# STEP-UP, BUILT-IN / EXTERNAL FET PFM CONTROL SWITCHING REGULATOR / SWITCHING REGULATOR CONTROLLER

The S-8351/8352 Series is a CMOS step-up switching regulator controller which mainly consists of a reference voltage source, an oscillation circuit, a comparator and PFM control circuit.  The PFM control circuit allows the duty ratio to be automatically switched according to the load (at light load : 50%, at high output current : 75%), enabling products with a low ripple over a wide range, high efficiency, and high output current (A, B, and D type).   Products with a fixed duty ratio of 75% are also available (C type).

The S-8351 Series can configure a step-up switching regulator with an external coil, capacitor, and diode.  A protection circuit turns off the built-in MOS FET when the voltage at the CONT pin exceeds the limit to prevent it from being damaged.  In addition to the above features, the small package and low current consumption, makes the S-8351 Series ideal for applications such as the power supply unit of portable equipment.

The S-8352 Series, which features an external transistor, is suitable for applications requiring a high output current.

## ■ Features

- Low voltage operation : Startup at 0.9 V min. ($I_{OUT}$ = 1 mA) guaranteed
- Low current consumption : During operation 23.2 $\mu$A ($V_{OUT}$ = 3.3 V, typ.)
  During shutdown 0.5 $\mu$A (max.)
- Duty ratio : 50 % / 75 % built-in auto-switching-type PFM control circuit (A, B, and D type)
  75 % built-in fixed-type PFM control circuit (C type)
- External parts : Coil, capacitor, and diode
- Output voltage : Selectable in 0.1 V steps between 2.0 V to 6.5 V (A, B, and C type)
  Selectable in 0.1 V steps between 1.5 V to 6.5 V (D type)
- Output voltage accuracy : ±2.4%
- Shutdown function (A type)
- $V_{DD}$ / $V_{OUT}$ separate type (D type)
- External transistor type available (S-8352 Series)
- Lead-free, Sn 100%, halogen-free[1]

  ***1.** Refer to "■ **Product Name Structure**" for details.

## ■ Applications

- Power supplies for portable equipment such as digital cameras, electronic notebooks, and PDAs
- Power supplies for audio equipment such as portable CD / MD players
- Constant voltage power supplies for cameras, video equipment, and communications equipment
- Power supplies for microcomputers

## ■ Packages

- SOT-23-3
- SOT-23-5
- SOT-89-3

## ■ Block Diagrams

### 1. S-8351 Series
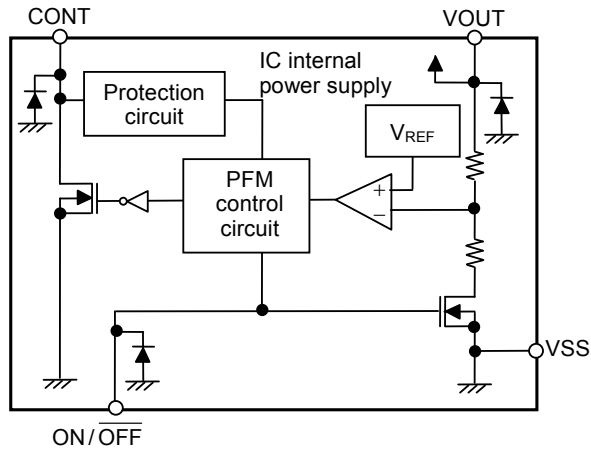
#### (1) A Type (With shutdown function)



**Figure 1**

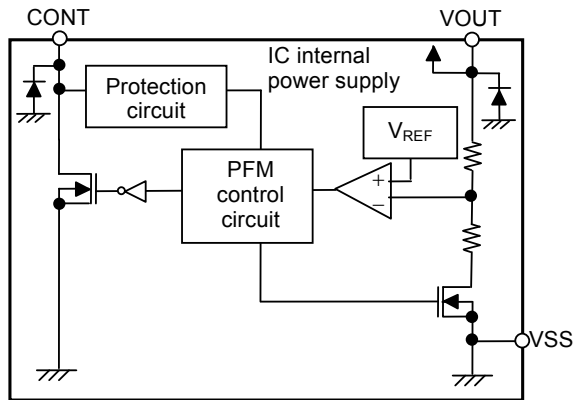#### (2) B and C Types (Without shutdown function, $V_{DD}$ / $V_{OUT}$ non-separate type)



**Figure 2**

#### (3) D Type ($V_{DD}$ / $V_{OUT}$ separate type)
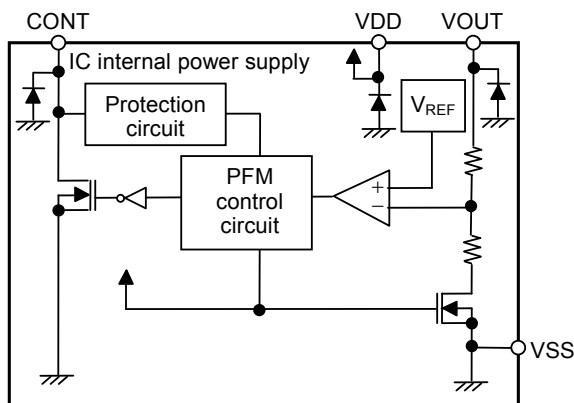


**Figure 3**

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## 2. S-8352 Series

### (1) A Type (With shutdown function)
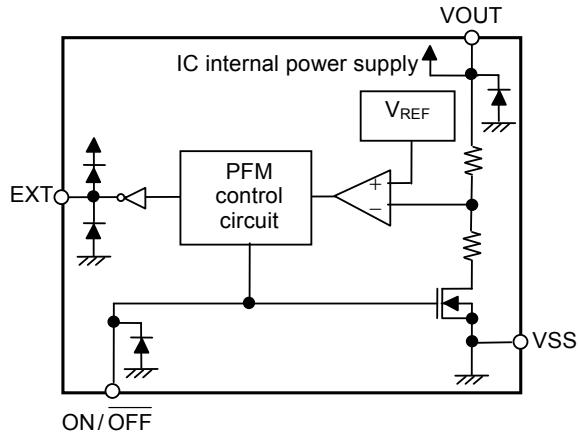


**Figure 4**

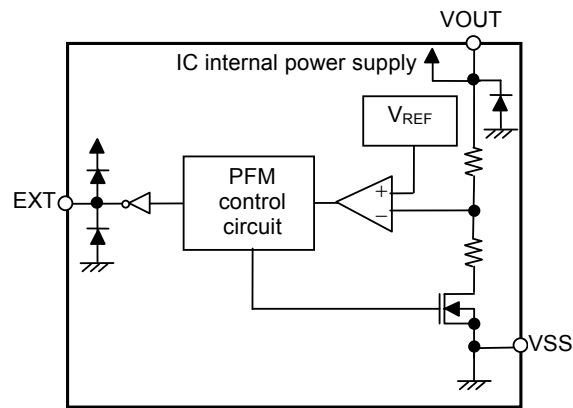### (2) B and C Type (Without Shutdown function, $V_{DD}$ / $V_{OUT}$ non-separate type)



**Figure 5**

### (3) D Type ($V_{DD}$ / $V_{OUT}$ separate type)



**Figure 6**

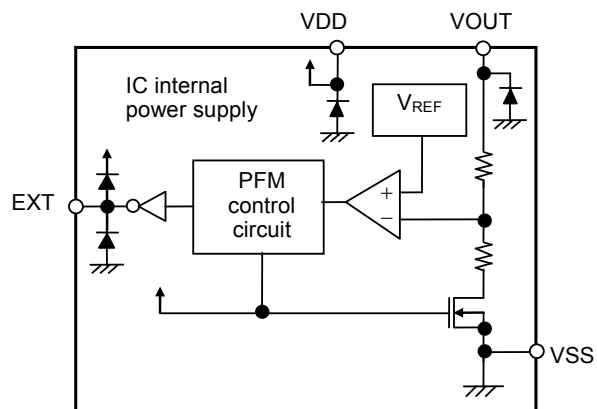**ABLIC Inc.**                                                                               3

# ■ Product Name Structure

The product types, output voltage, and packages for the S-8351/8352 Series can be selected at the user's request. Please refer to the "**3. Product Name**" for the definition of the product name, "**4. Package**" regarding the package drawings and "**5. Product Name List**" for the full product names.

## 1. Function List

### (1) Built-in Power MOS FET Type

**Table 1**

| Product Name | Controll system | Duty ratio [%] | Switching frequency [kHz] | Shutdown function | $V_{DD}$ / $V_{OUT}$ separate type | Package | Application |
|---|---|---|---|---|---|---|---|
| S-8351AxxMC | PFM | 50 / 75 | 100 | Yes | – | SOT-23-5 | Applications requiring shutdown function |
| S-8351BxxMA | PFM | 50 / 75 | 100 | – | – | SOT-23-3 | Applications not requiring shutdown function |
| S-8351CxxMA | PFM | 75 | 100 | – | – | SOT-23-3 | Applications not requiring shutdown function |
| S-8351CxxUA | PFM | 75 | 100 | – | – | SOT-89-3 | Applications not requiring shutdown function |
| S-8351DxxMC | PFM | 50 / 75 | 100 | – | Yes | SOT-23-5 | Applications in which output voltage is adjusted by external resistor |

### (2) External Power MOS FET Type

**Table 2**

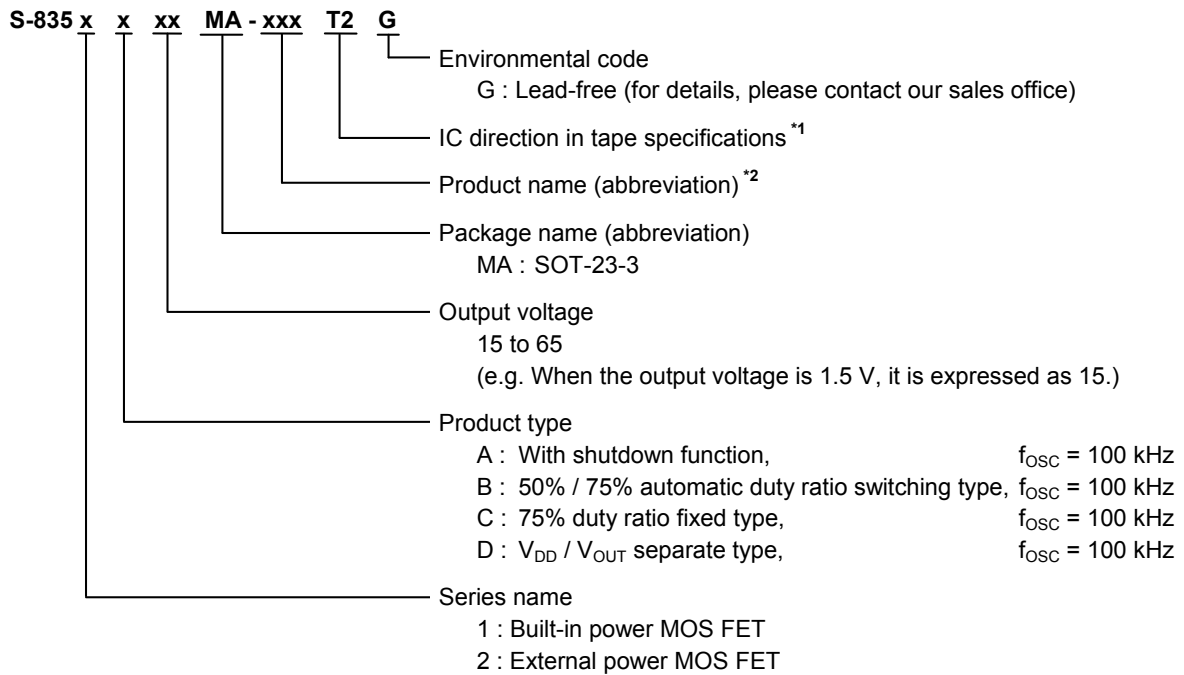| Product Name | Controll System | Duty Ratio [%] | Switching Frequency [kHz] | Shutdown Function | $V_{DD}$ / $V_{OUT}$ Separate Type | Package | Application |
|---|---|---|---|---|---|---|---|
| S-8352AxxMC | PFM | 50 / 75 | 100 | Yes | – | SOT-23-5 | Applications requiring shutdown function |
| S-8352BxxMA | PFM | 50 / 75 | 100 | – | – | SOT-23-3 | Applications not requiring shutdown function |
| S-8352CxxMA | PFM | 75 | 100 | – | – | SOT-23-3 | Applications not requiring shutdown function |
| S-8352CxxUA | PFM | 75 | 100 | – | – | SOT-89-3 | Applications not requiring shutdown function |
| S-8352DxxMC | PFM | 50 / 75 | 100 | – | Yes | SOT-23-5 | Applications in which output voltage is adjusted by external resistor |

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## 2.  Package and Function List by Product Type

**Table 3**

| Series Name | Type | Package Name (Abbreviation) | Shutdown Function Yes / No | $V_{DD}$ / $V_{OUT}$ Separate Type Yes / No |
|---|---|---|---|---|
| S-8351 Series, S-8352 Series | A (Duty ratio 50% / 75% auto-switching type) A = 100 kHz | MC | Yes | No |
| | B (Duty ratio 50% / 75% auto-switching type) B = 100 kHz | MA | No | No |
| | C (Duty ratio 75% fixed type) C = 100 kHz | MA / UA | No | No |
| | D (Duty ratio 50% / 75% auto-switching type) D = 100 kHz | MC | No | Yes |

## 3.  Product Name

### (1)  SOT-23-3

**S-835 x   x   xx   MA - xxx   T2   G**

- Environmental code
  - G : Lead-free (for details, please contact our sales office)
- IC direction in tape specifications [1]
- Product name (abbreviation) [2]
- Package name (abbreviation)
  - MA : SOT-23-3
- Output voltage
  - 15 to 65
  - (e.g. When the output voltage is 1.5 V, it is expressed as 15.)
- Product type
  - A :  With shutdown function,                          $f_{OSC}$ = 100 kHz
  - B :  50% / 75% automatic duty ratio switching type,  $f_{OSC}$ = 100 kHz
  - C :  75% duty ratio fixed type,                      $f_{OSC}$ = 100 kHz
  - D :  $V_{DD}$ / $V_{OUT}$ separate type,             $f_{OSC}$ = 100 kHz
- Series name
  - 1 : Built-in power MOS FET
  - 2 : External power MOS FET
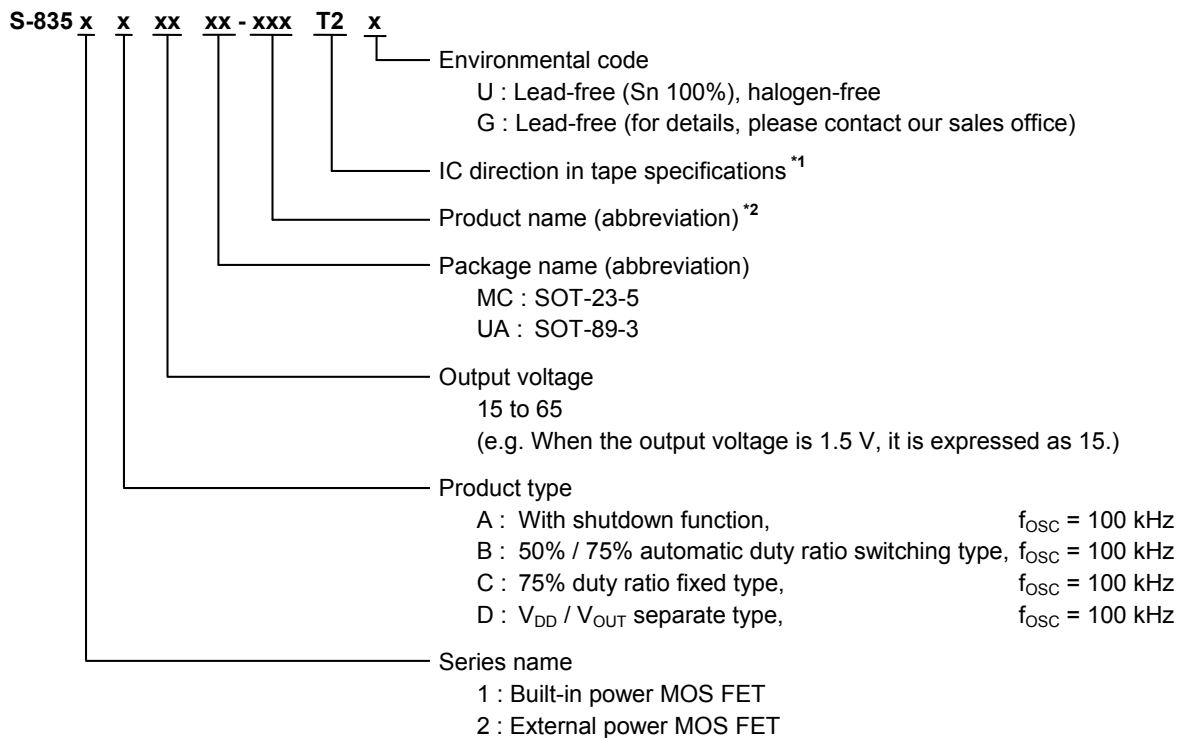
[1]. Refer to the tape specifications.
[2]. Refer to the **Table 4, 5** in the "**5.   Product Name List**".

**(2)  SOT-23-5, SOT-89-3**

**S-835 x x xx xx - xxx T2 x**

- Environmental code
  - U : Lead-free (Sn 100%), halogen-free
  - G : Lead-free (for details, please contact our sales office)

- IC direction in tape specifications [*1]

- Product name (abbreviation) [*2]

- Package name (abbreviation)
  - MC : SOT-23-5
  - UA : SOT-89-3

- Output voltage
  - 15 to 65
  - (e.g. When the output voltage is 1.5 V, it is expressed as 15.)

- Product type
  - A :  With shutdown function,                        $f_{OSC}$ = 100 kHz
  - B :  50% / 75% automatic duty ratio switching type, $f_{OSC}$ = 100 kHz
  - C :  75% duty ratio fixed type,                      $f_{OSC}$ = 100 kHz
  - D :  $V_{DD}$ / $V_{OUT}$ separate type,                $f_{OSC}$ = 100 kHz

- Series name
  - 1 : Built-in power MOS FET
  - 2 : External power MOS FET

**\*1.** Refer to the tape specifications.
**\*2.** Refer to the **Table 4, 5** in the "**5.   Product Name List**".

## 4.  Package

| Package Name | Drawing Code | | |
| --- | --- | --- | --- |
| | Package | Tape | Reel |
| SOT-23-3 | MP003-A-P-SD | MP003-A-C-SD | MP003-A-R-SD |
| SOT-23-5 | MP005-A-P-SD | MP005-A-C-SD | MP005-A-R-SD |
| SOT-89-3 | UP003-A-P-SD | UP003-A-C-SD | UP003-A-R-SD |

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## 5. Product Name List

### (1) S-8351 Series

**Table 4**

| Output voltage | S-8351AxxMC Series | S-8351BxxMA Series | S-8351CxxMA Series | S-8351CxxUA Series | S-8351DxxMC Series |
|---|---|---|---|---|---|
| 1.5 V | – | – | – | – | S-8351D15MC-J8AT2x |
| 2.0 V | S-8351A20MC-J2FT2x | S-8351B20MA-J4FT2G | – | – | S-8351D20MC-J8FT2x |
| 2.2 V | S-8351A22MC-J2HT2x | – | – | – | – |
| 2.5 V | S-8351A25MC-J2KT2x | S-8351B25MA-J4KT2G | – | S-8351C25UA-J6KT2x | – |
| 2.6 V | S-8351A26MC-J2LT2x | – | – | – | – |
| 2.7 V | S-8351A27MC-J2MT2x | S-8351B27MA-J4MT2G | – | – | – |
| 2.8 V | S-8351A28MC-J2NT2x | – | – | – | – |
| 3.0 V | S-8351A30MC-J2PT2x | S-8351B30MA-J4PT2G | – | S-8351C30UA-J6PT2x | S-8351D30MC-J8PT2x |
| 3.1 V | – | – | – | S-8351C31UA-J6QT2x | – |
| 3.2 V | S-8351A32MC-J2RT2x | – | – | S-8351C32UA-J6RT2x | – |
| 3.3 V | S-8351A33MC-J2ST2x | S-8351B33MA-J4ST2G | S-8351C33MA-J6ST2G | S-8351C33UA-J6ST2x | – |
| 3.5 V | S-8351A35MC-J2UT2x | – | – | S-8351C35UA-J6UT2x | – |
| 4.0 V | S-8351A40MC-J2ZT2x | – | – | – | S-8351D40MC-J8ZT2x |
| 4.5 V | S-8351A45MC-J3ET2x | S-8351B45MA-J5ET2G | – | – | – |
| 4.6 V | – | S-8351B46MA-J5FT2G | – | – | – |
| 4.7 V | S-8351A47MC-J3GT2x | – | – | – | – |
| 5.0 V | S-8351A50MC-J3JT2x | S-8351B50MA-J5JT2G | – | S-8351C50UA-J7JT2x | S-8351D50MC-J9JT2x |
| 5.5 V | S-8351A55MC-J3OT2x | S-8351B55MA-J5OT2G | – | – | – |
| 5.6 V | S-8351A56MC-J3PT2x | – | – | – | – |
| 6.0 V | S-8351A60MC-J3TT2x | – | – | – | S-8351D60MC-J9TT2x |

### (2) S-8352 Series

**Table 5**

| Output voltage | S-8352AxxMC Series | S-8352BxxMA Series | S-8352CxxUA Series | S-8352DxxMC Series |
|---|---|---|---|---|
| 2.0 V | – | – | – | S-8352D20MC-K8FT2x |
| 2.5 V | S-8352A25MC-K2KT2x | – | – | – |
| 3.0 V | S-8352A30MC-K2PT2x | S-8352B30MA-K4PT2G | S-8352C30UA-K6PT2x | S-8352D30MC-K8PT2x |
| 3.1 V | – | – | S-8352C31UA-K6QT2x | – |
| 3.2 V | S-8352A32MC-K2RT2x | – | S-8352C32UA-K6RT2x | – |
| 3.3 V | S-8352A33MC-K2ST2x | – | S-8352C33UA-K6ST2x | S-8352D33MC-K8ST2x |
| 3.5 V | S-8352A35MC-K2UT2x | – | – | – |
| 3.7 V | S-8352A37MC-K2WT2x | – | – | – |
| 4.0 V | S-8352A40MC-K2ZT2x | – | – | – |
| 4.6 V | S-8352A46MC-K3FT2x | – | – | – |
| 4.7 V | S-8352A47MC-K3GT2x | – | – | – |
| 5.0 V | S-8352A50MC-K3JT2x | S-8352B50MA-K5JT2G | S-8352C50UA-K7JT2x | – |
| 5.4 V | S-8352A54MC-K3NT2x | – | – | – |
| 5.6 V | – | – | S-8352C56UA-K7PT2x | – |

**Remark 1.** Please contact the ABLIC Inc. marketing department for products with an output voltage other than those specified above.
   **2.** x: G or U
   **3.** Please select products of environmental code = U for Sn 100%, halogen-free products.

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# ■ Pin Configurations

SOT-23-3
Top view



**Figure 7**

**Table 6 S-8351 Series B and C Types**
**(Without shutdown function, $V_{DD}$ / $V_{OUT}$ non-separate type)**

| Pin No. | Symbol | Pin Description |
|---|---|---|
| 1 | VOUT | Output voltage pin and IC power supply pin |
| 2 | VSS | GND pin |
| 3 | CONT | External inductor connection pin (Open-drain output) |

**Table 7 S-8352 Series B and C Types**
**(Without shutdown function, $V_{DD}$ / $V_{OUT}$ non-separate type)**

| Pin No. | Symbol | Pin Description |
|---|---|---|
| 1 | VOUT | Output voltage pin and IC power supply pin |
| 2 | VSS | GND pin |
| 3 | EXT | External transistor connection pin (CMOS output) |

SOT-23-5
Top view



**Figure 8**

**Table 8 S-8351 Series A Type**
**(With shutdown function, $V_{DD}$ / $V_{OUT}$ non-separate type)**

| Pin No. | Symbol | Pin Description |
|---|---|---|
| 1 | ON/$\overline{\text{OFF}}$ | Shutdown pin<br>"H": Normal operation (Step-up operating)<br>"L": Step-up stopped (Entire circuit stopped) |
| 2 | VOUT | Output voltage pin and IC power supply pin |
| 3 | NC[1] | No connection |
| 4 | VSS | GND pin |
| 5 | CONT | External inductor connection pin (Open-drain output) |

**[1].** The NC pin indicates electrically open.

**Table 9 S-8352 Series A Type**
**(With shutdown function, $V_{DD}$ / $V_{OUT}$ non-separate type)**

| Pin No. | Symbol | Pin Description |
|---|---|---|
| 1 | ON/$\overline{\text{OFF}}$ | Shutdown pin<br>"H": Normal operation (Step-up operating)<br>"L": Step-up stopped (Entire circuit stopped) |
| 2 | VOUT | Output voltage pin and IC power supply pin |
| 3 | NC[1] | No connection |
| 4 | VSS | GND pin |
| 5 | EXT | External transistor connection pin (CMOS output) |

**[1].** The NC pin indicates electrically open.

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**Table 10   S-8351 Series D Type**
**(Without shutdown function, $V_{DD}$ / $V_{OUT}$ separate type)**

| Pin No. | Symbol | Pin Description |
|---------|--------|-----------------|
| 1 | VOUT | Output voltage pin |
| 2 | VDD | IC power supply pin |
| 3 | NC[*1] | No connection |
| 4 | VSS | GND pin |
| 5 | CONT | External inductor connection pin (Open-drain output) |

**\*1.** The NC pin indicates electrically open.

**Table 11   S-8352 Series D Type**
**(Without shutdown function, $V_{DD}$ / $V_{OUT}$ separate type)**

| Pin No. | Symbol | Pin Description |
|---------|--------|-----------------|
| 1 | VOUT | Output voltage pin |
| 2 | VDD | IC power supply pin |
| 3 | NC[*1] | No connection |
| 4 | VSS | GND pin |
| 5 | EXT | External transistor connection pin (CMOS output) |

**\*1.** The NC pin indicates electrically open.

SOT-89-3
Top view



1    2    3
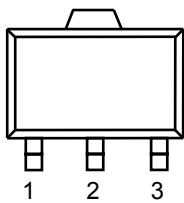
**Figure 9**

**Table 12   S-8351 Series C Type**
**(Without shutdown function, $V_{DD}$ / $V_{OUT}$ non-separate type)**

| Pin No. | Symbol | Pin Description |
|---------|--------|-----------------|
| 1 | VSS | GND pin |
| 2 | VOUT | Output voltage pin and IC power supply pin |
| 3 | CONT | External inductor connection pin (Open-drain output) |

**Table 13   S-8352 Series C Type**
**(Without shutdown function, $V_{DD}$ / $V_{OUT}$ non-separate type)**

| Pin No. | Symbol | Pin Description |
|---------|--------|-----------------|
| 1 | VSS | GND pin |
| 2 | VOUT | Output voltage pin and IC power supply pin |
| 3 | EXT | External transistor connection pin (CMOS output) |

## ■ Absolute Maximum Ratings

**Table 14**

(Ta = 25°C unless otherwise specified)

| Item | | Symbol | Absolute maximum rating | Unit |
|---|---|---|---|---|
| VOUT pin voltage | | $V_{OUT}$ | $V_{SS} - 0.3$ to $V_{SS} + 12$ | V |
| ON/$\overline{OFF}$ pin voltage [*1] | | $V_{ON/\overline{OFF}}$ | $V_{SS} - 0.3$ to $V_{SS} + 12$ | V |
| VDD pin voltage [*2] | | $V_{DD}$ | $V_{SS} - 0.3$ to $V_{SS} + 12$ | V |
| CONT pin voltage | | $V_{CONT}$ | $V_{SS} - 0.3$ to $V_{SS} + 12$ | V |
| EXT pin voltage | D type | $V_{EXT}$ | $V_{SS} - 0.3$ to $V_{DD} + 0.3$ | V |
| | Others | | $V_{SS} - 0.3$ to $V_{OUT} + 0.3$ | V |
| CONT pin current | | $I_{CONT}$ | 300 | mA |
| EXT pin current | | $I_{EXT}$ | $\pm 50$ | mA |
| Power dissipation | SOT-23-3 | $P_D$ | 150 (When not mounted on board) | mW |
| | | | 430 [*3] | mW |
| | SOT-23-5 | | 250 (When not mounted on board) | mW |
| | | | 600 [*3] | mW |
| | SOT-89-3 | | 500 (When not mounted on board) | mW |
| | | | 1000 [*3] | mW |
| Operating ambient temperature | | $T_{opr}$ | $-40$ to $+85$ | °C |
| Storage temperature | | $T_{stg}$ | $-40$ to $+125$ | °C |

**[*1].** With shutdown function

**[*2].** For $V_{DD}$ / $V_{OUT}$ separate type

**[*3].** When mounted on board

    [Mounted board]

      (1)   Board size :   114.3 mm × 76.2 mm × t1.6 mm

      (2)   Board name : JEDEC STANDARD51-7

**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.**
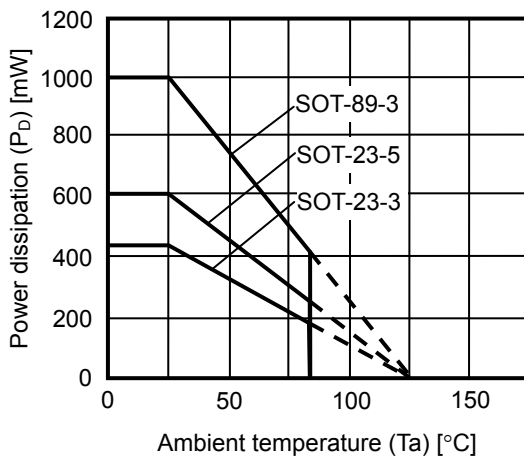
**(1)  When mounted on board**          **(2)  When not mounted on board**
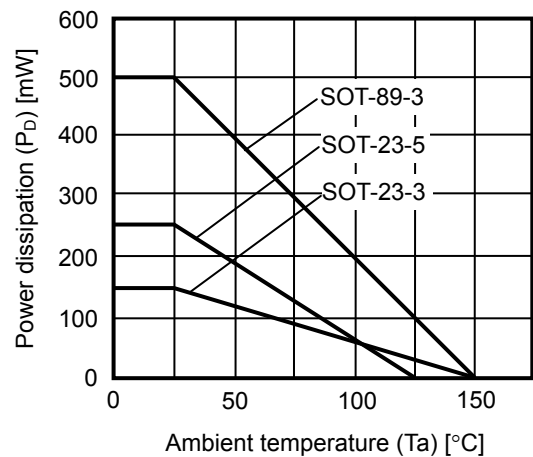


**Figure 10   Power Dissipation of Packages**

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# ■ Electrical Characteristics

## (1) S-8351 Series

**Table 15 (1 / 2)**

(Ta = 25°C unless otherwise specified)

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit | Measurement circuit |
|---|---|---|---|---|---|---|---|---|
| Output voltage | $V_{OUT}$ | – | | $V_{OUT(S)} \times 0.976$ | $V_{OUT(S)}$ | $V_{OUT(S)} \times 1.024$ | V | 1 |
| Input voltage | $V_{IN}$ | – | | – | – | 10 | V | 1 |
| Operation start voltage | $V_{ST1}$ | $I_{OUT}$ = 1 mA | | – | – | 0.9 | V | 1 |
| Oscillation start voltage | $V_{ST2}$ | No external parts, Voltage applied to $V_{OUT}$, CONT pin pulled up to $V_{OUT}$ with 300 Ω resistor | | – | – | 0.8 | V | 2 |
| Input current during no- load | $I_{IN}$ | $I_{OUT}$ = 0 mA | S-8351x15 to 29 | – | 8.5 | – | μA | 1 |
| | | | S-8351x30 to 49 | – | 9.0 | – | μA | 1 |
| | | | S-8351x50 to 65 | – | 9.5 | – | μA | 1 |
| Current consumption 1 | $I_{SS1}$ | $V_{OUT} = V_{OUT(S)} \times 0.95$ | S-8351x15 to 19 | – | 9.6 | 16.0 | μA | 2 |
| | | | S-8351x20 to 29 | – | 15.7 | 26.2 | μA | 2 |
| | | | S-8351x30 to 39 | – | 23.2 | 38.6 | μA | 2 |
| | | | S-8351x40 to 49 | – | 32.0 | 53.3 | μA | 2 |
| | | | S-8351x50 to 59 | – | 42.1 | 70.2 | μA | 2 |
| | | | S-8351x60 to 65 | – | 54.9 | 91.5 | μA | 2 |
| Current consumption 2 | $I_{SS2}$ | $V_{OUT} = V_{OUT(S)} + 0.5$ V | S-8351x15 to 19 | – | 2.3 | 3.5 | μA | 2 |
| | | | S-8351x20 to 29 | – | 2.5 | 3.8 | μA | 2 |
| | | | S-8351x30 to 39 | – | 2.7 | 4.1 | μA | 2 |
| | | | S-8351x40 to 49 | – | 2.9 | 4.4 | μA | 2 |
| | | | S-8351x50 to 59 | – | 3.1 | 4.7 | μA | 2 |
| | | | S-8351x60 to 65 | – | 3.3 | 5.1 | μA | 2 |
| Current consumption during shutdown (With shutdown function) | $I_{SSS}$ | $V_{ON/\overline{OFF}}$ = 0 V | | – | – | 0.5 | μA | 2 |
| Switching current | $I_{SW}$ | $V_{CONT}$ = 0.4 V | S-8351x15 to 19 | 50.2 | 91.2 | – | mA | 2 |
| | | | S-8351x20 to 24 | 65.0 | 118.2 | – | mA | 2 |
| | | | S-8351x25 to 29 | 78.5 | 142.7 | – | mA | 2 |
| | | | S-8351x30 to 39 | 90.7 | 164.8 | – | mA | 2 |
| | | | S-8351x40 to 49 | 110.9 | 201.6 | – | mA | 2 |
| | | | S-8351x50 to 59 | 125.7 | 228.6 | – | mA | 2 |
| | | | S-8351x60 to 65 | 135.2 | 245.8 | – | mA | 2 |
| Switching transistor leakage current | $I_{SWQ}$ | No external parts, $V_{CONT} = V_{OUT}$ = 10 V, $V_{ON/\overline{OFF}}$ = 0 V | | – | – | 0.5 | μA | 2 |
| CONT pin limit voltage | $V_{CONTLMT}$ | Apply to CONT pin, Confirm oscillation stop | | – | 0.9 | – | V | 2 |
| Line regulation | $\Delta V_{OUT1}$ | $V_{IN} = V_{OUT(S)} \times 0.4$ to $\times 0.6$ | | – | 30 | 60 | mV | 1 |
| Load regulation | $\Delta V_{OUT2}$ | $I_{OUT}$ = 10 μA to $V_{OUT(S)}$ / 250 × 1.25 | | – | 30 | 60 | mV | 1 |
| Output voltage temperature coefficient | $\dfrac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}$ | Ta = – 40°C to + 85°C | | – | ±50 | – | ppm / °C | 1 |
| Oscillation frequency | $f_{OSC}$ | $V_{OUT} = V_{OUT(S)} \times 0.95$, Measured waveform at CONT pin | | 90 | 100 | 110 | kHz | 2 |
| Duty ratio 1 | Duty1 | $V_{OUT} = V_{OUT(S)} \times 0.95$, Measured waveform at CONT pin | | 70 | 75 | 80 | % | 2 |
| Duty ratio 2 (For A, B, D type) | Duty2 | Measured waveform at CONT pin at light load | | – | 50 | – | % | 1 |

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**Table 15 (2 / 2)**

(Ta = 25°C unless otherwise specified)

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit | Measurement circuit |
|---|---|---|---|---|---|---|---|---|
| ON/$\overline{\text{OFF}}$ pin input voltage (With shutdown function) | $V_{SH}$ | $V_{OUT} = V_{OUT(S)} \times 0.95$, Measured oscillation at CONT pin | | 0.75 | – | – | V | 2 |
| | $V_{SL1}$ | $V_{OUT} = V_{OUT(S)} \times 0.95$, Judged oscillation stop at CONT pin | At $V_{OUT} \geq 1.5$ V | – | – | 0.3 | V | 2 |
| | $V_{SL2}$ | | At $V_{OUT} < 1.5$ V | – | – | 0.2 | V | 2 |
| ON/$\overline{\text{OFF}}$ pin input current (With shutdown function) | $I_{SH}$ | $V_{ON/\overline{OFF}} = 10$ V | | – 0.1 | – | 0.1 | μA | 2 |
| | $I_{SL}$ | $V_{ON/\overline{OFF}} = 0$ V | | – 0.1 | – | 0.1 | μA | 2 |
| Efficiency | EFFI | – | S-8351x30 | – | 86 | – | % | 1 |
| | | | S-8351x50 | – | 88 | – | % | 1 |

External parts

Coil: CDRH6D28-101 (100 μH) of Sumida Corporation

Diode: MA2Z748 (Shottky type) of Matsushita Electric Industrial Co., Ltd.

Capacitor: F93 (16 V, 47 μF tantalum type) of Nichicon Corporation

$V_{IN} = V_{OUT(S)} \times 0.6$ applied, $I_{OUT} = V_{OUT(S)} / 250$ Ω

With shutdown function : ON/$\overline{\text{OFF}}$ pin is connected to $V_{OUT}$

For $V_{DD}$ / $V_{OUT}$ separate type : VDD pin is connected to VOUT pin

**Remark 1.** $V_{OUT(S)}$ specified above is the set output voltage value, and $V_{OUT}$ is the typical value of the actual output voltage.

**2.** $V_{DD}$ / $V_{OUT}$ separate type

A step-up operation is performed from $V_{DD} = 0.8$ V. However, 1.8 V$\leq V_{DD}$<10 V is recommended stabilizing the output voltage and oscillation frequency. ($V_{DD} \geq 1.8$ V must be applied for products with a set value of less than 1.9 V.)
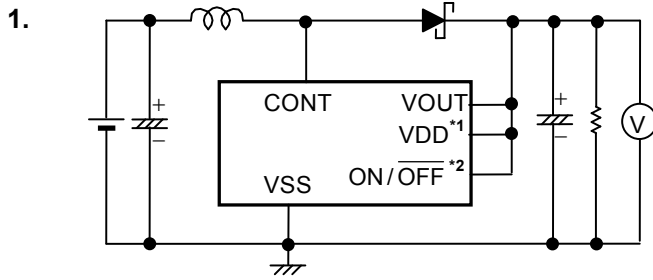
**(2) S-8352 Series**

**Table 16 (1 / 2)**

(Ta = 25°C unless otherwise specified)

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit | Measurement circuit |
|---|---|---|---|---|---|---|---|---|
| Output voltage | $V_{OUT}$ | – | | $V_{OUT(S)} \times 0.976$ | $V_{OUT(S)}$ | $V_{OUT(S)} \times 1.024$ | V | 3 |
| Input voltage | $V_{IN}$ | – | | – | – | 10 | V | 3 |
| Operation start voltage | $V_{ST1}$ | $I_{OUT}$ = 1 mA | | – | – | 0.9 | V | 3 |
| Oscillation start voltage | $V_{ST2}$ | No external parts, Voltage applied to $V_{OUT}$ | | – | – | 0.8 | V | 4 |
| Current consumption 1 | $I_{SS1}$ | $V_{OUT} = V_{OUT(S)} \times 0.95$ | S-8352x15 to 19 | – | 7.4 | 12.3 | μA | 4 |
| | | | S-8352x20 to 29 | – | 12.0 | 20.0 | μA | 4 |
| | | | S-8352x30 to 39 | – | 17.8 | 29.6 | μA | 4 |
| | | | S-8352x40 to 49 | – | 24.7 | 41.1 | μA | 4 |
| | | | S-8352x50 to 59 | – | 32.7 | 54.5 | μA | 4 |
| | | | S-8352x60 to 65 | – | 43.0 | 71.6 | μA | 4 |
| Current consumption 2 | $I_{SS2}$ | $V_{OUT} = V_{OUT(S)} + 0.5$ V | S-8352x15 to 19 | – | 2.3 | 3.5 | μA | 4 |
| | | | S-8352x20 to 29 | – | 2.5 | 3.8 | μA | 4 |
| | | | S-8352x30 to 39 | – | 2.7 | 4.1 | μA | 4 |
| | | | S-8352x40 to 49 | – | 2.9 | 4.4 | μA | 4 |
| | | | S-8352x50 to 59 | – | 3.1 | 4.7 | μA | 4 |
| | | | S-8352x60 to 65 | – | 3.3 | 5.1 | μA | 4 |
| Current consumption during shutdown (With shutdown function) | $I_{SSS}$ | $V_{ON/\overline{OFF}} = 0$ V | | – | – | 0.5 | μA | 4 |
| EXT pin output current | $I_{EXTH}$ | $V_{EXT} = V_{OUT} - 0.4$ V | S-8352x15 to 19 | – 3.5 | – 6.3 | – | mA | 4 |
| | | | S-8352x20 to 24 | – 5.2 | – 9.4 | – | mA | 4 |
| | | | S-8352x25 to 29 | – 6.8 | – 12.3 | – | mA | 4 |
| | | | S-8352x30 to 39 | – 8.2 | – 14.9 | – | mA | 4 |
| | | | S-8352x40 to 49 | – 10.7 | – 19.4 | – | mA | 4 |
| | | | S-8352x50 to 59 | – 12.5 | – 22.8 | – | mA | 4 |
| | | | S-8352x60 to 65 | – 13.9 | – 25.2 | – | mA | 4 |
| | $I_{EXTL}$ | $V_{EXT} = -0.4$ V | S-8352x15 to 19 | 3.8 | 6.9 | – | mA | 4 |
| | | | S-8352x20 to 24 | 5.6 | 10.2 | – | mA | 4 |
| | | | S-8352x25 to 29 | 7.3 | 13.3 | – | mA | 4 |
| | | | S-8352x30 to 39 | 8.9 | 16.2 | – | mA | 4 |
| | | | S-8352x40 to 49 | 11.6 | 21.1 | – | mA | 4 |
| | | | S-8352x50 to 59 | 13.7 | 25.0 | – | mA | 4 |
| | | | S-8352x60 to 65 | 15.3 | 27.8 | – | mA | 4 |
| Line regulation | $\Delta V_{OUT1}$ | $V_{IN} = V_{OUT(S)} \times 0.4$ to $\times 0.6$ | | – | 30 | 60 | mV | 3 |
| Load regulation | $\Delta V_{OUT2}$ | $I_{OUT}$ = 10 μA to $V_{OUT(S)} / 100 \times 1.25$ | | – | 30 | 60 | mV | 3 |
| Output voltage temperature coefficient | $\dfrac{\Delta V_{OUT}}{\Delta Ta \cdot V_{OUT}}$ | Ta = – 40°C to + 85°C | | – | ±50 | – | ppm / °C | 3 |
| Oscillation frequency | $f_{OSC}$ | $V_{OUT} = V_{OUT(S)} \times 0.95$, Measured waveform at EXT pin | | 90 | 100 | 110 | kHz | 4 |
| Duty ratio 1 | Duty1 | $V_{OUT} = V_{OUT(S)} \times 0.95$, Measured waveform at EXT | | 70 | 75 | 80 | % | 4 |
| Duty ratio 2 (For A, B, D type) | Duty2 | Measured waveform at EXT pin at light load | | – | 50 | – | % | 3 |

**Table 16 (2 / 2)**

(Ta = 25°C unless otherwise specified)

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit | Measurement circuit |
|------|--------|-----------|---|------|------|------|------|---------------------|
| ON/$\overline{\text{OFF}}$ pin input voltage (With shutdown function) | $V_{SH}$ | $V_{OUT} = V_{OUT(S)} \times 0.95$, Measured oscillation at EXT | | 0.75 | – | – | V | 4 |
| | $V_{SL1}$ | $V_{OUT} = V_{OUT(S)} \times 0.95$, Judged oscillation stop at EXT pin | At $V_{OUT} \geq 1.5$ V | – | – | 0.3 | V | 4 |
| | $V_{SL2}$ | | At $V_{OUT} < 1.5$ V | – | – | 0.2 | V | 4 |
| ON/$\overline{\text{OFF}}$ pin input current (With shutdown function) | $I_{SH}$ | $V_{ON/\overline{OFF}} = 10$ V | | –0.1 | – | 0.1 | μA | 4 |
| | $I_{SL}$ | $V_{ON/\overline{OFF}} = 0$ V | | –0.1 | – | 0.1 | μA | 4 |
| Efficiency | EFFI | – | S-8352x30 | – | 83 | – | % | 3 |
| | | | S-8352x50 | – | 85 | – | % | 3 |

External parts

Coil: CDRH6D28-101 (100 μH) from Sumida Corporation
Diode: MA2Z748 (Shottky type) from Matsushita Electric Industrial Co., Ltd.
Capacitor: F93 (16 V, 47 μF tantalum type) from Nichicon Corporation
Transistor: CPH3210 from Sanyo Electric Co., Ltd.
Base resistor (Rb): 1 kΩ
Base capacitor (Cb): 2200 pH (ceramic type)

$V_{IN} = V_{OUT(S)} \times 0.6$ applied, $I_{OUT} = V_{OUT(S)}$ / 100 Ω

With shutdown function : ON/$\overline{\text{OFF}}$ pin is connected to $V_{OUT}$

For $V_{DD}$ / $V_{OUT}$ separate type : VDD pin is connected to VOUT pin

**Remark 1.** $V_{OUT(S)}$ specified above is the set output voltage value, and $V_{OUT}$ is the typical value of the actual output voltage.

**2.** $V_{DD}$ / $V_{OUT}$ separate type
A step-up operation is performed from $V_{DD} = 0.8$ V. However, 1.8 V$\leq V_{DD}$<10 V is recommended stabilizing the output voltage and oscillation frequency. ($V_{DD} \geq 1.8$ V must be applied for products with a set value of less than 1.9 V.)

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## ■ Measurement Circuits

**1.**



**Figure 11**

**2.**



**Figure 12**

**3.**



**Figure 13**

**4.**
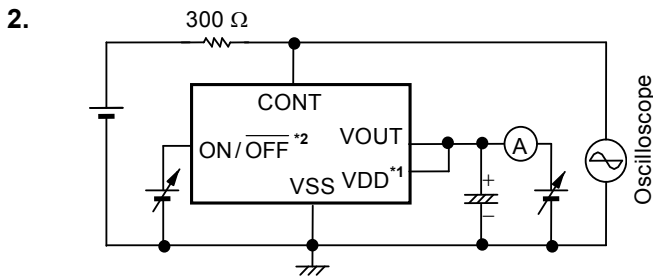


**Figure 14**

**\*1.** For $V_{DD}$ / $V_{OUT}$ separate type
**\*2.** With shutdown function

## ■ Operation

### 1. Step-up DC-DC Converter

The S-8351/8352 Series is a DC-DC converter that uses a pulse frequency modulation method (PFM) and features low current consumption.   This series is an especially efficient DC-DC converter at an output current of 100 $\mu$A or lower.

In conventional fixed-duty PFM DC-DC converters, although a low duty ratio allows a lower ripple voltage when the current load is light, the efficiency is decreased when the output load current is large.   Conversely, a high duty ratio increases the output load current and efficiency, but increases the ripple voltage when the output load current is low.

In the A, B, and D types, the duty ratio is automatically switched 75% when the output load current is high to secure the load drive capability and 50% when the output load current is low to control the load drive capability to decrease pulse skipping.   This suppresses a drop in the ripple frequency, enabling control of the increase in the ripple voltage. The C type adopts a 75% fixed-duty PFM method.   The ripple voltage increases more than that of the duty switching type with the load is low, but the efficiency is better.

In the A, B, and D types, the duty ratio is not rapidly changed, but rather smoothly switched in the intermediate area between 50% and 75%.   Therefore, fluctuation of the ripple voltage caused by duty switching is minimized. **Figures 15, 16** show the ripple voltage characteristics versus the output current.

**S-8351A30MC**
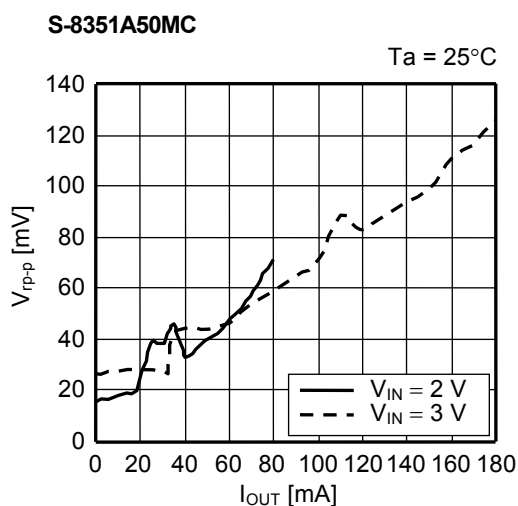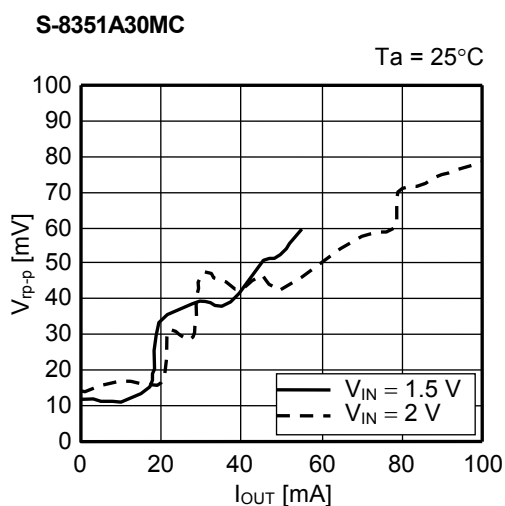


**Figure 15  Output Current ($I_{OUT}$) vs. Ripple Voltage ($V_{rp-p}$) Characteristics**

**S-8351A50MC**



**Figure 16  Output Current ($I_{OUT}$) vs. Ripple Voltage ($V_{rp-p}$) Characteristics**

These figures show that the ripple voltage decreases as the output load current ($I_{OUT}$) changes from large to small. The ripple voltage becomes particularly small when $I_{OUT}$ is in the coil current discontinuous region of 20 mA or less.

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### 2. ON/$\overline{\text{OFF}}$ Pin (Shutdown Pin) (A Type)

ON/$\overline{\text{OFF}}$ pin stops or starts step-up operation.

Setting the ON/$\overline{\text{OFF}}$ pin to the "L" level stops operation of all the internal circuits and reduces the current consumption significantly.

DO NOT use the ON/$\overline{\text{OFF}}$ pin in a floating state because it has the structure shown in **Figure 17** and is not pulled up or pulled down internally. DO NOT apply a voltage of between 0.3 V and 0.75 V to the ON/$\overline{\text{OFF}}$ pin because applying such a voltage increases the current consumption. If the shutdown pin is not used, connect it to the VOUT pin.

The ON/$\overline{\text{OFF}}$ pin does not have hysteresis.

**Table 17**

| ON/$\overline{\text{OFF}}$ pin | CR oscillation circuit | Output voltage |
|---|---|---|
| "H" | Operation | Fixed |
| "L" | Stop | $\cong V_{IN}$ [*1] |

**\*1.** Voltage obtained by subtracting the voltage drop due to the DC resistance of the inductor and the diode forward voltage from $V_{IN}$.
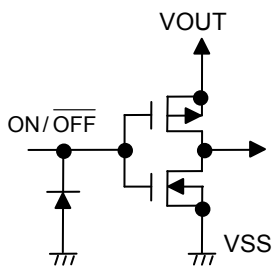


**Figure 17　ON/$\overline{\text{OFF}}$ Pin Structure**

### 3. Operation

The following are the basic equations [(1) through (7)] of the step-up switching regulator. (Refer to **Figure 18**.)
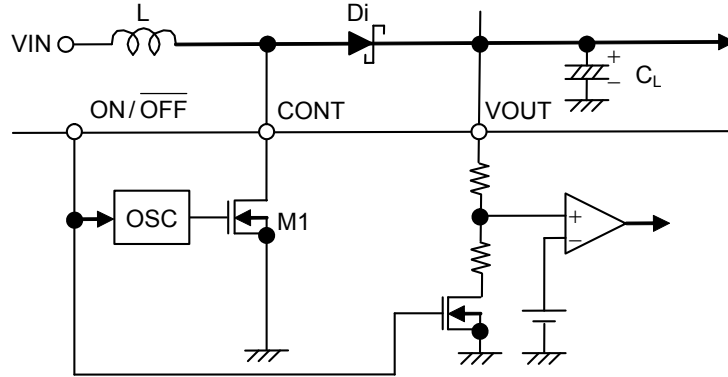


**Figure 18   Step-Up Switching Regulator Circuit for Basic Equation**

Voltage at CONT pin at the moment M1 is turned ON ($V_A$) [*1] :

$$V_A = V_S \, ^{*2}$$ (1)

    **\*1.** Current flowing through L ($I_L$) is zero.
    **\*2.** Non-saturated voltage of M1.

The change in $I_L$ over time :

$$\frac{dI_L}{dt} = \frac{V_L}{L} = \frac{V_{IN} - V_S}{L}$$ (2)

Integration of equation (2) ($I_L$) :

$$I_L = \left( \frac{V_{IN} - V_S}{L} \right) \bullet t$$ (3)

$I_L$ flows while M1 is ON ($t_{ON}$).   The time of $t_{ON}$ is determined by the oscillation frequency of OSC.

The peak current ($I_{PK}$) after $t_{ON}$ :

$$I_{PK} = \left( \frac{V_{IN} - V_S}{L} \right) \bullet t_{ON}$$ (4)

The energy stored in L is represented by $1/2 \bullet L \, (I_{PK})^2$.

When M1 is turned OFF ($t_{OFF}$), the energy stored in L is emitted through a diode to the output capacitor.

Then, the reverse voltage ($V_L$) is generated :
$$V_L = (V_{OUT} + V_D{}^{*1}) - V_{IN}$$ (5)
    **\*1.** Diode forward voltage

The voltage at CONT pin rises only by $V_{OUT} + V_D$.

The change in the current ($I_L$) flowing through the diode into $V_{OUT}$ during $t_{OFF}$ :

$$\frac{dI_L}{dt} = \frac{V_L}{L} = \frac{V_{OUT} + V_D - V_{IN}}{L}$$ (6)

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Integration of the equation (6) is as follows :

$$I_L = I_{PK} - \left( \frac{V_{OUT} + V_D - V_{IN}}{L} \right) \bullet t \quad \text{(7)}$$

During $t_{ON}$, the energy is stored in L and is not transmitted to $V_{OUT}$.  When receiving the output current ($I_{OUT}$) from $V_{OUT}$, the energy of the capacitor ($C_L$) is consumed.  As a result, the pin voltage of $C_L$ is reduced, and goes to the lowest level after M1 is turned ON ($t_{ON}$).  When M1 is turned OFF, the energy stored in L is transmitted through the diode to $C_L$, and the voltage of $C_L$ rises rapidly.  $V_{OUT}$ is a time function, and therefore indicates the maximum value (ripple voltage ($V_{P-P}$) ) when the current flowing through into $V_{OUT}$ and load current ($I_{OUT}$) match.

Next, the ripple voltage is determined as follows.

$I_{OUT}$ vs. $t_1$ (time) from when M1 is turned OFF (after $t_{ON}$) to when $V_{OUT}$ reaches the maximum level :

$$I_{OUT} = I_{PK} - \left( \frac{V_{OUT} + V_D - V_{IN}}{L} \right) \bullet t_1 \quad \text{(8)}$$

$$\therefore t_1 = (I_{PK} - I_{OUT}) \bullet \left( \frac{L}{V_{OUT} + V_D - V_{IN}} \right) \quad \text{(9)}$$

When M1 is turned OFF ($t_{OFF}$), $I_L = 0$ (when the energy of the inductor is completely transmitted).  Based on equation (7) :

$$\left( \frac{L}{V_{OUT} + V_D - V_{IN}} \right) = \frac{t_{OFF}}{I_{PK}} \quad \text{(10)}$$

When substituting equation (10) for equation (9) :

$$t_1 = t_{OFF} - \left( \frac{I_{OUT}}{I_{PK}} \right) \bullet t_{OFF} \quad \text{(11)}$$

Electric charge $\Delta Q_1$ which is charged in $C_L$ during $t_1$ :

$$\Delta Q_1 = \int_0^{t1} I_L dt = I_{PK} \bullet \int_0^{t1} dt - \frac{V_{OUT} + V_D - V_{IN}}{L} \bullet \int_0^{t1} t dt = I_{PK} \bullet t_1 - \frac{V_{OUT} + V_D - V_{IN}}{L} \bullet \frac{1}{2} t_1^2 \quad \text{(12)}$$

When substituting equation (12) for equation (9) :

$$\Delta Q1 = I_{PK} - \frac{1}{2}(I_{PK} - I_{OUT}) \bullet t_1 = \frac{I_{PK} + I_{OUT}}{2} \bullet t_1 \quad \text{(13)}$$

A rise in voltage ($V_{P-P}$) due to $\Delta Q_1$ :

$$V_{P-P} = \frac{\Delta Q_1}{C_L} = \frac{1}{C_L} \bullet \left( \frac{I_{PK} + I_{OUT}}{2} \right) \bullet t_1 \quad \text{(14)}$$

When taking into consideration $I_{OUT}$ to be consumed during $t_1$ and the Equivalent Series Resistance ($R_{ESR}$) of $C_L$ :

$$V_{P-P} = \frac{\Delta Q_1}{C_L} = \frac{1}{C_L} \bullet \left( \frac{I_{PK} + I_{OUT}}{2} \right) \bullet t1 + \left( \frac{I_{PK} + I_{OUT}}{2} \right) \bullet R_{ESR} - \frac{I_{OUT} \bullet t_1}{C_L} \quad \text{(15)}$$

When substituting equation (11) for equation (15) :

$$V_{P-P} = \frac{(I_{PK} - I_{OUT})^2}{2 I_{PK}} \bullet \frac{t_{OFF}}{C_L} + \left( \frac{I_{PK} + I_{OUT}}{2} \right) \bullet R_{ESR} \quad \text{(16)}$$

Therefore to reduce the ripple voltage, it is important that the capacitor connected to the output pin has a large capacity and a small $R_{ESR}$.

## ■ External Parts Selection

### 1. Inductor

To minimize the loss due to inductor direct current resistance, select an inductor with the smallest possible direct current resistance (less than 1 $\Omega$).   Set the inductance value (L value) to around 22 $\mu$H to 1 mH.

To make the average value of the output voltage ($V_{OUT}$) constant, it is necessary to supply the energy corresponding to the output current ($I_{OUT}$) from the inductor.   The amount of charge required for $I_{OUT}$ is $I_{OUT} \times (t_{ON} + t_{OFF})$.   Because the inductor can supply energy only during $t_{OFF}$, the charge is obtained by integrating equation (7) in the "**3.**

**Operation**" in the "**■ Operation**" with $0 \rightarrow t_{OFF}$, namely, $\dfrac{I_{PK}}{2} \bullet t_{OFF}$ .   Thus,

$$\frac{I_{PK}}{2} \bullet t_{OFF} = I_{OUT} \times (t_{ON} + t_{OFF}) \quad\text{.....................................................................} \quad (17)$$

$$\therefore I_{PK} = 2 \bullet \frac{t_{ON} + t_{OFF}}{t_{OFF}} \bullet I_{OUT} \quad\text{.............................................................} \quad (18)$$

When the oscillation duty ratio of OSC is 75%, $I_{PK} = 8 \bullet I_{OUT}$.   Therefore, an $I_{PK}$ current which is eight times $I_{OUT}$ flows into transistor (M1).

The S-8351 Series includes a switching current controller which monitors the current flowing into the CONT pin by the voltage (CONT control voltage) and controls the current.   This controller prevents destruction of the IC due to excess current.

If an inductor with a large L value is selected, both $I_{PK}$ and $I_{OUT}$ decrease.   Since the energy stored in the inductor is equal to $\dfrac{1}{2} L \bullet (I_{PK})^2$, the energy decreases because $I_{PK}$ decreases in steps of squares offsetting the increase of L value.   As a result, stepping up at a low voltage becomes difficult and the minimum operating input voltage becomes high.   However, the direct current resistance loss of L value and the M1 transistor decreases by the amount $I_{PK}$ decreased, and the inductance efficiency improves.

On the other hand, if an inductor with a smaller L value is selected, both $I_{PK}$ and $I_{OUT}$ increase.   Accordingly, the minimum operating input voltage becomes low but the inductance efficiency deteriorates.

**Caution   An excessively large $I_{PK}$ may cause magnetic saturation for some core materials, leading to the destruction of the IC.   Use a core with material that satisfies $I_{sat}$ [*1] $> I_{PK}$**

**\*1.** Level of current that causes magnetic saturation.

### 2. Diode

Use an external diode that meets the following requirements :
- Low forward voltage :   $V_F < 0.3$ V
- High switching speed : 500 ns max.
- Reverse voltage :        $V_{OUT} + V_F$ or more
- Current rate :             $I_{PK}$ or more

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### 3.    Capacitor ($C_{IN}$, $C_L$)

A capacitor on the input side ($C_{IN}$) improves the efficiency by reducing the power impedance and stabilizing the input current. Select a $C_{IN}$ value according to the impedance of the power supply used.

A capacitor on the output side ($C_L$) is used for smoothing the output voltage. For step-up types, the output voltage flows intermittently to the load current, so step-up types need a larger capacitance than step-down types. Therefore, select an appropriate capacitor in accordance with the ripple voltage, which increases in case of a higher output voltage or a higher load current. The capacitor value should be 10 $\mu$F or more.

A capacitor at the output side ($C_L$) is used for smoothing the ripple voltage.    Select an appropriate capacitor with a small equivalent series resistance ($R_{ESR}$) and a large capacitance.    The capacitor value should be 10 $\mu$F or mpre.    A tantalum electrolytic capacitor and an organic semiconductor capacitor are especially recommended because of their superior low-temperature and leakage current characteristics.

### 4.    External Transistor (S-8352 Series)

For the S-8352 Series, connecting an external transistor increases the output current.    An enhancement (N-channel) MOS FET type or a bipolar (NPN) type can be used as the external transistor.

#### 4. 1    Enhancement (N-channel) MOS FET Type

**Figure 19** is a circuit example using a MOS FET transistor (N-channel).
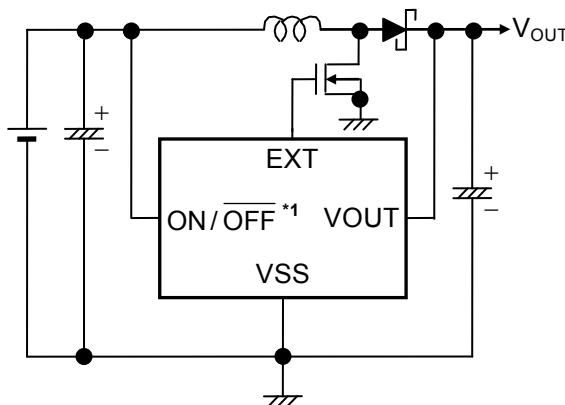


**\*1.** For A type.

**Figure 19    Circuit Example Using MOS FET (N-channel) Type**

An N-channel power MOS FET should be used for the MOS FET.    In particular, the EXT pin can drive a MOS FET with a gate capacitance of around 1000 pF.    Because the gate voltage and current of the external power MOS FET are supplied from the stepped-up output voltage ($V_{OUT}$), the MOS FET is driven more effectively.

A large current may flow during startup, depending on the MOS FET selection.    The S-8352 Series does not feature overcurrent protection for the external MOS FET, so perform sufficient evaluation using the actual devices. Also recommend to use a MOS FET with an input capacitance of 700 pF or less.

Since the ON-resistance of the MOS FET might depend on the difference between the output voltage ($V_{OUT}$) and the threshold voltage of the MOS FET, and affect the output current as well as the efficiency, the threshold voltage should be low.    When the output voltage is as low as 2.0 V,   like in the S-8352A20, the circuit operates only when the MOS FET has a threshold voltage lower than the output voltage.

### 4. 2  Bipolar (NPN) Type

A circuit example using the CPH3210 ($h_{FE}$ = 200 to 560) from Sanyo Electric Co., Ltd. as a bipolar transistor (NPN) is shown in **Figure 24 to 26** in the "■ **Standard Circuits**".  The $h_{FE}$ value and $R_b$ value of the bipolar transistor determine the driving capacity to increase the output current using a bipolar transistor.  A peripheral circuit example of the transistor is shown in **Figure 20**.
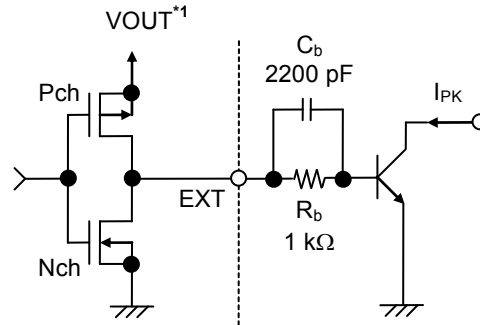


**\*1.** $V_{DD}$ for D type.

**Figure 20   External Transistor Peripheral Circuit**

The recommended $R_b$ value is around 1 k$\Omega$.  Actually, calculate the necessary base current ($I_b$) from the bipolar transistor ($h_{FE}$) using  $I_b = \dfrac{I_{PK}}{h_{FE}}$ , and select the smaller $R_b$ value than  $R_b = \dfrac{V_{OUT} - 0.7}{I_b} - \dfrac{0.4}{\left| I_{EXTH} \right|}$ **\*1**.

A small $R_b$ value can increase the output current, but the efficiency decreases.  Since a current may flow on the pulse and the voltage may drop due to wiring resistance or other factors in the actual circuit, therefore the optimum $R_b$ value should be determined by experiment.

Connecting the speed-up capacitor ($C_b$) in parallel with the $R_b$ resistance as shown in **Figure 20**, decreases switching loss and improves the efficiency.

The $C_b$ value is calculated according to  $C_b \leq \dfrac{1}{2\pi \bullet R_b \bullet f_{osc} \bullet 0.7}$ .

Select a $C_b$ value after performing sufficient evaluation since the optimum $C_b$ value differs depending upon the characteristics of the bipolar transistor.

**\*1.** For D type,  $R_b = \dfrac{V_{DD} - 0.7}{I_b} - \dfrac{0.4}{\left| I_{EXTH} \right|}$ .

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### 5. $V_{DD}$ / $V_{OUT}$ Separate Type (For S-8351/8352 Series D Type)

The D type provides separate internal circuit power supply (VDD pin) and output voltage setting pin (VOUT pin) in the IC, making it ideal for the following applications.
  (1) Changing the output voltage value using an external resistor
  (2) Setting a high output voltage value, such as +15 V

**Cautions 1. This IC starts a step-up operation at $V_{DD}$ = 0.8 V, but set $1.8 \leq V_{DD} \leq 10$ V to stabilize the output voltage and frequency of the oscillator.   (Input a voltage of 1.8 V or more at the VDD pin for all products with a setting less than 1.9 V.)   An input voltage of 1.8 V or more at the VDD pin allows connection of the VDD pin to either the input voltage VIN pin or output VOUT pin.**

**2. Choose external resistors $R_A$ and $R_B$ so as to not affect the output voltage, considering that there is impedance between the VOUT pin and VSS pin in the IC chip.   The internal resistance between the VOUT pin and VSS pin is as follows :**
  **(1) S-835xx18 : 2.1 M$\Omega$ to 14.8 M$\Omega$**
  **(2) S-835xx20 : 1.4 M$\Omega$ to 14.8 M$\Omega$**
  **(3) S-835xx30 : 1.4 M$\Omega$ to 14.2 M$\Omega$**
  **(4) S-835xx50 : 1.4 M$\Omega$ to 12.1 M$\Omega$**

**3. Attach a capacitor ($C_C$) in parallel to the $R_A$ resistance when an unstable event such as oscillation of the output voltage occurs.   Calculate $C_C$ using the following equation :**

$$C_C\left[F\right] = \frac{1}{2 \cdot \pi \cdot R_A \cdot 20\text{ kHz}}$$

# ■ Standard Circuits

## 1. S-8351 Series

### (1) A type
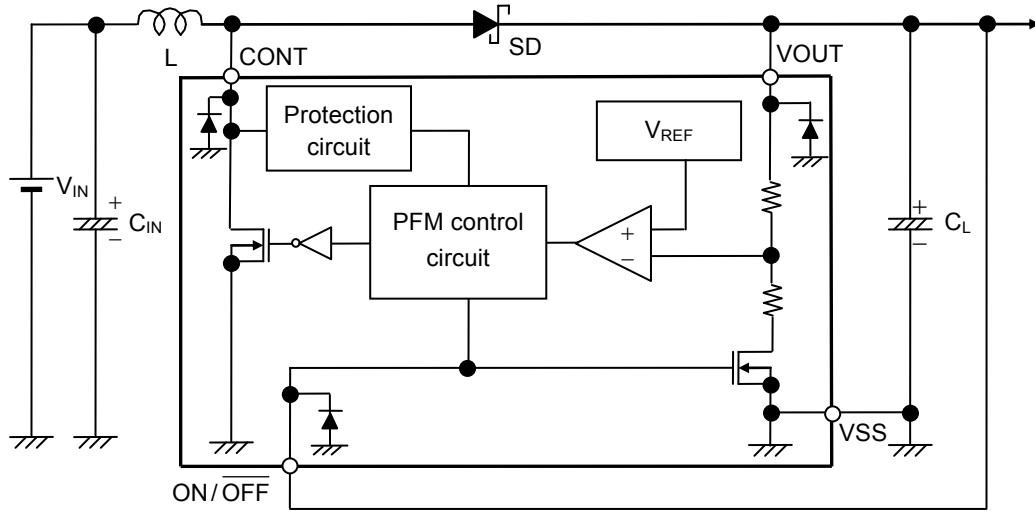


**Figure 21**

### (2) B and C types
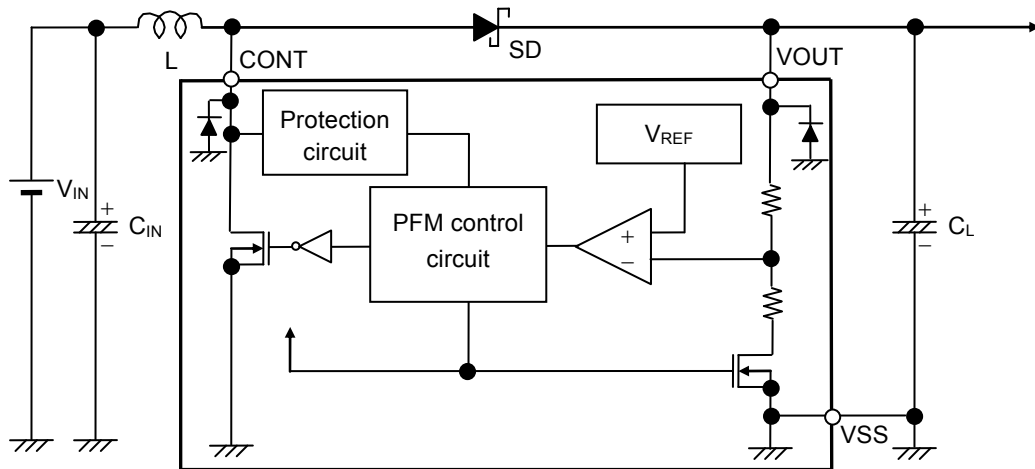


**Figure 22**

**(3)   D type**
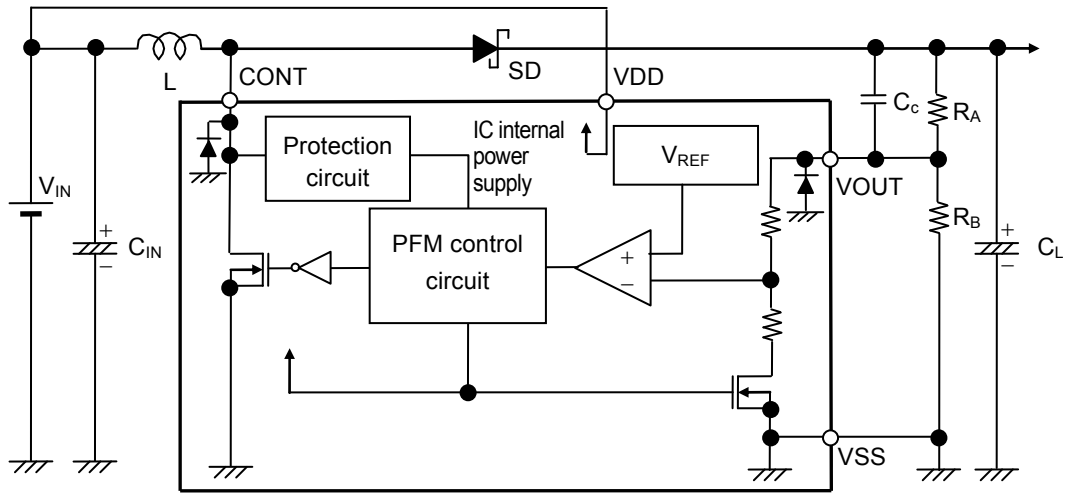


**Figure 23**

**Caution   The above connection diagram will not guarantee successful operation.   Perform through evaluation using the actual application to set the constant.**

## 2. S-8352 Series

### (1) A type
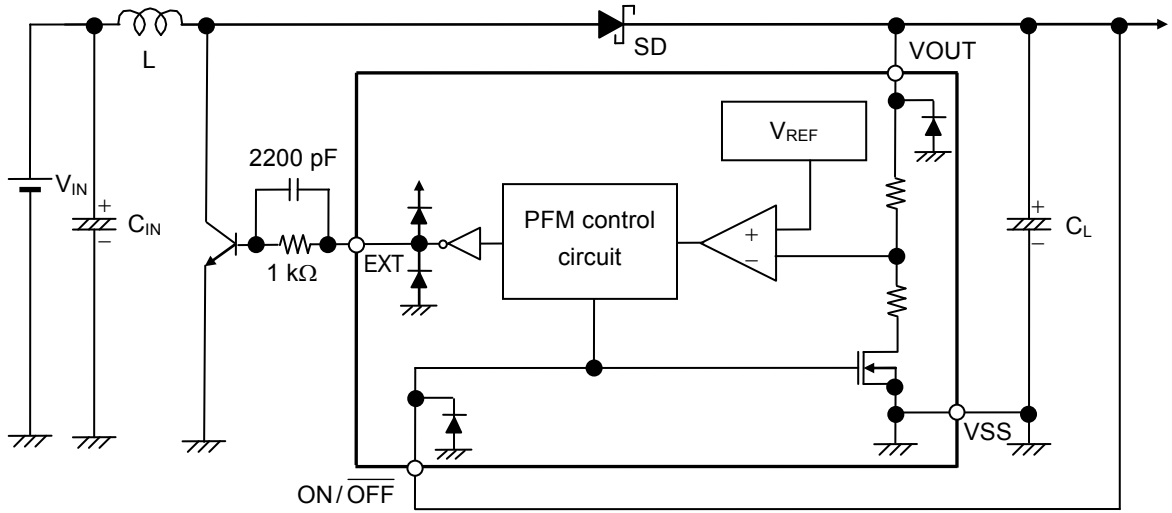


**Figure 24**

### (2) B and C types
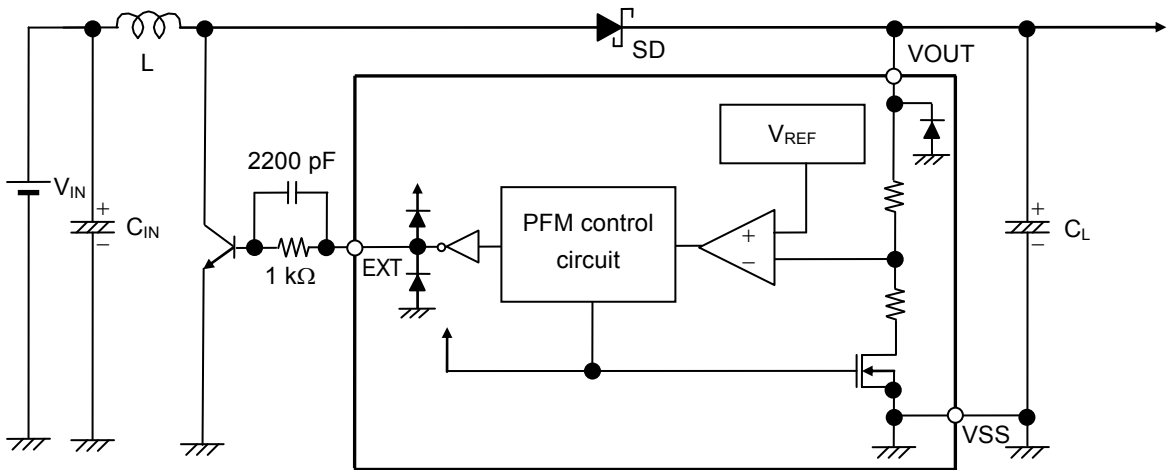


**Figure 25**

**(3) D type**
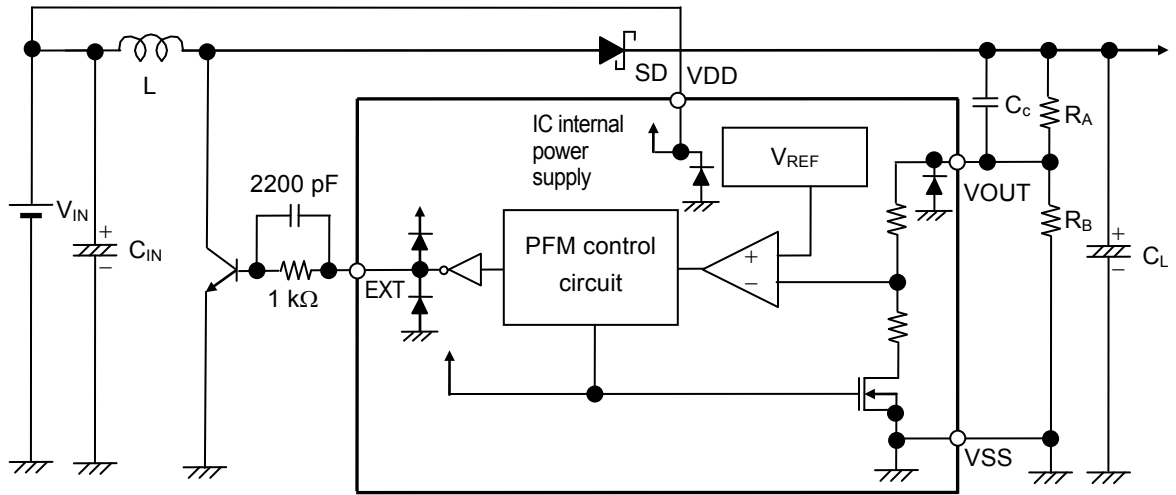


**Figure 26**

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

## ■ Precautions

- Mount the external capacitors, the diode, and the coil as close as possible to the IC.

- Characteristics ripple voltage and spike noise occur in IC containing switching regulators.  Moreover, rush current flows at the time of a power supply injection.  Because they largely depend on the coil and the capacitor and impedance used, fully check them using an actually mounted model.

- Make sure that the dissipation of the switching transistor (especially at a high temperature) does not exceed the allowable power dissipation of the package.

- The performance of this IC varies depending on the design of the PCB patterns, peripheral circuits and external parts. Thoroughly test all settings with your device. Also, try to use the recommended external parts. If not, contact an ABLIC Inc. sales person.

- When the impedance of the power supply is high, the shutdown pin is switched from "L" to "H", or $V_{IN}$ is connected to the power supply, note that the power supply voltage drops temporarily because a rush current flows into the power supply.

- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection IC.

- ABLIC Inc. claims no responsibility for any and all disputes arising out of or in connection with any infringement of the products including this IC upon patents owned by third party.

**ABLIC Inc.**

# ■ Characteristics (Typical Data)

### 1.  Input voltage ($V_{IN}$) vs. Powe Supply Input Current at No Load ($I_{IN}$)
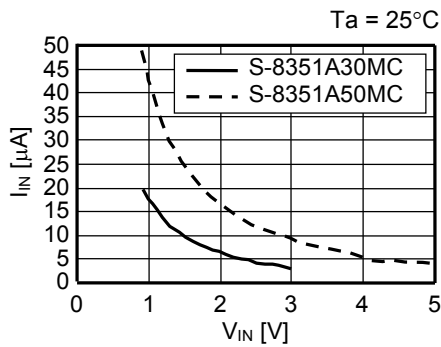
Ta = 25°C

Legend:
— S-8351A30MC
- - - S-8351A50MC

($I_{IN}$ [μA] vs $V_{IN}$ [V])

### 2.  Output Voltage ($V_{OUT}$) vs. Current Consumption 1 ($I_{SS1}$)

S-8351A

Ta = 25 °C

($I_{SS1}$ [μA] vs $V_{OUT}$ [V])

S-8352A

Ta = 25 °C

($I_{SS1}$ [μA] vs $V_{OUT}$ [V])

### 3.  Temperature (Ta) vs. Current Consumption 1 ($I_{SS1}$)

Legend:
— S-8351A30MC
- - - S-8351A50MC

($I_{SS1}$ [μA] vs Ta [°C])

Legend:
— S-8352A30MC
- - - S-8352A50MC

($I_{SS1}$ [μA] vs Ta [°C])
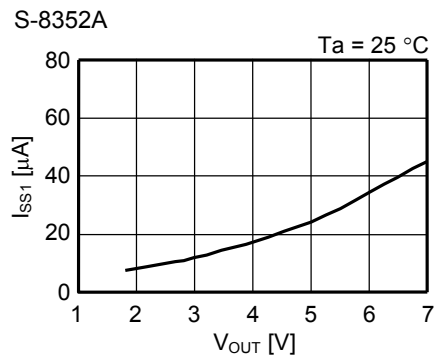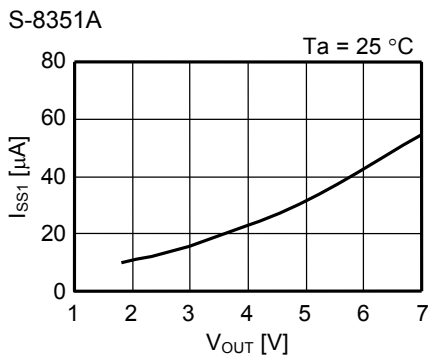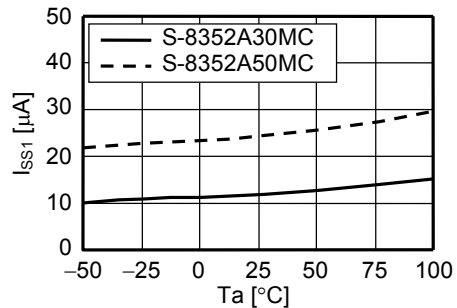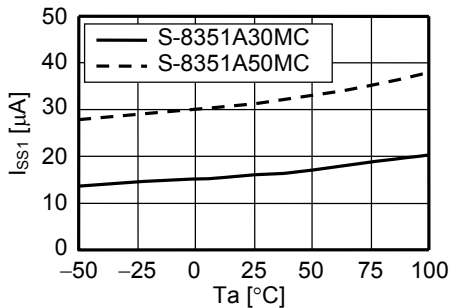
### 4.  Output Voltage ($V_{OUT}$) vs. Current Consumption 2 ($I_{SS2}$)     5.  Temperature (Ta) vs. Current Consumption 2 ($I_{SS2}$)

Ta = 25°C

($I_{SS2}$ [μA] vs $V_{OUT}$ [V])

Legend:
— S-8351A30MC
- - - S-8351A50MC

($I_{SS1}$ [μA] vs Ta [°C])
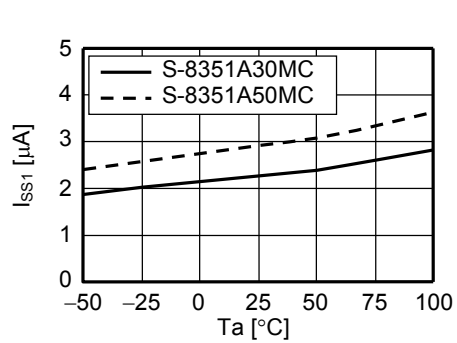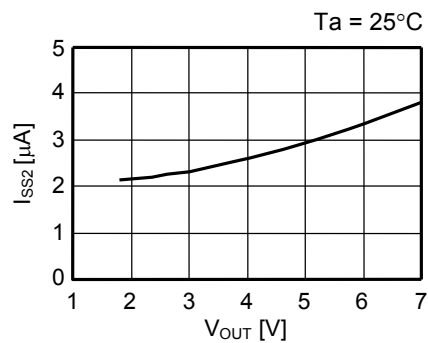
### 6. Temperature (Ta) vs. Oscillation Frequency (f$_{OSC}$)
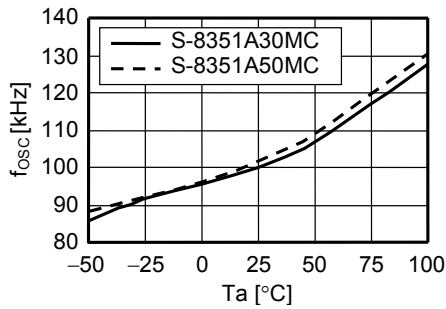


### 7. Temperature (Ta) vs. Duty Ratio 1 (Duty1)
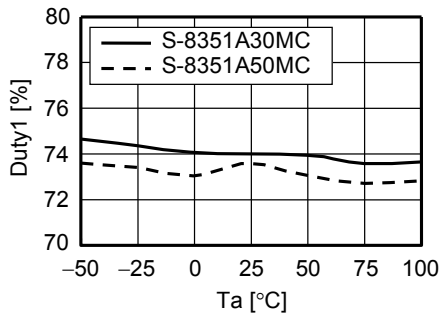


### 8. Temperature (Ta) vs. Duty Ratio 2 (Duty2)
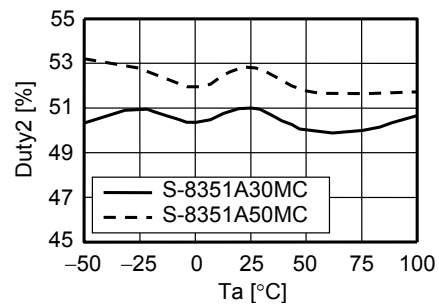


### 9. Output Voltage (V$_{OUT}$) vs. Switching Current (I$_{SW}$)

Ta = 25°C
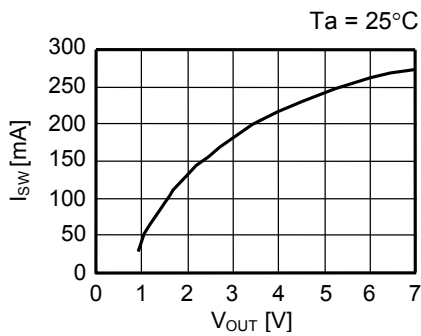


### 10. Temperature (Ta) vs. Switching Current (I$_{SW}$)
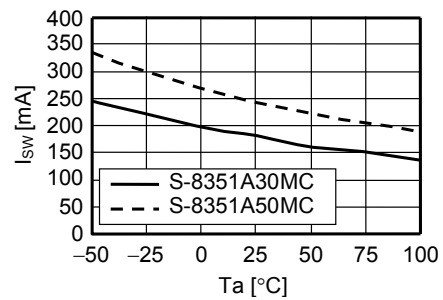


### 11. Output Voltage (V$_{OUT}$) vs. EXT Pin Output Current "H" (I$_{EXTH}$)

Ta = 25°C
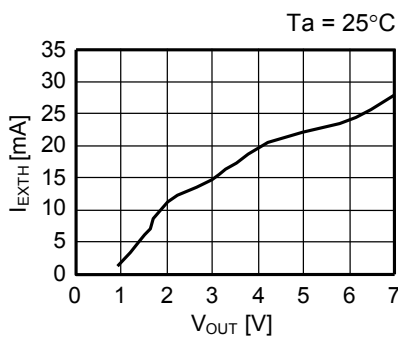


### 12. Temperature (Ta) vs. EXT Pin Output Current "H" (I$_{EXTH}$)

**ABLIC Inc.**
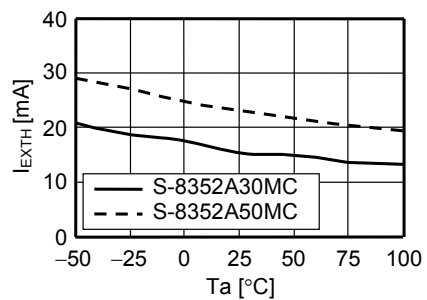
**13. Output Voltage ($V_{OUT}$) vs. EXT Pin Output Current "L" ($I_{EXTL}$)**　**14. Temperature (Ta) vs. EXT Pin Output Current "L" ($I_{EXTL}$)**

Ta = 25°C
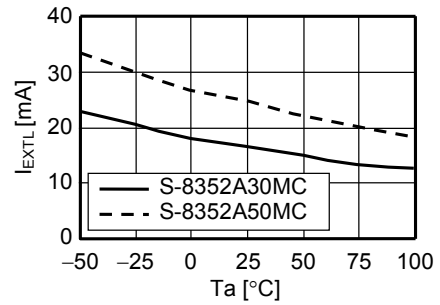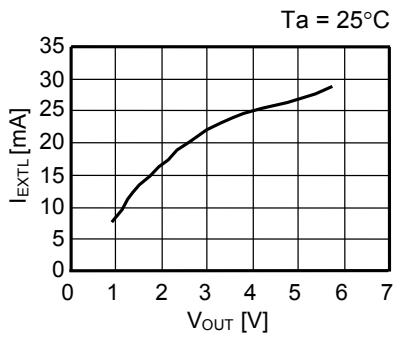
**15. Temperature (Ta) vs. Operation Start Voltage ($V_{ST1}$)**　**16. Temperature (Ta) vs. Retention Voltage ($V_{HLD}$)**
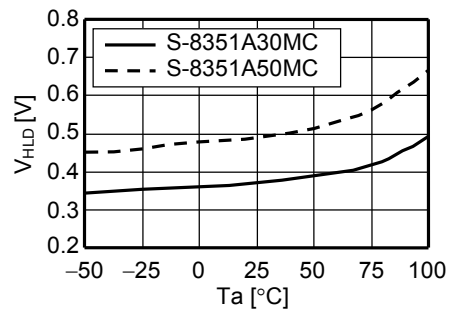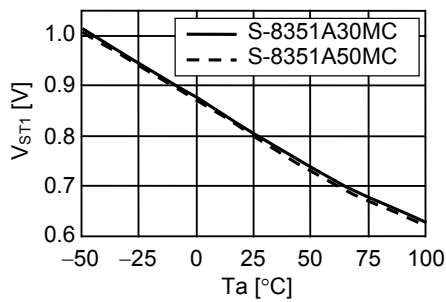
### 17. Transient Response Characteristics

The conditions for external parts are the same as those specified in the electrical characteristics.

**(1) Power-on (Ta = 25°C, $R_L$ = 250 Ω)**

S-8351A30MC

$V_{IN} = 0 \rightarrow 1.8$ V

Input voltage [0.5 V / div]

Output voltage [0.5 V / div]

t [0.2 ms / div]

S-8351A50MC

$V_{IN} = 0 \rightarrow 3$ V

Input voltage [1 V / div]

Output voltage [1 V / div]

t [0.2 ms / div]

S-8352A30MC

$V_{IN} = 0 \rightarrow 1.8$ V

Input voltage [0.5 V / div]

Output voltage [0.5 V / div]

t [0.2 ms / div]

S-8352A50MC

$V_{IN} = 0 \rightarrow 3$ V

Input voltage [1 V / div]

Output voltage [1 V / div]

t [0.2 ms / div]
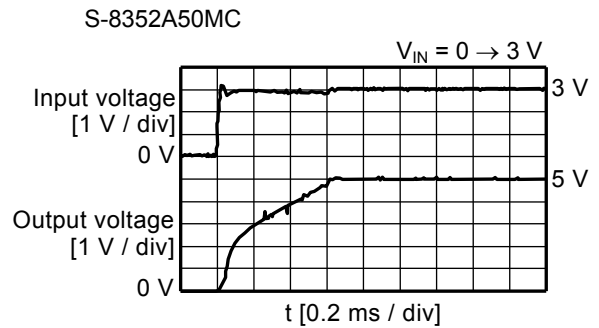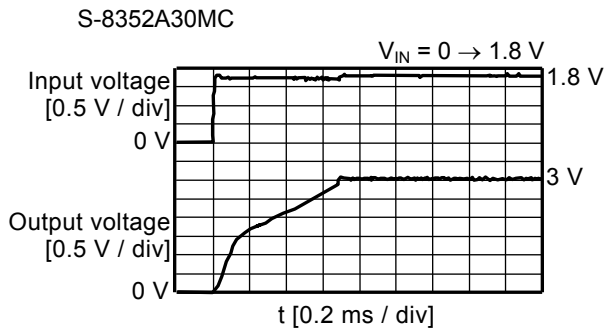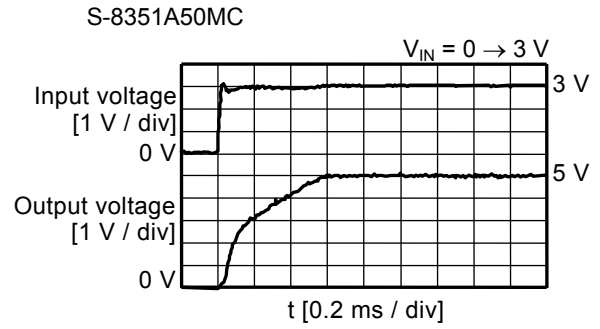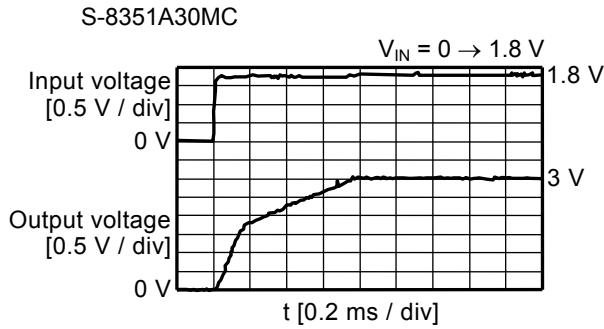
**(2) Power Supply Voltage Fluctuation (Ta = 25°C, $R_L$ = 250 Ω)**

S-8351A30MC

$V_{IN} = 1.2 \rightarrow 1.8$ V

Input voltage [0.5 V /div]

Output voltage [0.1 V / div]

t [0.1 ms / div]

S-8351A30MC

$V_{IN} = 1.8 \rightarrow 1.2$ V

Input voltage [0.5 V / div]

Output voltage [0.1 V / div]

t [0.1 ms / div]

S-8351A50MC

$V_{IN} = 2 \rightarrow 3$ V

Input voltage [0.5 V / div]

Output voltage [0.1 V / div]

t [0.1 ms / div]

S-8351A50MC

$V_{IN} = 3 \rightarrow 2$ V

Input voltage [0.5 V / div]

Output voltage [0.1 V / div]

t [0.1 ms / div]

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S-8352A30MC

$V_{IN} = 1.2 \rightarrow 1.8$ V

Input voltage
[0.5 V /div]
1.2 V

1.8 V

Output voltage
[0.1 V / div]

3 V

t [0.1 ms / div]

S-8352A30MC

$V_{IN} = 1.8 \rightarrow 1.2$ V

1.8 V

Input voltage
[0.5 V / div]

1.2 V

Output voltage
[0.1 V / div]

3 V

t [0.1 ms / div]

S-8352A50MC

$V_{IN} = 2 \rightarrow 3$ V

Input voltage
[0.5 V /div]
2 V

3 V

Output voltage
[0.1 V / div]

5 V

t [0.1 ms / div]

S-8352A50MC

$V_{IN} = 3 \rightarrow 2$ V

3 V

Input voltage
[0.5 V / div]

2 V

Output voltage
[0.1 V / div]

5 V

t [0.1 ms / div]

**(3) Load Current Fluctuation (Ta = 25°C)**

S-8351A30MC

$V_{IN} = 1.8$ V, $I_{OUT} = 10\ \mu A \rightarrow 12$ mA

Output current

$I_{OUT} = 12$ mA

Output voltage
[0.1 V / div]

3 V

t [0.1 ms / div]

S-8351A30MC

$V_{IN} = 1.8$ V, $I_{OUT} = 12$ mA $\rightarrow 10\ \mu A$

Output current

$I_{OUT} = 10\ \mu A$

Output voltage
[0.1 V / div]

3 V

t [0.1 ms / div]

S-8351A50MC

$V_{IN} = 3$ V, $I_{OUT} = 10\ \mu A \rightarrow 20$ mA

Output current

$I_{OUT} = 20$ mA

Output voltage
[0.1 V / div]

5 V

t [0.1 ms / div]

S-8351A50MC

$V_{IN} = 3$ V, $I_{OUT} = 20$ mA $\rightarrow 10\ \mu A$

Output current

$I_{OUT} = 10\ \mu A$

Output voltage
[0.1 V / div]

5 V

t [0.1 ms / div]

S-8352A30MC
$V_{IN}$ = 1.8 V, $I_{OUT}$ = 10 μA → 12 mA

Output current

$I_{OUT}$ = 12 mA

Output voltage [0.1 V / div]
3 V

t [0.1 ms / div]

S-8352A30MC
$V_{IN}$ = 1.8 V, $I_{OUT}$ = 12 mA → 10 μA

Output current

$I_{OUT}$ = 10 μA

Output voltage [0.1 V / div]
3 V

t [0.1 ms / div]

S-8352A50MC
$V_{IN}$ = 3 V, $I_{OUT}$ = 10 μA → 20 mA

Output current

$I_{OUT}$ = 20 mA

Output voltage [0.1 V / div]
5 V

t [0.1 ms / div]

S-8352A50MC
$V_{IN}$ = 3 V, $I_{OUT}$ = 20 mA → 10 μA

Output current

$I_{OUT}$ = 10 μA

Output voltage [0.1 V / div]
5 V

t [0.1 ms / div]

**(4)  ON/$\overline{\text{OFF}}$  Pin Response (Ta = 25°C, $R_L$ = 250 Ω)**

S-8351A30MC
$V_{IN}$ = 1.8 V

ON/$\overline{\text{OFF}}$  voltage

ON

OFF

Output voltage [0.3 V / div]
3 V

t [0.1 ms / div]

S-8351A50MC
$V_{IN}$ = 3 V

ON/$\overline{\text{OFF}}$  voltage

ON

OFF

Output voltage [0.5 V / div]
5 V

t [0.1 ms / div]

S-8352A30MC
$V_{IN}$ = 1.8 V

ON/$\overline{\text{OFF}}$  voltage

ON

OFF

Output voltage [0.3 V / div]
3 V

t [0.1 ms / div]

S-8352A50MC
$V_{IN}$ = 3 V

ON/$\overline{\text{OFF}}$  voltage

ON

OFF

Output voltage [0.5 V / div]
5 V

t [0.1 ms / div]
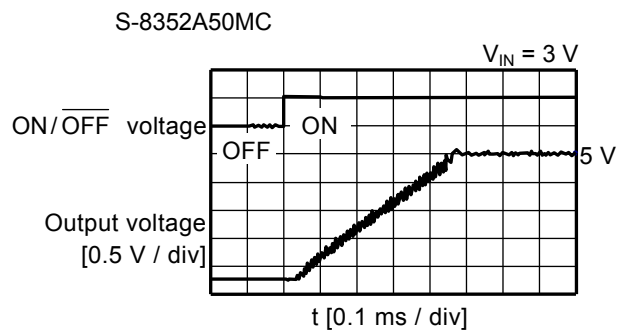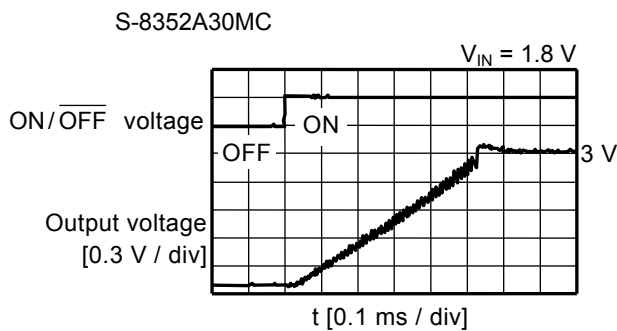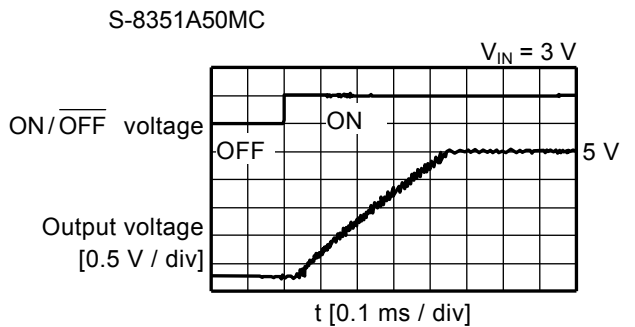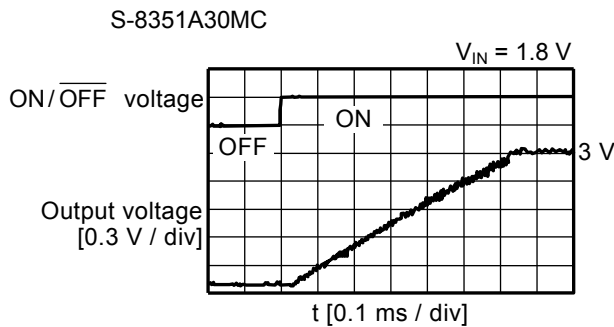
# ■ Reference Data

Use this reference data to choose the external parts.   This reference data makes it possible to choose the recommended external part based on the application and characteristics data.

### 1.   External Parts for Reference Data

**Table 18**

| Condition | Product Name | Output Voltage V | Power MOS FET | Coil |
|---|---|---|---|---|
| 1 | S-8351A30MC | 3.0 | Built-in | CDRH6D28-470 |
| 2 | S-8351A30MC | 3.0 | Built-in | CDRH6D28-101 |
| 3 | S-8351A30MC | 3.0 | Built-in | CXLP120-101 |
| 4 | S-8351A50MC | 5.0 | Built-in | CDRH6D28-101 |
| 5 | S-8351A50MC | 5.0 | Built-in | CDRH125-221 |
| 6 | S-8351A50MC | 5.0 | Built-in | CXLP120-470 |
| 7 | S-8352A30MC | 3.0 | External | CDRH6D28-220 |
| 8 | S-8352A30MC | 3.0 | External | CDRH6D28-101 |
| 9 | S-8352A30MC | 3.0 | External | CXLP120-470 |
| 10 | S-8352A50MC | 5.0 | External | CDRH6D28-220 |
| 11 | S-8352A50MC | 5.0 | External | CDRH6D28-101 |
| 12 | S-8352A50MC | 5.0 | External | CXLP120-101 |

The properties of the external parts are shown below.

**Table 19    Evaluation coil**

| Part | Product Name | Manufacturer | Characteristics |
|---|---|---|---|
| Coil | CDRH6D28-220 | Sumida Corporation | 22 $\mu$H, DCR$^{*1}$ = 0.128 $\Omega$, $I_{MAX}$$^{*2}$ = 1200 mA |
| | CDRH6D28-470 | Sumida Corporation | 47 $\mu$H, DCR$^{*1}$ = 0.238 $\Omega$, $I_{MAX}$$^{*2}$ = 800 mA |
| | CDRH6D28-101 | Sumida Corporation | 100 $\mu$H, DCR$^{*1}$ = 0.535 $\Omega$, $I_{MAX}$$^{*2}$ = 540 mA |
| | CDRH125-221 | Sumida Corporation | 220 $\mu$H, DCR$^{*1}$ = 0.4 $\Omega$, $I_{MAX}$$^{*2}$ = 800 mA |
| | CXLP120-470 | Sumitomo Special Metals Co., Ltd | 47 $\mu$H, DCR$^{*1}$ = 0.95 $\Omega$, $I_{MAX}$$^{*2}$ = 450 mA |
| | CXLP120-101 | Sumitomo Special Metals Co., Ltd | 100 $\mu$H, DCR$^{*1}$ = 2.5 $\Omega$, $I_{MAX}$$^{*2}$ = 200 mA |

**\*1.** Direct current resistance
**\*2.** Maximum allowable current

**Table 20    Properties of External Parts**

| Part | Product Name | Manufacturer | Characteristics |
|---|---|---|---|
| Diode | MA2Z748 | Matsushita Electronic Components Co., Ltd. | $V_F$$^{*1}$ = 0.4V, $I_F$$^{*2}$ = 0.3A (Shottky type) |
| Capacitor (Output capacitance) | F93 | Nichicon Corporation | 16V, 47$\mu$F (Tantalum type) |
| Transistor (NPN) | CPH3210 | Sanyo Electric Co.,Ltd. | $V_{CBO}$$^{*3}$ = 40V, $V_{CEO}$$^{*4}$ = 30V hFE$^{*5}$ = 200 min. ($V_{CE}$ = 2V, $I_C$ = 500mA) fT$^{*6}$ = 290 MHz typ. ($V_{CE}$ = 10V, $I_C$ = 500mA) |

**\*1.**  Forward voltage, **\*2.**   Forward current, **\*3.**   Collector-to-base voltage, **\*4.**   Collector-to-emitter voltage, **\*5.**   DC current gain, **\*6.**   Gain-bandwidth product

**Caution  The above values shown in the characteristics column of Table 19 and 20 are based on the materials provided by each manufacture.  However, consider the characteristics of the original materials when using the above products.**

## 2. Step-up Characteristics (Ta = 25°C)

The data of the step-up characteristics ((a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$) characteristics (Input voltage stepped up), (b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$) characteristics (Input voltage stepped down), (c) Output current ($I_{OUT}$) vs. Output voltage ($V_{OUT}$) characteristics, (d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$) characteristics under conditions of 1 to 12 in **Table 18** is shown below.

### Condition 1   S-8351A30MC

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage raising)
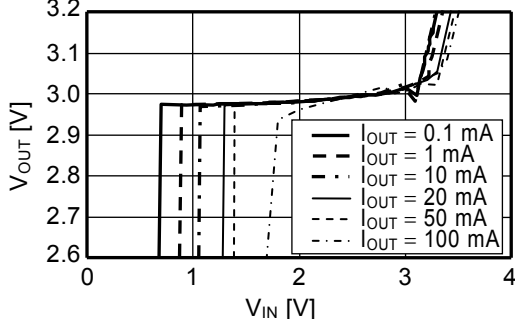
(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage falling)
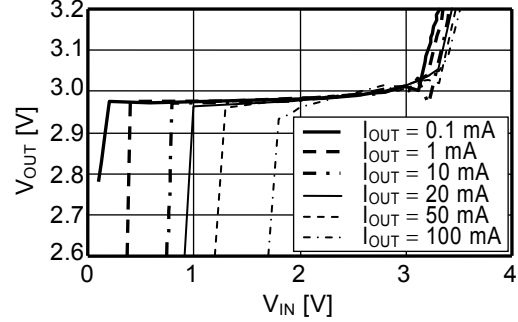
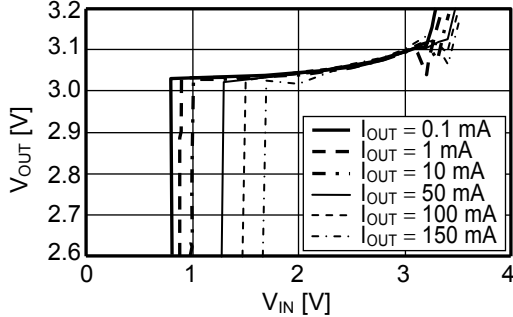(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)
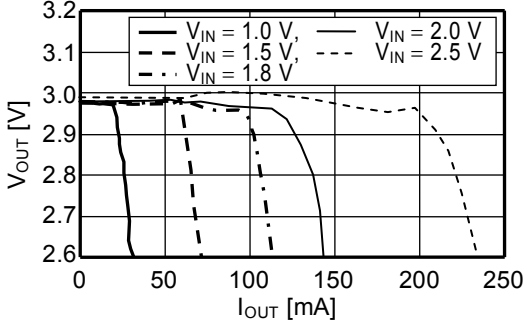
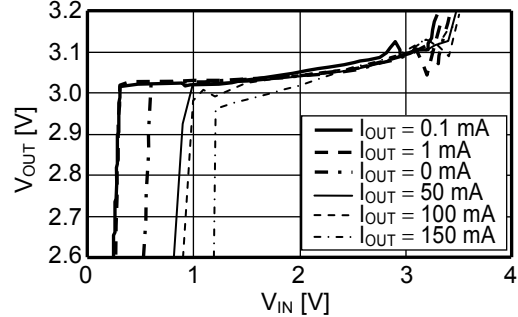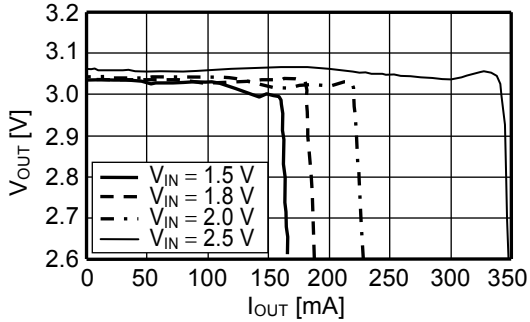(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)
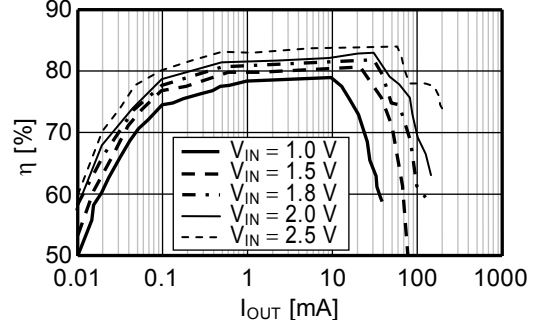
### Condition 2   S-8351A30MC

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
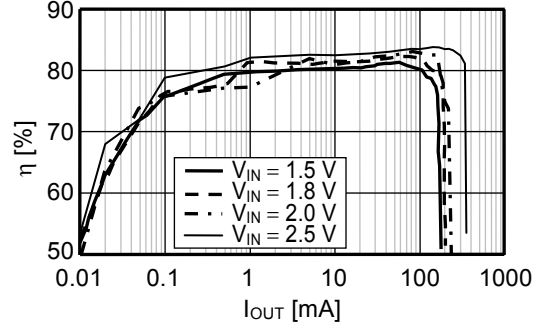(Input voltage raising)
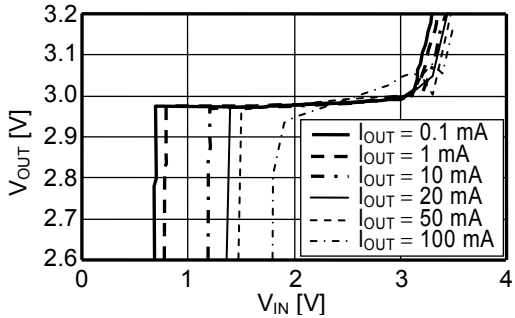
(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage falling)

(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)

(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)

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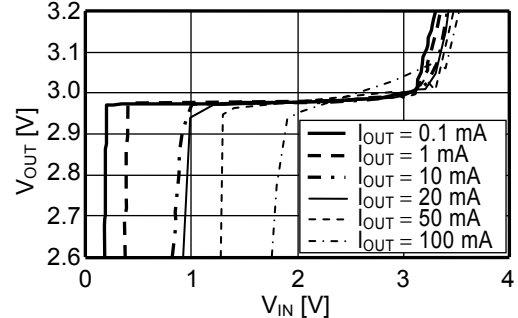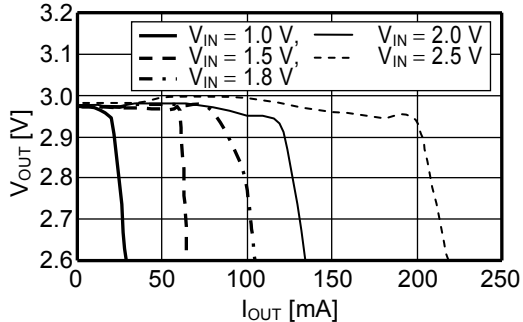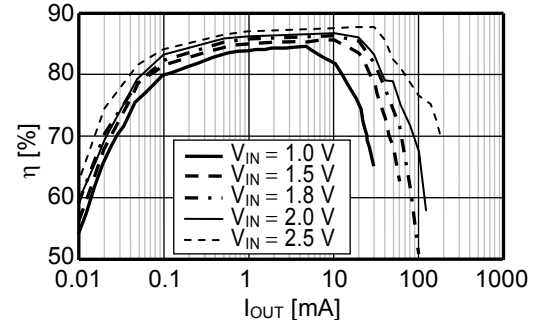
**Condition 3   S-8351A30MC**

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage raising)
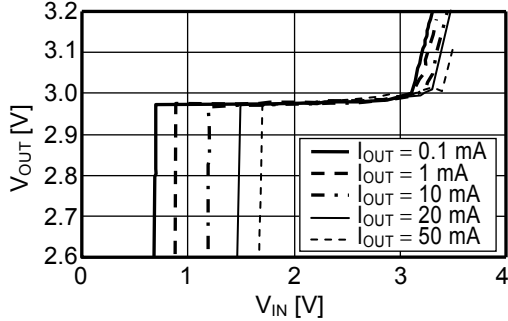
(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage falling)
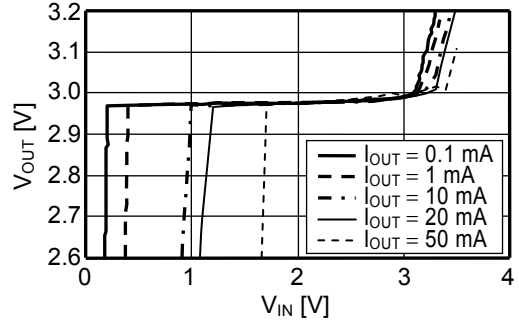
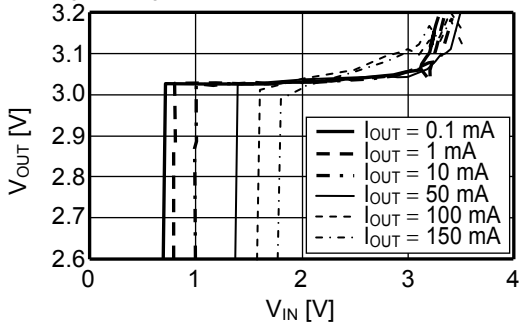(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)
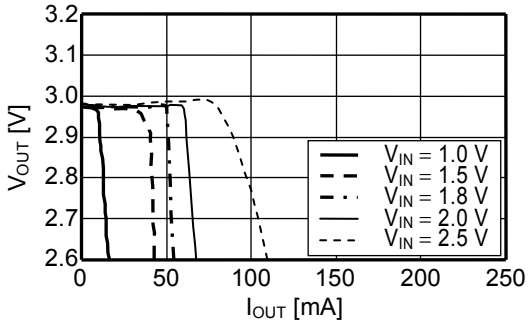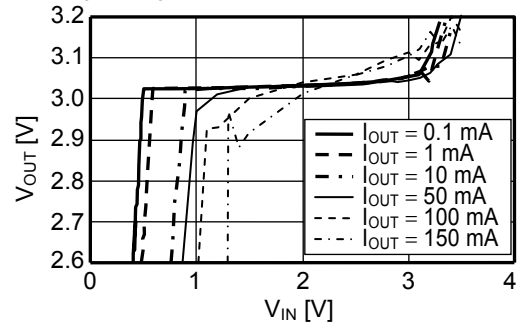
(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)
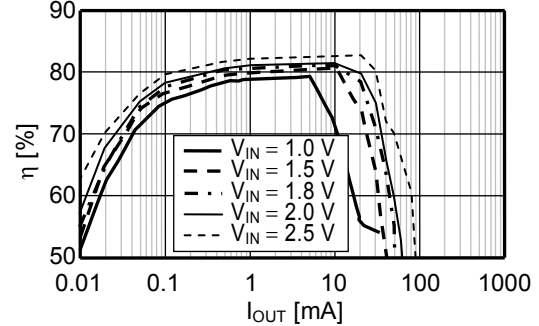
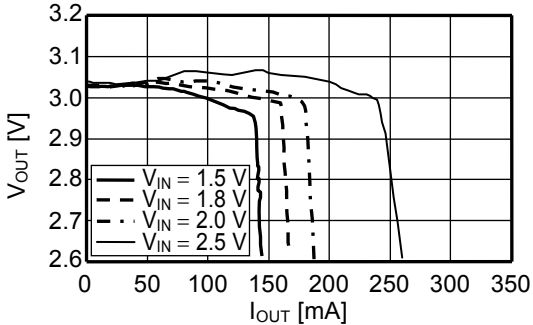**Condition 4   S-8351A50MC**

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
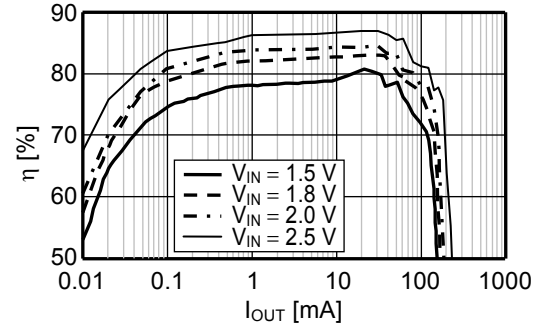(Input voltage raising)
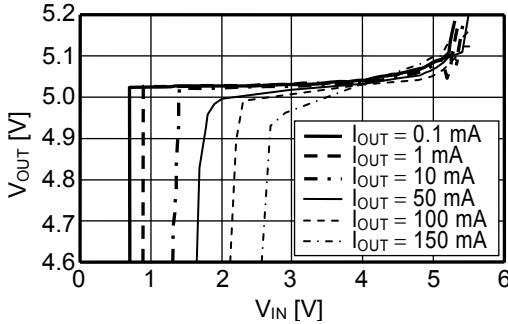
(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage falling)
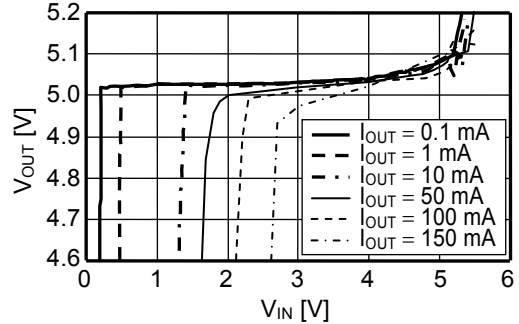
(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)
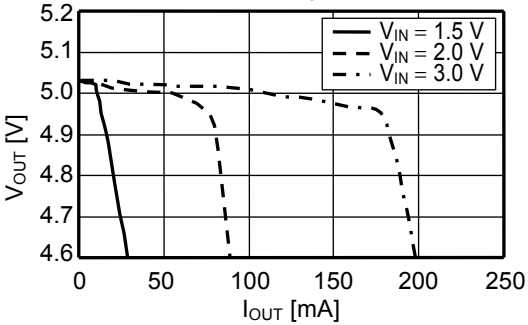
(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)
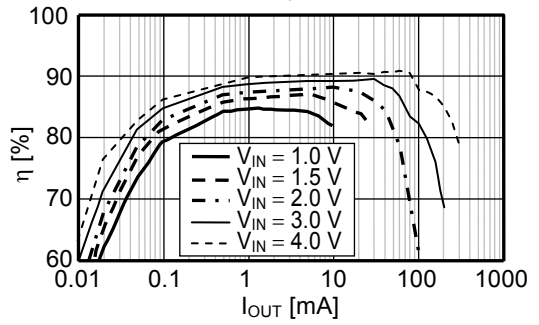
**Condition 5 S-8351A50MC**

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage raising)
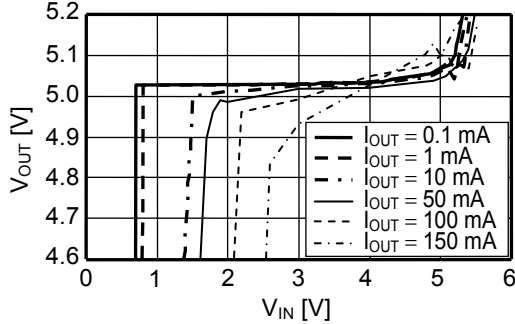


(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage falling)
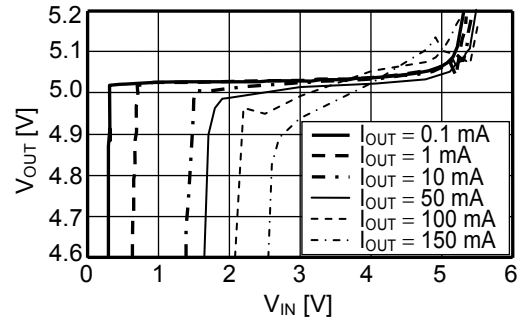
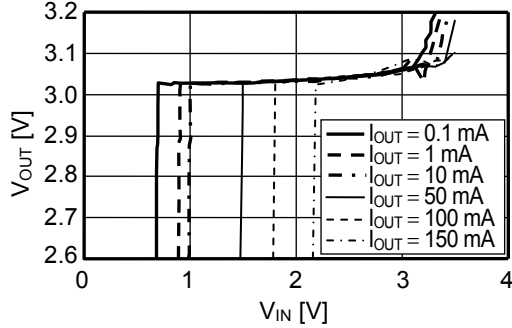

(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)
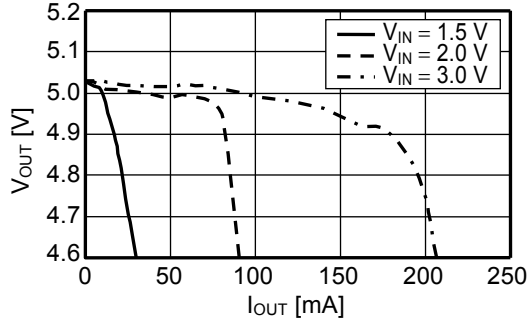


(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)
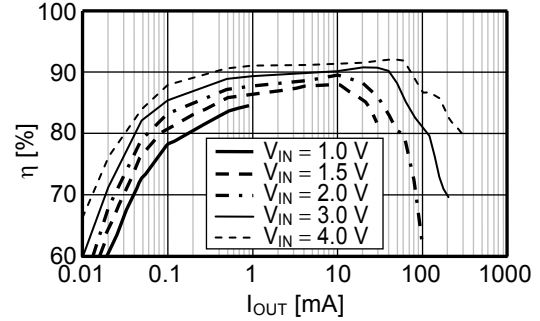


**Condition 6 S-8351A50MC**

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage raising)
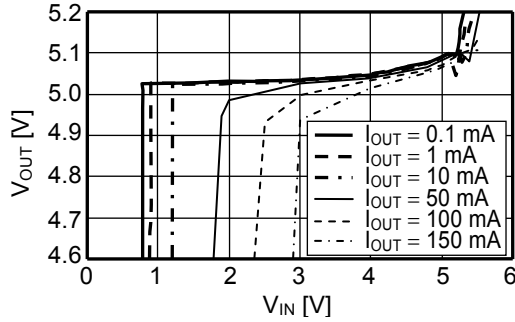


(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
(Input voltage falling)
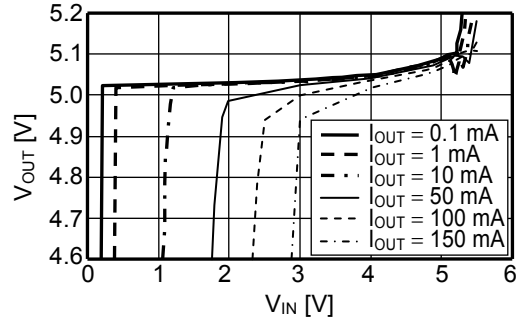


(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)
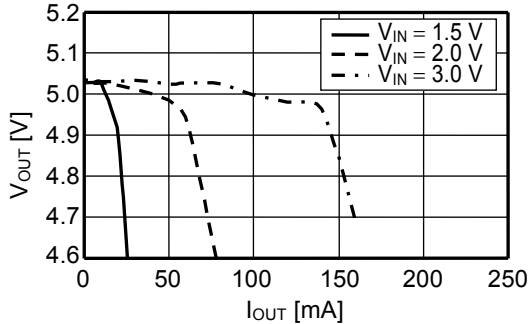

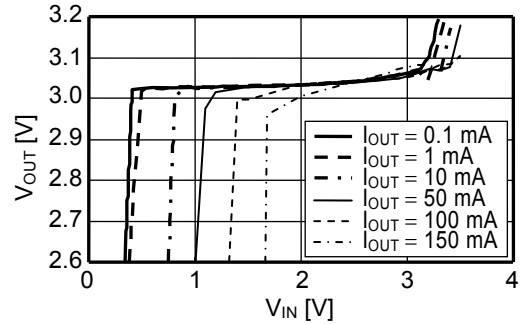
(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)
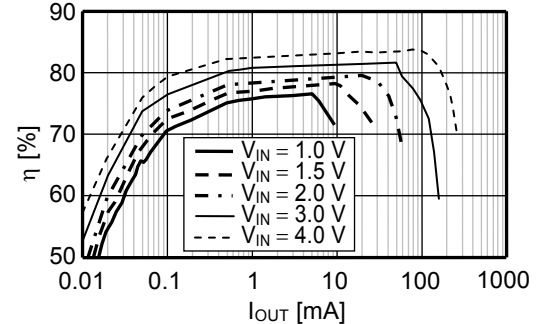
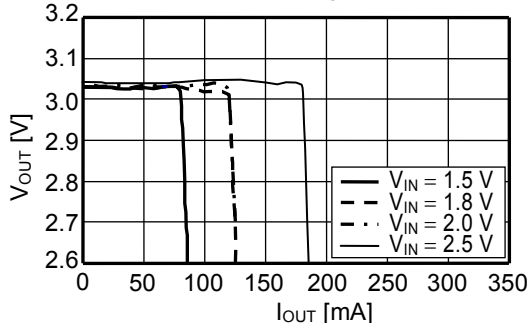**Condition 7   S-8352A30MC**

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
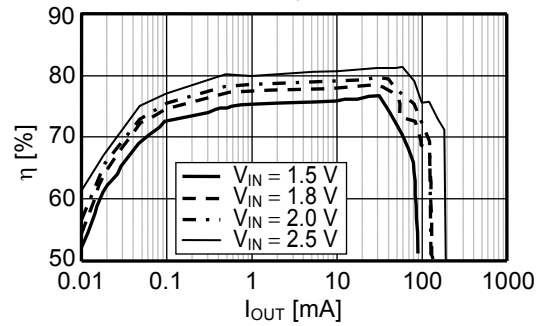   (Input voltage raising)

(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
   (Input voltage falling)

(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)

(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)

**Condition 8   S-8352A30MC**

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
   (Input voltage raising)

(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
   (Input voltage falling)
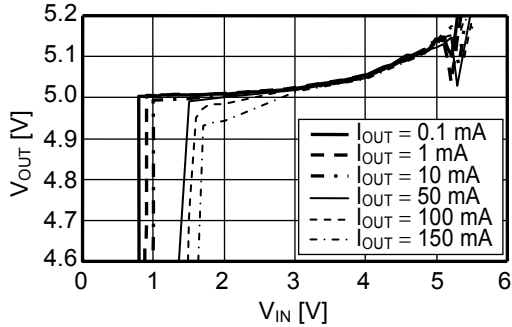
(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)

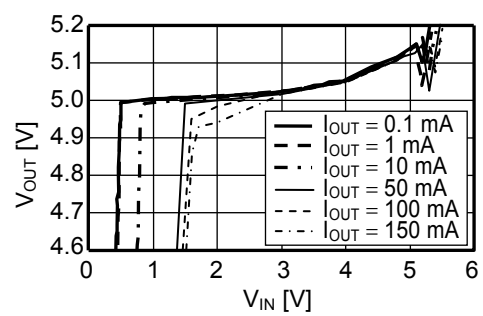(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)
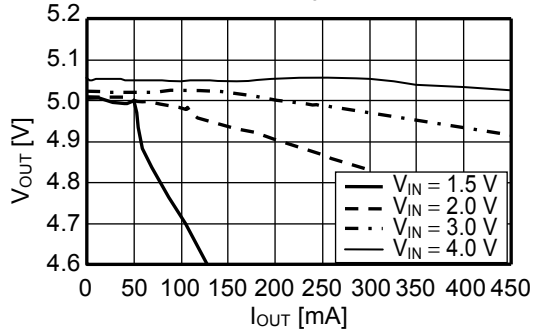
### Condition 9　S-8352A30MC

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
　(Input voltage raising)

(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
　(Input voltage falling)

(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)

(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)

### Condition 10　S-8352A50MC

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
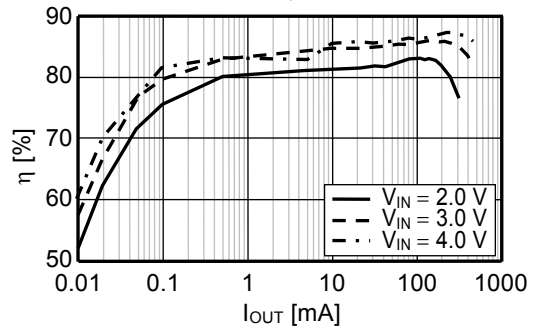　(Input voltage raising)

(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
　(Input voltage falling)

(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)

(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)

## Condition 11    S-8352A50MC

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
   (Input voltage raising)



(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
   (Input voltage falling)



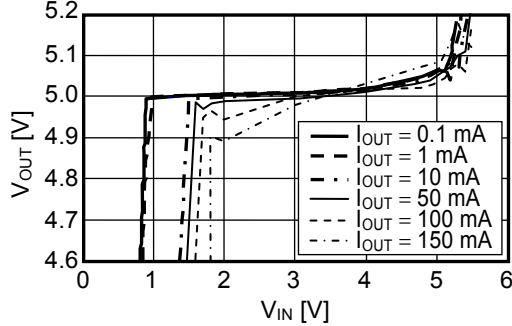(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)



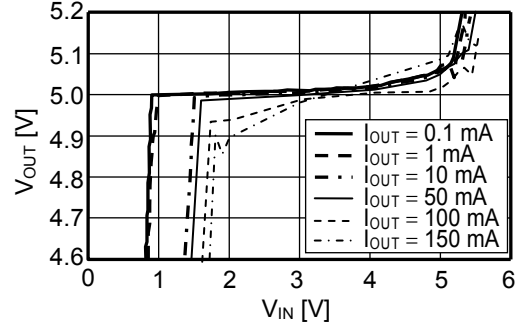(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)
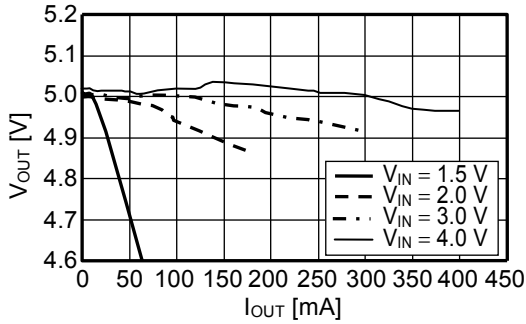


## Condition 12    S-8352A50MC

(a) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
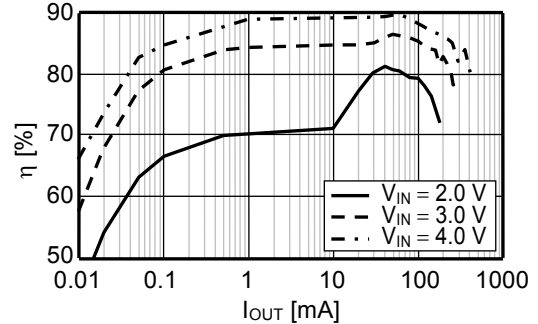   (Input voltage raising)



(b) Input voltage ($V_{IN}$) vs. Output voltage ($V_{OUT}$)
   (Input voltage falling)



(c) Output current ($I_{OUT}$) vs.Output voltage ($V_{OUT}$)
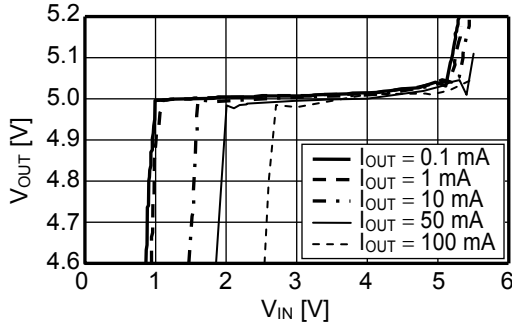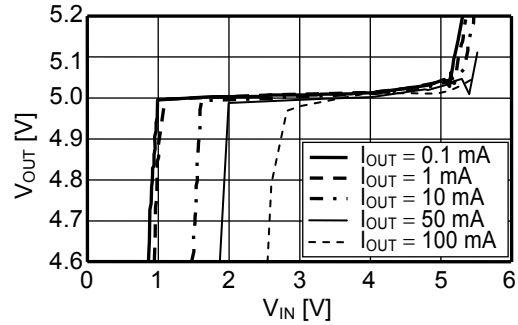


(d) Output current ($I_{OUT}$) vs. Efficiency ($\eta$)



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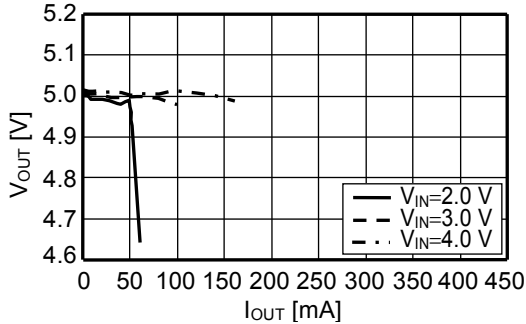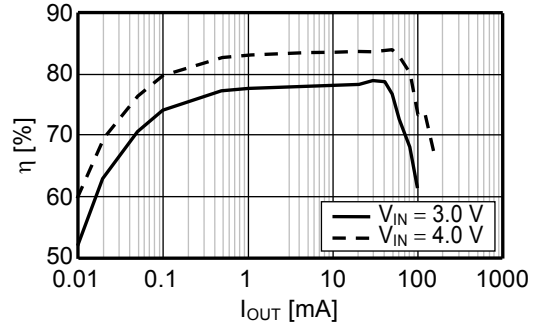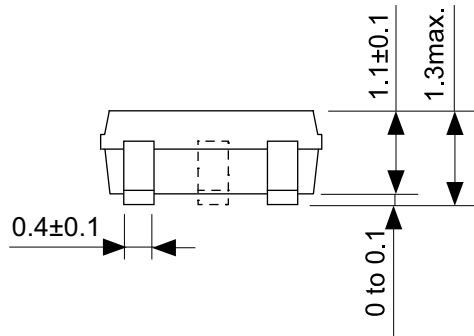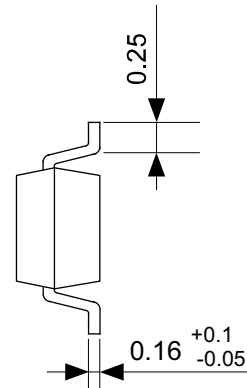
No. MP003-A-P-SD-1.2

| TITLE | SOT233-A-PKG Dimensions |
|-------|-------------------------|
| No. | MP003-A-P-SD-1.2 |
| ANGLE | |
| UNIT | mm |
| | |

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1.5 $^{+0.1}_{-0}$   2.0±0.05   4.0±0.1   1.75±0.1   0.2±0.05

2.5±0.1

3.5±0.05   8.0 $^{+0.3}_{-0.1}$

3.3±0.1

1.1±0.1

4.0±0.1

0.75

1.4±0.1

3.25±0.1

1.0±0.1

3   2

1

Feed direction
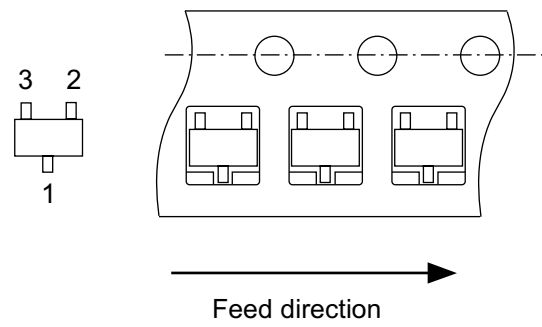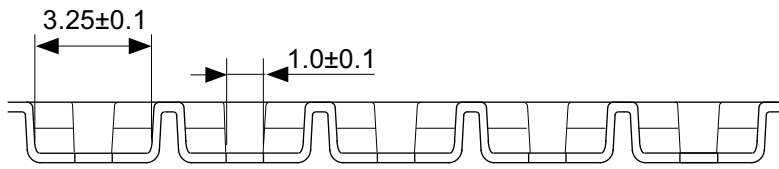
No. MP003-A-C-SD-2.0

| TITLE | SOT233-A-Carrier Tape |
|---|---|
| No. | MP003-A-C-SD-2.0 |
| ANGLE | |
| UNIT | mm |
| | |
| **ABLIC Inc.** | |

12.5max.

$\varnothing 60 ^{+1}_{-0}$

$\varnothing 180 ^{+0}_{-3}$

9.0±0.3

Enlarged drawing in the central part

21±0.5

$\varnothing 13±0.2$

2±0.2

(60°)  (60°)
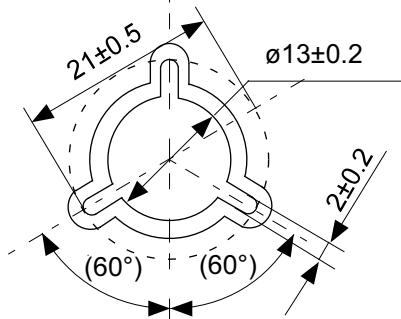
No. MP003-A-R-SD-1.1

| TITLE | SOT233-A-Reel | | |
|---|---|---|---|
| No. | MP003-A-R-SD-1.1 | | |
| ANGLE | | QTY. | 3,000 |
| UNIT | mm | | |
| | | | |
| | ABLIC Inc. | | |

2.9±0.2

1.9±0.2

5    4

1.6

$2.8^{+0.2}_{-0.3}$

1    2    3

0.45

$0.16^{+0.1}_{-0.06}$

1.1±0.1

1.3max.

0.95±0.1

0.4±0.1

0 to 0.15

No. MP005-A-P-SD-1.3

| TITLE | SOT235-A-PKG Dimensions |
|-------|--------------------------|
| No. | MP005-A-P-SD-1.3 |
| ANGLE | ⊕⊏ |
| UNIT | mm |
| | |

ABLIC Inc.

ø1.5 +0.1 -0

2.0±0.05

4.0±0.1(10 pitches:40.0±0.2)

1.75±0.1

0.25±0.1

3.5±0.05

8.0±0.2

3.25±0.15

ø1.0 +0.2 -0

4.0±0.1

1.4±0.2

3.2±0.2

3 2 1

4 5

Feed direction

No. MP005-A-C-SD-2.1

| TITLE | SOT235-A-Carrier Tape |
|-------|-----------------------|
| No. | MP005-A-C-SD-2.1 |
| ANGLE | |
| UNIT | mm |
| | |

**ABLIC Inc.**

12.5max.

∅60 $^{+1}_{-0}$

∅180 $^{+0}_{-3}$

9.0±0.3

Enlarged drawing in the central part

∅21±0.5

∅13±0.2

2±0.2

(60°)  (60°)

No. MP005-A-R-SD-1.1

| TITLE | SOT235-A-Reel | | |
|---|---|---|---|
| No. | MP005-A-R-SD-1.1 | | |
| ANGLE | | QTY. | 3,000 |
| UNIT | mm | | |
| | | | |
| **ABLIC Inc.** | | | |

4.5±0.1

1.6±0.2

2.5±0.1

1 2 3

1.5±0.1 1.5±0.1

0.8min.

1.5±0.1

4.0 +0.25 -0.35

0.4±0.05

0.4

2.5

0.4

45°

0.2

0.4±0.1

0.4±0.1

0.45±0.1
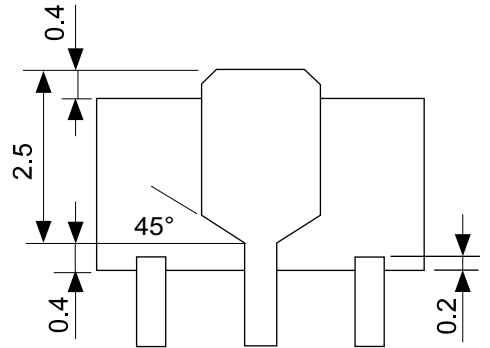
No. UP003-A-P-SD-2.0

| TITLE | SOT893-A-PKG Dimensions |
|-------|-------------------------|
| No. | UP003-A-P-SD-2.0 |
| ANGLE | ⊕ ⊏ |
| UNIT | mm |
| | |

**ABLIC Inc.**

ø1.5 +0.1 -0

2.0±0.05

4.0±0.1(10 pitches : 40.0±0.2)

1.5±0.1

5.65±0.05

12.0±0.2

ø1.5 +0.1 -0

8.0±0.1

0.3±0.05

2.0±0.1

4.35±0.1

4.75±0.1
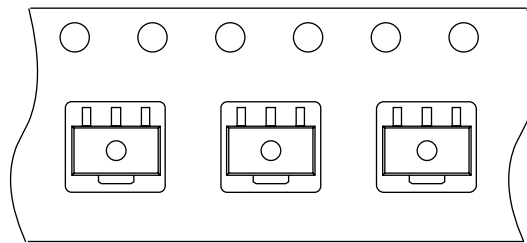
Feed direction

No. UP003-A-C-SD-2.0

| TITLE | SOT893-A-Carrier Tape |
|---|---|
| No. | UP003-A-C-SD-2.0 |
| ANGLE | |
| UNIT | mm |
| | |

**ABLIC Inc.**

16.5max.

ø60 $^{+1}_{-0}$

ø180 $^{+0}_{-3}$

13.0±0.3

Enlarged drawing in the central part

ø21±0.5

ø13±0.2

2±0.2

(60°)  (60°)
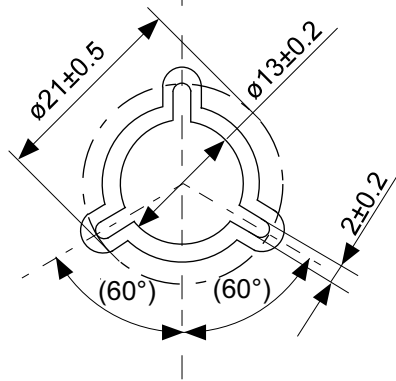
No. UP003-A-R-SD-1.1

| TITLE | SOT893-A-Reel | | |
|---|---|---|---|
| No. | UP003-A-R-SD-1.1 | | |
| ANGLE | | QTY. | 1,000 |
| UNIT | mm | | |
| | | | |
| | ABLIC Inc. | | |

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