# High Voltage Intelligent Power Device【HVIPD】 Introduction of the Conversion Board for Evaluation (DIP26 to SSOP30)

## Description

This application note is a document for introduction of connection conversion board which can be used when new product TPD420*F series (package: SSOP30) is evaluated as the successor for conventional TPD41**K series (package: DIP26), which are applied for brushless DC motors.

# Table of Contents

# List of Figures



# List of Tables

# 0. Introduction

This application note is a document for introduction of connection conversion board which can be used when new product TPD420*F series (package: SSOP30) is evaluated as the successor for conventional TPD41**K series (package: DIP26), which are applied for brushless DC motors. TPD420*F series is motor driver IC which includes FET drivers with built-in level shift in the input stage, MOFETs in the output stage and various protective functions. In addition, a compact surface mount-type packaging SSOP30 is applied reduce the size of the control board. The brushless DC motor has a square wave drive (120-degree conduction) and a sine wave drive (180-degree conduction), and the high-voltage intelligent power device introduced in this application note supports sine wave drive and realizes low noise and low vibration of the motor by combining with our motor controller IC and microcomputer.

# 1. Product List

**Table 1-1 Product List**

| Product name | Rating | Package | Function | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Output stage | Configuration | SD (Shutdown) Function | Overcurrent Protection | Thermal Shutdown | Under voltage Protection | Conduction Mode (Note 2) | Assumed motor Output (Note 3) |
| TPD4123K (Note 1) | 500V/1A | DIP26 | IGBT | 1 Chip | - | Y | Y | Y | 180 degrees | 30W |
| TPD4123AK (Note 1) | 500V/1A | DIP26 | IGBT | 1 Chip | Y | - | Y | Y | 180 degrees | 30W |
| TPD4144K (Note 1) | 500V/2A | DIP26 | IGBT | 1 Chip | - | Y | Y | Y | 180 degrees | 40W |
| TPD4144AK (Note 1) | 500V/2A | DIP26 | IGBT | 1 Chip | Y | - | Y | Y | 180 degrees | 40W |
| TPD4135K (Note 1) | 500V/3A | DIP26 | IGBT | 1 Chip | - | Y | Y | Y | 180 degrees | 60W |
| TPD4135AK (Note 1) | 500V/3A | DIP26 | IGBT | 1 Chip | Y | - | Y | Y | 180 degrees | 60W |
| TPD4204F | 600V/2.5A | SSOP30 | MOS FET | Module | Y | Y | Y | Y | 180 degrees | 40W |
| TPD4206F | 500V/2.5A | SSOP30 | MOS FET | Module | Y | Y | Y | Y | 180 degrees | 40W |
| TPD4207F | 600V/5A | SSOP30 | MOS FET | Module | Y | Y | Y | Y | 180 degrees | 80W |

Note 1: DIP26 products including (Note 1) are scheduled to discontinue the production.
Note 2: Control is possible using a combination microcomputer or controller IC (Table 1-2 and Table 1-3).
Note 3: Motor output is for reference only and varies depending on drive and heat dissipation conditions.

TPD41**K series (DIP26) is a one-chip IGBT configuration (Figure 1-1), and TPD420*F series (SSOP30) is a MOSFET module configuration (Figure 1-2).

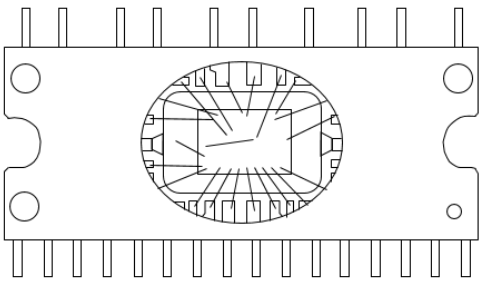


**Figure 1-1 Internal Structural Diagram: DIP26**

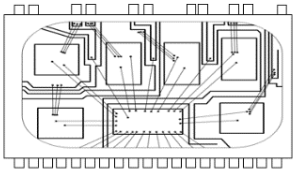


**Figure 1-2 Internal Structural Diagram: SSOP30**

**Sine wave drive (180-degree conduction) type**

The K type of TPD41** series has only overcurrent protection to turn off the input signal to the output transistor when the RS pin voltage exceeds 0.5V, and the AK type has only a shutdown function to turn off the input signal to the output transistor by inputting the "L" signal to the SD pin by an external circuit. However, TPD420*F series has a built-in overcurrent protection function and shutdown function, which can be used together.

**TPD4123K/TPD4144K/TPD4135K**

Built-in overcurrent protection function.

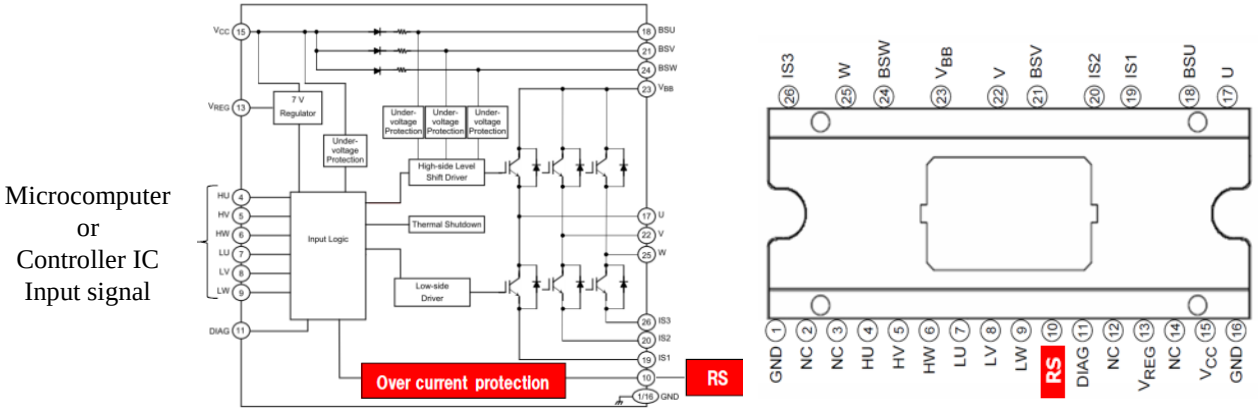



**Figure 1-3 TPD4123K/TPD4144K/TPD4135K Block diagram and pin assignment**

**TPD4123AK/TPD4144AK/TPD4135AK**

The overcurrent protection function has been deleted and the SD (shutdown) function has been added.

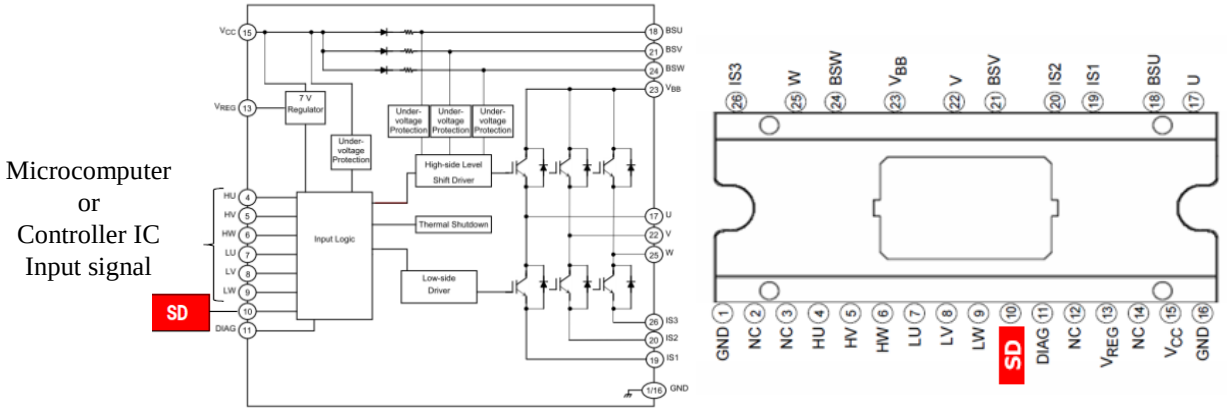



**Figure 1-4 TPD4123AK/TPD4144AK/TPD4135AK Block diagram and pin assignment**

**TPD4204F/TPD4206F/TPD4207F**

Both the overcurrent protection function and the SD (shutdown) function are built-in.

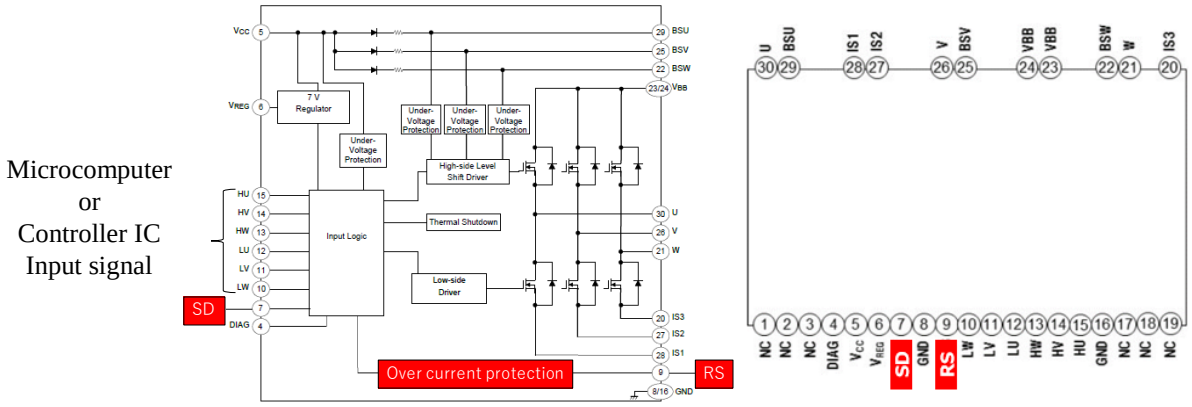



**Figure 1-5 TPD4204F/TPD4206F/TPD4207F Block diagram and pin assignment**

In combination with our motor controller ICs and microcomputers (see Table 1-2 and Table 1-3 Recommended Products), sine wave drive (180-degree conduction) is possible, which realizes low noise and low vibration of the motor.

**Table 1-2 Controller IC List Sine Wave Drive Type (Example of Products)**

| Product name | PKG | Vcc / Io | Position detection | Function | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Automatic lead angle Control | Oscillator Circuit Integrated | Electric current Restrictions | Gate Block | Position detection Fault protection | $V_{CC}$ Voltage reduction protection |
| TB6551FAG | SSOP24 | 12V/2mA | Hall effect IC | External setting | - | Y | Y | Y | Y |
| TB6556FG | SSOP30 | 12V/2mA | Hall effect IC | Y | - | Y | Y | Y | Y |
| TB6584FNG/AFNG (Note 1) | SSOP30 | 18V/2mA | Hall element or Hall effect IC | Y | Y | Y | Y | Y | Y |
| TB6634FNG | SSOP30 | 18V/2mA | Hall element or Hall effect IC | Y | Y | Y | Y | Y | Y |
| TB6631FNG | SSOP30 | 18V/2mA | Hall element or Hall effect IC | Y (Note 2) | Y | Y | Y | Y | Y |
| TC78B041FNG | SSOP30 | 18V/2mA | Hall element or Hall effect IC | Y (Note 3) | Y | Y | Y | Y | Y |
| TC78B042FTG | QFN32 | 18V/2mA | Hall element or Hall effect IC | Y (Note 3) | Y | Y | Y | Y | Y |

Note 1: Specifications such as modulation generation method and automatic advance angle mode differ. Refer to the data sheet of each product for details.
Note 2: Internal auto lead angle control function based on FG signal frequency.
Note 3: Intelligent Phase Control, Our unique automatic phase adjustment function.

**Table 1-3 Microcomputer List Sine Wave Drive Type (Example of Products)**

| Product name | Package | ROM Size (Bytes) | RAM Size (Bytes) | Maximum operation Frequency (MHz) | Working voltage (V) | |
|---|---|---|---|---|---|---|
| | | | | | Minimum | Maximum |
| TMPM375FSDMG | SSOP30 | 64K | 4K | 40(Note 1) | 4.5 | 5.5 |
| TMPM372FWUG | LQFP64 | 128K | 6K | 80(Note 2) 32(Note 1) | 4.5 | 5.5 |
| TMPM373FWDUG | LQFP48 | | | | | |
| TMPM374FWUG | LQFP44 | | | | | |
| TMPM370FYDFG | QFP100 | 256K | 10K | 80(Note 2) | 4.5 | 5.5 |
| TMPM370FYFG | LQFP100 | | | | | |
| TMPM376FDDFG | QFP100 | 512K | 32K | 80(Note 2) | 4.5 | 5.5 |
| TMPM376FDFG | LQFP100 | | | | | |

Note 1: Ambient temperature -40℃～105℃
Note 2: Ambient temperature -40℃～85℃

# 2. Packaging compared SSOP30 with conventional product DIP26

## 2.1 SSOP30 Packaging Features

Similar to DIP26, SSOP30 realizes easy wiring of the board by separating the high-voltage terminal and the control terminal on both sides of the packaging. It is also thinner and smaller than DIP26. In addition, SSOP30 is equipped with a MOSFET to reduce power dissipation.

## 2.2 Package Dimensions

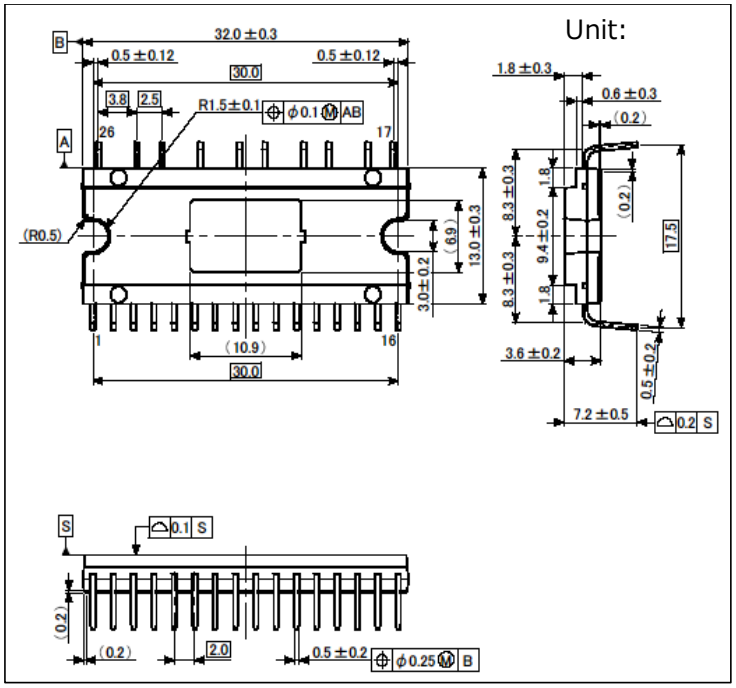



Figure 2-1 DIP26 Dimensions

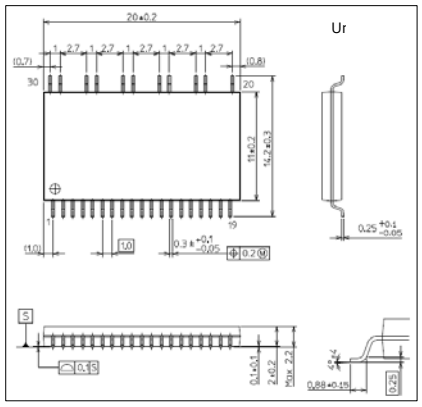


Figure 2-2 SSOP30 Dimensions

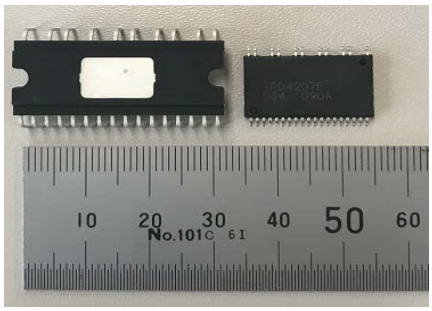



Figure 2-3 Comparing DIP26 and SSOP30

## 2.3 SSOP30 Marking

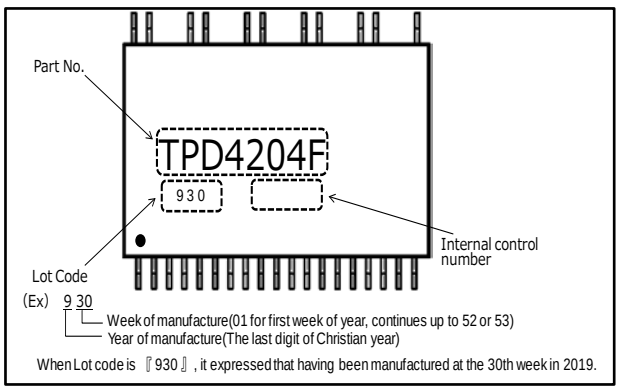


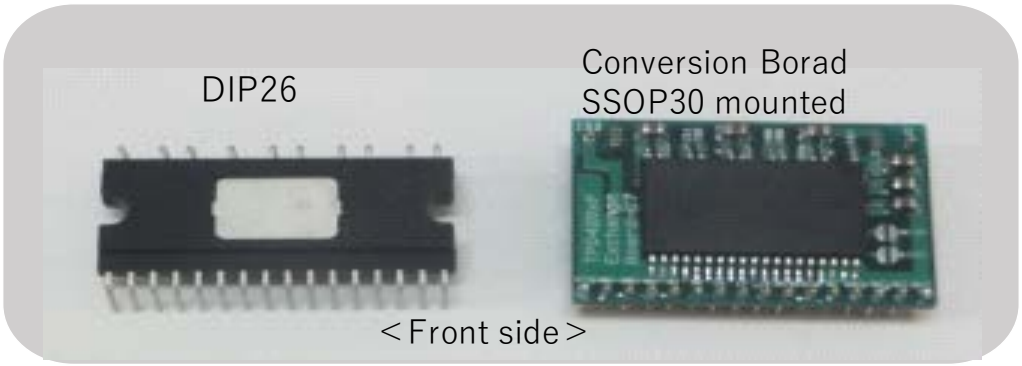

Figure 2-4 SSOP30 Marking

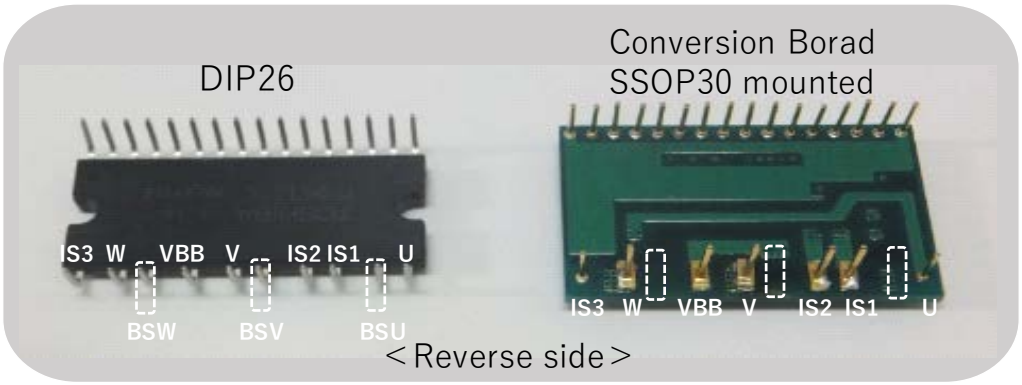
# 3. Introduction of "DIP26 to SSOP30 connection conversion board"

Package-size and pin assignment differ between DIP26 and SSOP30. Conversion board (four-layer boards with through-hole construction) is available to evaluate SSOP30 as the successor for DIP26.

## 3.1 Handling the Conversion Board

If there is a board designed for DIP26 at present, DIP26 can be removed from it, and the operation can be checked by inserting and soldering a conversion board which required components such as SSOP30, pins and others are assembled with. A bootstrap-capacitors are mounted on the conversion board, and BUS/BSV/BSW terminal on the conversion board to the board for DIP26 are not connected. In addition, there is no need to remove the bootstrap-capacitors mounted on

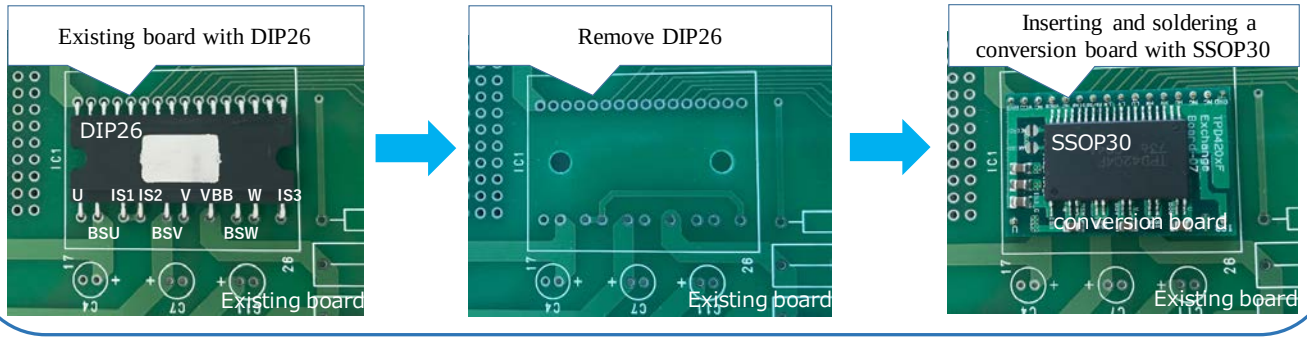




SSOP30 can be evaluated by inserting and soldering a conversion board with a SSOP30 into an existing board designed for DIP26.

By using a conversion board, it is possible to evaluate SSOP30 with an existing board for DIP26.




## 3.2 Conversion Board Layout Diagram

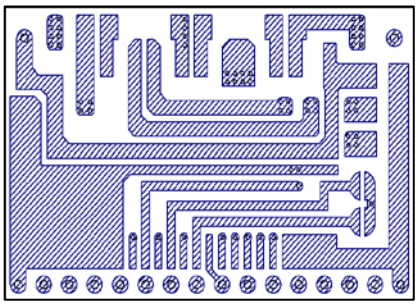


Figure 3-1 Front side Pattern

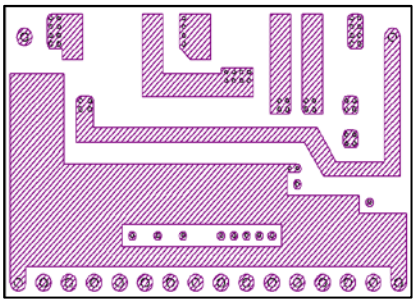


Figure 3-2 Reverse side Pattern

## 4. DIP26 and SSOP30 comparisons

SSOP30 packages are smaller than conventional DIP26, but the power dissipation is reduced by changing the output device from IGBT to MOSFET, which reduces the effect of heat generation due to miniaturization.

In the following examples, when the motor is rotated at an input power of Pin=30W, the power loss is reduced approximately 1.25W when HVIPD is changed from TPD4144K(DIP26) to TPD4204F(SSOP30), and the surface temperature of the package is reduced approximately 55 degrees.

Evaluating condition, Controller IC : TB6551FAG, $V_{BB}$=280V, $V_{CC}$=15V, fs=16.5kHz,
$V_e$ = 3V (Voltage command input terminal of TB6551FAG), Ta=25°C, heat sink less

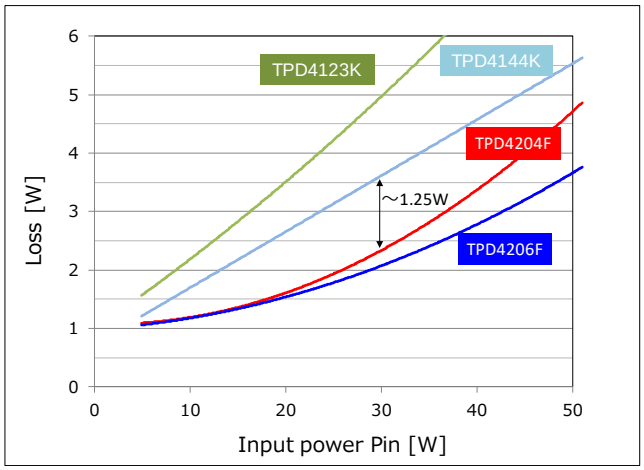



Figure 4-1 Loss-Input power Curve

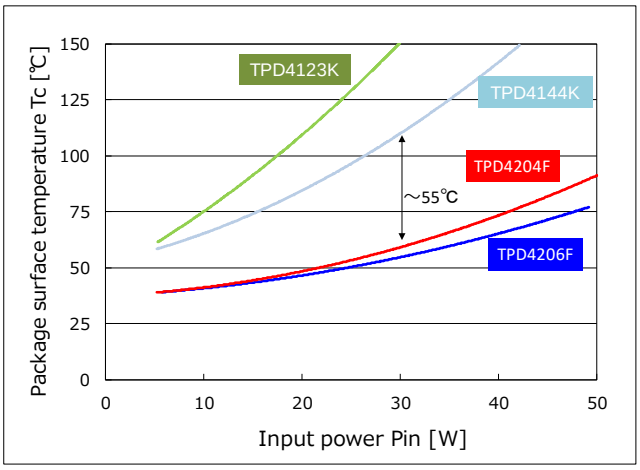



Figure 4-2 Package Surface Temperature-Input Power Curve

## RESTRICTIONS ON PRODUCT USE

Toshiba Corporation and its subsidiaries and affiliates are collectively referred to as “TOSHIBA”.
Hardware, software and systems described in this document are collectively referred to as “Product”.

- TOSHIBA reserves the right to make changes to the information in this document and related Product without notice.
- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.
- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the "TOSHIBA Semiconductor Reliability Handbook" and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. **TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.**
- **PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT ("UNINTENDED USE"). ** Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, lifesaving and/or life supporting medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, and devices related to power plant. **IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT.** For details, please contact your TOSHIBA sales representative or contact us via our website.
- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.
- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.
- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.
- **ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.**
- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.
- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. **TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.**

## Toshiba Electronic Device & Strage Corporation

https://toshiba.semicon-storage.com/jp/