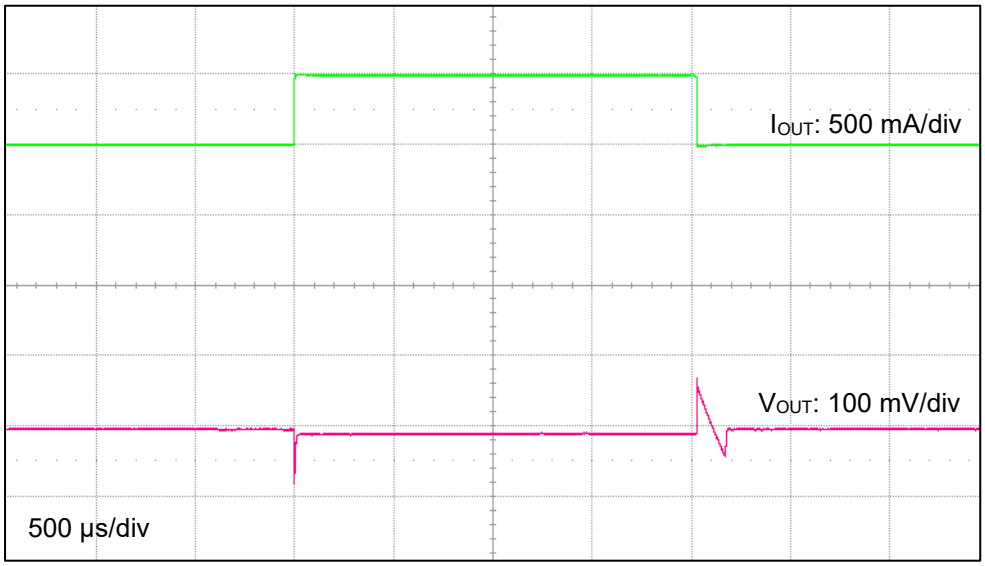
## 12.5. Load Transient Response

**($C_{IN}$ = 1 µF, $C_{OUT}$ = 2.2 µF, $I_{OUT}$ = 1 mA ⇔ 500 mA, $t_r$ = 1µs, $t_f$ = 1µs, Ta = 25 °C)**

$V_{OUT}$ = 1.2V ($V_{IN}$ = 1.7 V, $V_{BIAS}$ = 3.3 V)




$V_{OUT}$ = 1.8 V ($V_{IN}$ = 2.5 V, $V_{BIAS}$ = 3.5 V)



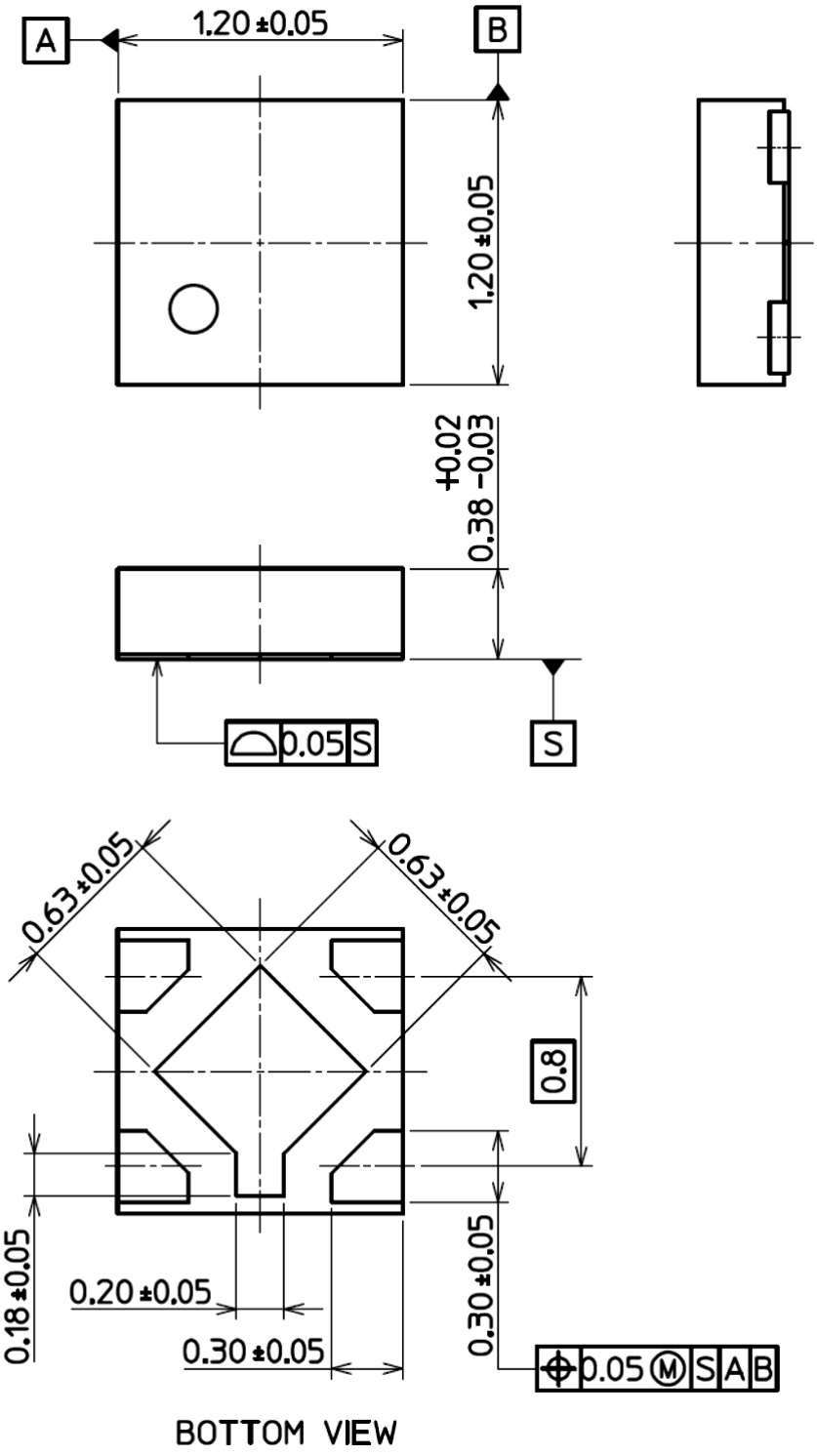

The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

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## 13. Package Dimensions

DFN5B

Unit: mm



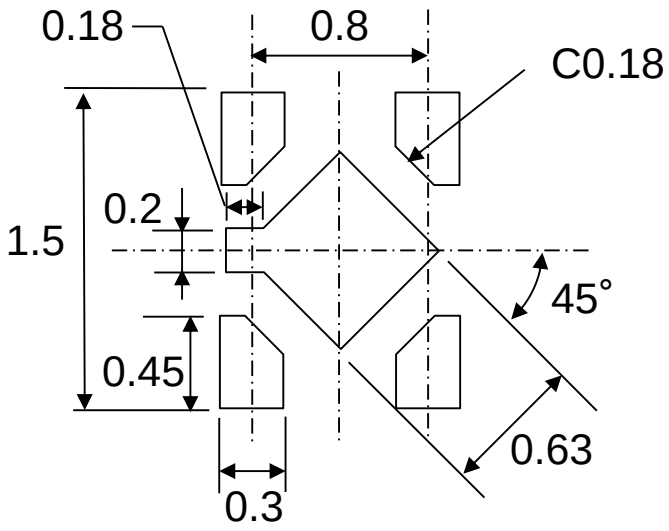

Weight : 1.4 mg (Typ.)

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## 14. Land pattern dimensions for reference only

DFN5B

Unit: mm



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