SMALL PACKAGE PWM CONTROL, PWM/PFM SWITCHING CONTROL STEP-UP SWITCHING REGULATOR

S-8353/54 Series

The S-8353/54 Series is a CMOS step-up switching regulator which mainly consists of a reference voltage source, an oscillation circuit, a power MOS FET, an error amplifier, a phase compensation circuit, a PWM controller (S-8353) and a PWM/PFM switching controller (S-8354).

The step-up switching regulator can be configured simply by attaching a coil, capacitor, and diode externally. In addition to the above features, the small package and low power consumption of this series make it ideal for portable device applications requiring high efficiency.

The S-8353 Series realizes low ripple, high efficiency, and excellent transient characteristics due to its PWM controller, which can vary the duty ratio linearly from 0% to 83% (from 0% to 78% for 250 kHz models), optimally-designed error amplifier, and phase compensation circuits.

The S-8354 Series features a PWM/PFM switching controller that can switch the operation to a PFM controller with a duty ratio is 15% under a light load to prevent a decline in the efficiency due to the IC operating current.

■ Features

- Low voltage operation: Start-up is guaranteed from 0.9 V (I_{OUT} = 1 mA)
- Low current consumption: During operation: 18.7 µA (3.3 V, 50 kHz, typ.)
  During shutdown: 0.5 µA (max.)
- Duty ratio: Built-in PWM/PFM switching control circuit (S-8354)
  15 to 83% (30 kHz and 50 kHz models), 15 to 78% (250 kHz models)
- External parts: Coil, capacitor, and diode
- Output voltage: Can be set in 0.1 V steps between 1.5 and 6.5 V (for V_{DD}/V_{OUT} separate types) or 2.0 and 6.5 V (for other than V_{DD}/V_{OUT} separate types). Accuracy of ±2.4%.
- Oscillation frequency: 30, 50, and 250 kHz
- Soft start function: 6 ms (50 kHz, typ.)
- SOT-23-3, 23-5, and 89-3 packages

■ Packages

- SOT-23-3 (Package code: MP003-A)
- SOT-23-5 (Package code: MP005-A)
- SOT-89-3 (Package code: UP003-A)

■ 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

■ Selection Guide

1. Function List

Product Name	Control System	Switching Frequency (kHz)	Shutdown Function	V_{DD}/V_{OUT} Separate Type	Package	Application
S-8353AxxMC	PWM	50	Yes	–	SOT-23-5	Application requiring shutdown function
S-8353AxxMA	PWM	50	–	–	SOT-23-3	Application not requiring shutdown function
S-8353AxxUA	PWM	50	–	–	SOT-89-3	Application not requiring shutdown function
S-8353CxxMA	PWM	30	–	–	SOT-23-3	For pager
S-8353DxxMC	PWM	50	–	Yes	SOT-23-5	Application in which output voltage is adjusted by external resistance
S-8353HxxMC	PWM	250	Yes	–	SOT-23-5	Application requiring shutdown function and thin coil
S-8353HxxMA	PWM	250	–	–	SOT-23-3	Application not requiring shutdown function and requiring thin coil
S-8353HxxUA	PWM	250	–	–	SOT-89-3	Application not requiring shutdown function and requiring thin coil
S-8353JxxMC	PWM	250	–	Yes	SOT-23-5	Application in which output voltage is adjusted by external resistance and that requires thin coil
S-8354AxxMC	PWM/PFM switching	50	Yes	–	SOT-23-5	Application requiring shutdown function
S-8354AxxMA	PWM/PFM switching	50	–	–	SOT-23-3	Application not requiring shutdown function
S-8354AxxUA	PWM/PFM switching	50	–	–	SOT-89-3	Application not requiring shutdown function
S-8354CxxMA	PWM/PFM switching	30	–	–	SOT-23-3	For pager
S-8354DxxMC	PWM/PFM switching	50	–	Yes	SOT-23-5	Application in which output voltage is adjusted by external resistance
S-8354HxxMC	PWM/PFM switching	250	Yes	–	SOT-23-5	Application requiring shutdown function and thin coil
S-8354HxxMA	PWM/PFM switching	250	–	–	SOT-23-3	Application not requiring shutdown function and requiring thin coil
S-8354HxxUA	PWM/PFM switching	250	–	–	SOT-89-3	Application not requiring shutdown function and requiring thin coil
S-8354JxxMC	PWM/PFM switching	250	–	Yes	SOT-23-5	Application in which output voltage is adjusted by external resistance and that requires thin coil

2. Product Name

S-835 x x xx xx - xxx – T2

- T2: IC direction in tape specification
- xxx: Product name (abbreviation)
- xx: Package name (abbreviation)
  - MA ; SOT-23-3 (without shutdown function)
  - MC ; SOT-23-5 (with shutdown function or V_{DD}/V_{OUT} separate type)
  - UA ; SOT-89-3 (without shutdown function)
- xx: Output voltage ×10
- x: Product type
  - A ; Normal product f_{OSC} = 50 kHz
  - C ; Normal product f_{OSC} = 30 kHz
  - D ; V_{DD}/V_{OUT} separate type f_{OSC} = 50 kHz
  - H ; Normal product f_{OSC} = 250 kHz
  - J ; V_{DD}/V_{OUT} separate type f_{OSC} = 250 kHz
- x: Control system
  - 3 ; PWM control
  - 4 ; PWM/PFM switching control

3. Product Name List

3.1 S-8353 Series

Output Voltage (V)	S-8353AxxMC Series	S-8353AxxMA Series	S-8353AxxUA Series	S-8353CxxMA Series
2.0 V	S-8353A20MC-IQF-T2	—	—	—
2.5 V	S-8353A25MC-IQK-T2	—	—	—
2.7 V	S-8353A27MC-IQM-T2	—	—	—
2.8 V	S-8353A28MC-IQN-T2	—	—	—
3.0 V	S-8353A30MC-IQP-T2	S-8353A30MA-IQP-T2	—	S-8353C30MA-IPS-T2
3.1 V	—	—	—	—
3.3 V	S-8353A33MC-IQS-T2	S-8353A33MA-IQS-T2	S-8353A33UA-IQS-T2	—
3.8 V	S-8353A38MC-IQX-T2	—	—	—
4.0 V	—	—	—	—
4.5 V	—	—	—	—
5.0 V	S-8353A50MC-IRJ-T2	S-8353A50MA-IRJ-T2	S-8353A50UA-IRJ-T2	—

Output Voltage (V)	S-8353DxxMC Series	S-8353HxxMC Series	S-8353JxxMC Series
2.0 V	S-8353D20MC-IUF-T2	—	S-8353J20MC-IYF-T2
2.5 V	—	—	S-8353J25MC-IYK-T2
2.7 V	—	—	—
2.8 V	—	—	—
3.0 V	S-8353D30MC-IUP-T2	S-8353H30MC-IWP-T2	—
3.1 V	—	S-8353H31MC-IWQ-T2	—
3.3 V	—	S-8353H33MC-IWS-T2	—
3.8 V	—	—	—
4.0 V	—	S-8353H40MC-IWZ-T2	—
4.5 V	—	S-8353H45MC-IXE-T2	—
5.0 V	S-8353D50MC-IVJ-T2	S-8353H50MC-IXJ-T2	S-8353J50MC-IZJ-T2

Remark Please contact our sales office it a product with an output voltage other than the adove is required.

3.2 S-8354 Series

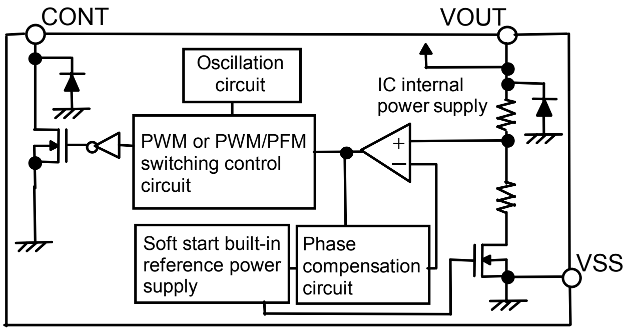
Output Voltage (V)	S8354AxxMC Series	S8354AxxMA Series	S8354AxxUA Series	S-8354DxxMC Series
2.0 V	—	—	—	S-8354D20MC-JUF-T2
2.7 V	—	S-8354A27MA-JQM-T2	—	—
3.0 V	S-8354A30MC-JQP-T2	S-8354A30MA-JQP-T2	S-8354A30UA-JQP-T2	—
3.3 V	S-8354A33MC-JQS-T2	S-8354A33MA-JQS-T2	S-8354A33UA-JQS-T2	—
4.0 V	S-8354A40MC-JQZ-T2	—	—	—
5.0 V	S-8354A50MC-JRJ-T2	S-8354A50MA-JRJ-T2	S-8354A50UA-JRJ-T2	—

Output Voltage (V)	S8354HxxMC Series	S-8354JxxMC Series
2.0 V	—	—
2.7 V	—	—
3.0 V	S-8354H30MC-JWP-T2	—
3.3 V	S-8354H33MC-JWS-T2	—
4.0 V	—	—
5.0 V	S-8354H50MC-JXJ-T2	S-8354J50MC-JZJ-T2

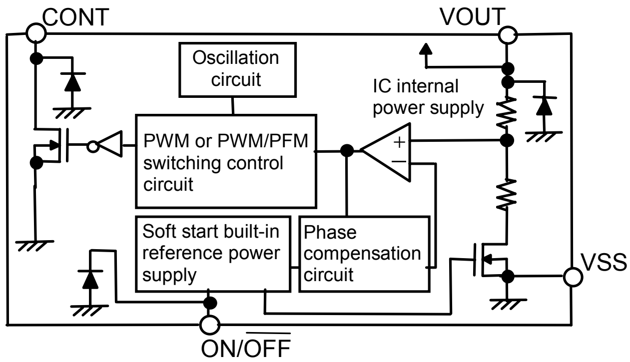
Remark Please contact our sales office it a product with an output voltage other than the adove is required.

■ Block Diagram

(1) A, C, H Type (without shutdown function)



(2) A, H Type (with shutdown function)



(3) D, J Type (V_{DD}/V_{OUT} separate type (variable output voltage type))

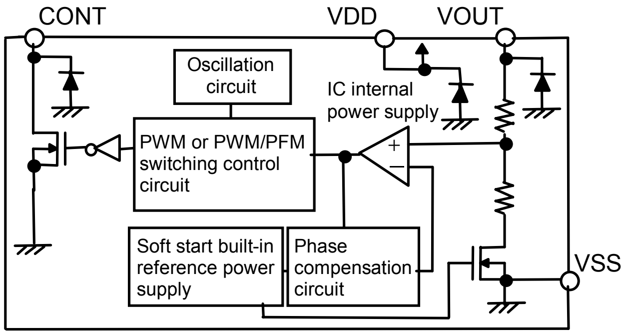


Figure 1. Block Diagram

■ Pin Assignment

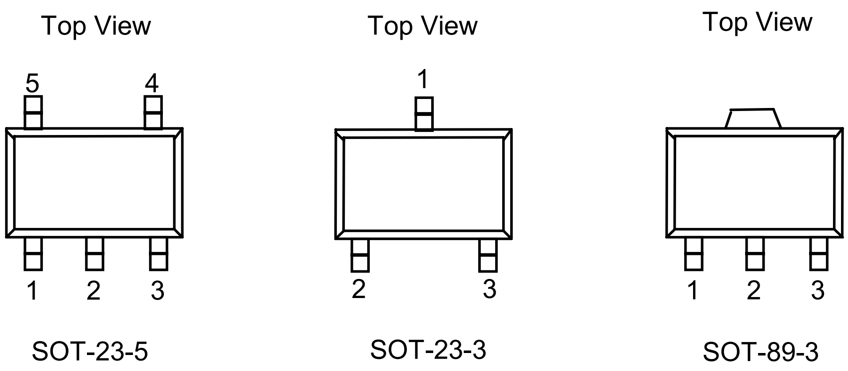


Figure 2. Pin Assignment

S-8353/54A, C, H Type (without shutdown function)
PKG: SOT-23-3

Pin No.	Pin Name	Functions
1	VOUT	Output voltage pin and IC power supply pin
2	VSS	GND pin
3	CONT	External inductor connection pin

S-8353/54A, H Type (without shutdown function)
PKG: SOT-89-3

Pin No.	Pin Name	Functions
1	VSS	GND pin
2	VOUT	Output voltage pin and IC power supply pin
3	CONT	External inductor connection pin

S-8353/54D, J Type (V_{DD}/V_{OUT} separate type)
PKG: SOT-23-5

Pin No.	Pin Name	Functions
1	VOUT	Output voltage pin
2	VDD	IC power supply pin
3	–	(N.C.)
4	VSS	GND pin
5	CONT	External inductor connection pin

S-8353/54A, H Type (with shutdown function)
PKG: SOT-23-5

Pin No.	Pin Name	Functions
1	ON/$\overline{\text{OFF}}$	Shutdown pin “H”: Normal operation (step-up operation) “L”: Stop step-up (entire circuit stopped)
2	VOUT	Output voltage pin and IC power supply pin
3	–	(N.C.)
4	VSS	GND pin
5	CONT	External inductor connection pin

■ Absolute Maximum Ratings

Table 1. Absolute Maximum Ratings

(Unless otherwise specified, Ta = 25°C)

Parameter	Symbol		Ratings	Unit
VOUT pin voltage	V_{OUT}		V_{SS} − 0.3 to V_{SS} + 12	V
$\mathrm{ON}/\overline{\mathrm{OFF}}$ pin voltage*1	$V_{ON/\overline{OFF}}$		V_{SS} − 0.3 to V_{SS} + 12	
VDD pin voltage*2	V_{DD}		V_{SS} − 0.3 to V_{SS} + 12	
CONT pin voltage	V_{CONT}		V_{SS} − 0.3 to V_{SS} + 12	
CONT pin current	I_{CONT}		300	mA
Power dissipation	P_D	SOT-89-3	500	mW
		SOT-23-5	250	
		SOT-23-3	150	
Operating temperature	T_{opr}		−40 to +85	°C
Storage temperature	T_{stg}		−40 to +125	

***1.** With shutdown function
***2.** For V_{DD}/V_{OUT} separate types

Caution **Although the IC contains a static electricity protection circuit, static electricity or voltage that exceeds the limit of the protection circuit should not be applied.**

■ Electrical Characteristics

1. 50 kHz Types (S-835xAxx, S-835xDxx)

Table 2. Electrical Characteristics

(Unless otherwise specified, Ta = 25°C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}	–		V_{OUT}(S) × 0.976	V_{OUT}(S)	V_{OUT}(S) × 1.024	V	2
Input voltage	V_{IN}	–		–	–	10	V	2
Operation start voltage	V_{ST1}	I_{OUT} = 1 mA		–	–	0.9	V	2
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT}		–	–	0.8	V	1
Operation holding voltage	V_{HLD}	I_{OUT} = 1 mA, measured by decreasing V_{IN} voltage gradually		0.7	–	–	V	2
Current consumption 1	I_{SS1}	$V_{OUT} = V_{OUT}$(S) × 0.95	S-835xx15 to 19	–	10.8	18.0	µA	1
			S-835xx20 to 29	–	13.3	22.2	µA	1
			S-835xx30 to 39	–	18.7	31.1	µA	1
			S-835xx40 to 49	–	24.7	41.1	µA	1
			S-835xx50 to 59	–	31.0	51.6	µA	1
			S-835xx60 to 65	–	37.8	63.0	µA	1
Current consumption 2	I_{SS2}	$V_{OUT} = V_{OUT}$(S) + 0.5	S-835xx15 to 19	–	4.8	9.5	µA	1
			S-835xx20 to 29	–	5.0	9.9	µA	1
			S-835xx30 to 39	–	5.1	10.2	µA	1
			S-835xx40 to 49	–	5.3	10.6	µA	1
			S-835xx50 to 59	–	5.5	10.9	µA	1
			S-835xx60 to 65	–	5.7	11.3	µA	1
Current consumption during shutdown (with hutdown function)	I_{SSS}	Shutdown pin = 0 V		–	–	0.5	µA	1
Switching current	I_{SW}	V_{CONT} = 0.4 V	S-835xx15 to 19	80	128	–	mA	1
			S-835xx20 to 24	103	165	–	mA	1
			S-835xx25 to 29	125	200	–	mA	1
			S-835xx30 to 39	144	231	–	mA	1
			S-835xx40 to 49	176	282	–	mA	1
			S-835xx50 to 59	200	320	–	mA	1
			S-835xx60 to 65	215	344	–	mA	1
Switching transistor leak current	I_{SWQ}	$V_{CONT} = V_{OUT}$ = 10 V		–	–	0.5	mV	1
Line regulation	ΔV_{OUT1}	$V_{IN} = V_{OUT}$(S) × 0.4 to × 0.6		–	30	60	µA	2
Load regulation	ΔV_{OUT2}	I_{OUT} = 10 µA to V_{OUT}(S) / 250 × 1.25		–	30	60	µA	2
Output voltage temperature coefficient	$\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}$	Ta = –40°C to +85°C		–	±50	–	ppm/°C	2
Oscillation frequency	f_{OSC}	$V_{OUT} = V_{OUT}$(S) × 0.95		42.5	50	57.5	kHz	1
Max. duty ratio	MaxDuty	$V_{OUT} = V_{OUT}$(S) × 0.95		75	83	90	%	1
PWM/PFM switching duty ratio (S-8354)	PFMDuty	$V_{IN} = V_{OUT}$(S) – 0.1 V, no load		10	15	24	%	1
Shutdown pin input voltage (for shutdown function built-in type)	V_{SH}	Oscillation measured at CONT pin		0.75	–	–	V	1
	V_{SL1}	Stop of oscillation judged at CONT pin	When V_{OUT} ≥ 1.5 V	–	–	0.3	V	1
	V_{SL2}		When V_{OUT} < 1.5 V	–	–	0.2	V	1
Shutdown pin input current (for shutdown function built-in type)	I_{SH}	Shutdown pin = V_{OUT}(S) × 0.95		–0.1	–	0.1	µA	1
	I_{SL}	Shutdown pin = 0 V		–0.1	–	0.1	µA	1
Soft start time	t_{SS}	–		3.0	6.0	12.0	ms	2
Efficiency	EFFI	–		–	85	–	%	2

External parts

- Coil: CDRH6D28-101 of Sumida Corporation
- Diode: MA2Z748 (Schottky type) of Matsushita Electronic Components Co., Ltd.
- Capacitor: F93 (16 V, 22 µF tantalum type) of Nichicon Corporation

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

Shutdown function built-in type: ON/$\overline{\text{OFF}}$ pin is connected to V_{OUT}
V_{DD}/V_{OUT} separate type: VDD pin is connected to VOUT pin

Remarks **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:
Step-up operation is performed from V_{DD} = 0.8 V. However, 1.8 V ≤ V_{DD} < 10 V is recommended to stabilize the output voltage and oscillation frequency.
(V_{DD} ≥ 1.8 V must be applied for products with a set value of less than 1.9 V.)

2. 30 kHz Type (S-835xCxx)

Table 3. Electrical Characteristics

(Unless otherwise specified, Ta = 25°C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}	–		$V_{OUT}(S)$ × 0.976	$V_{OUT}(S)$	$V_{OUT}(S)$ × 1.024	V	2
Input voltage	V_{IN}	–		–	–	10	V	2
Operation start voltage	V_{ST1}	I_{OUT} = 1 mA		–	–	0.9	V	2
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT}		–	–	0.8	V	1
Operation holding voltage	V_{HLD}	I_{OUT} = 1 mA, measured by decreasing V_{IN} voltage gradually		0.7	–	–	V	2
Current consumption 1	I_{SS1}	$V_{OUT} = V_{OUT}(S) \times 0.95$	S-835xx20 to 29	–	9.8	16.4	μA	1
			S-835xx30 to 39	–	13.1	21.9		
			S-835xx40 to 49	–	16.8	28.0		
			S-835xx50 to 59	–	20.7	34.5		
			S-835xx60 to 65	–	24.8	41.4		
Current consumption 2	I_{SS2}	$V_{OUT} = V_{OUT}(S) + 0.5$	S-835xx20 to 29	–	4.5	9.0	μA	
			S-835xx30 to 39	–	4.7	9.4		
			S-835xx40 to 49	–	4.9	9.7		
			S-835xx50 to 59	–	5.1	10.1		
			S-835xx60 to 65	–	5.2	10.4		
Switching current	I_{SW}	V_{CONT} = 0.4 V	S-835xx20 to 24	52	83	–	mA	
			S-835xx25 to 29	62	100	–		
			S-835xx30 to 39	72	115	–		
			S-835xx40 to 49	88	141	–		
			S-835xx50 to 59	100	160	–		
			S-835xx60 to 65	108	172	–		
Switching transistor leak current	I_{SWQ}	$V_{CONT} = V_{OUT}$ = 10 V		–	–	0.5	μA	
Line regulation	ΔV_{OUT1}	$V_{IN} = V_{OUT}(S) \times 0.4$ to × 0.6		–	30	60	mV	2
Load regulation	ΔV_{OUT2}	I_{OUT} = 10 μA to $V_{OUT}(S)$ / 250 × 1.25		–	30	60	mV	2
Output voltage temperature coefficient	$\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}$	Ta = −40°C to +85°C		–	±50	–	ppm/°C	2
Oscillation frequency	f_{OSC}	$V_{OUT} = V_{OUT}(S) \times 0.95$		25	30	35	kHz	1
Max. duty ratio	MaxDuty	$V_{OUT} = V_{OUT}(S) \times 0.95$		75	83	90	%	1
PWM/PFM switching duty ratio (S-8354)	PFMDuty	$V_{IN} = V_{OUT}(S) - 0.1$ V, no load		10	15	24	%	1
Soft start time	t_{SS}	–		3.0	6.0	12.0	ms	2
Efficiency	EFFI	–		–	84	–	%	2

External parts
- Coil: CDRH6D28-101 of Sumida Corporation
- Diode: MA2Z748 (Schottky type) of Matsushita Electronic Components Co., Ltd.
- Capacitor: F93 (16 V, 22 μF tantalum type) of Nichicon Corporation

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

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

3. 250 kHz Types (S-835xHxx, S-835xJxx)

Table 4. Electrical Characteristics

(Unless otherwise specified, Ta = 25°C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}	–		$V_{OUT}(S) \times 0.976$	$V_{OUT}(S)$	$V_{OUT}(S) \times 1.024$	V	2
Input voltage	V_{IN}	–		–	–	10		
Operation start voltage	V_{ST1}	I_{OUT} = 1 mA		–	–	0.9		
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT}		–	–	0.8		1
Operation holding voltage	V_{HLD}	I_{OUT} = 1 mA, measured by decreasing V_{IN} voltage gradually		0.7	–	–		2
Current consumption 1	I_{SS1}	$V_{OUT} = V_{OUT}(S) \times 0.95$	S-835xx15 to 19	–	36.5	60.8	µA	1
			S-835xx20 to 29	–	48.3	80.5		
			S-835xx30 to 39	–	74.3	123.8		
			S-835xx40 to 49	–	103.1	171.9		
			S-835xx50 to 59	–	134.1	223.5		
			S-835xx60 to 65	–	167.0	278.4		
Current consumption 2	I_{SS2}	$V_{OUT} = V_{OUT}(S) + 0.5$	S-835xx15 to 19	–	9.1	18.2		
			S-835xx20 to 29	–	9.3	18.6		
			S-835xx30 to 39	–	9.5	18.9		
			S-835xx40 to 49	–	9.7	19.3		
			S-835xx50 to 59	–	9.8	19.6		
			S-835xx60 to 65	–	10.0	19.9		
Current consumption during shutdown (with hutdown function)	I_{SSS}	Shutdown pin = 0 V		–	–	0.5		
Switching current	I_{SW}	V_{CONT} = 0.4 V	S-835xx15 to 19	80	128	–	mA	
			S-835xx20 to 24	103	165	–		
			S-835xx25 to 29	125	200	–		
			S-835xx30 to 39	144	231	–		
			S-835xx40 to 49	176	282	–		
			S-835xx50 to 59	200	320	–		
			S-835xx60 to 65	215	344	–		
Switching transistor leak current	I_{SWQ}	$V_{CONT} = V_{OUT}$ = 10 V		–	–	0.5	µA	
Line regulation	ΔV_{OUT1}	$V_{IN} = V_{OUT}(S) \times 0.4$ to $\times 0.6$		–	30	60	mV	2
Load regulation	ΔV_{OUT2}	I_{OUT} = 10 µA to $V_{OUT}(S)$ / 250 × 1.25		–	30	60		
Output voltage temperature coefficient	$\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}$	Ta = −40°C to +85°C		–	±50	–	ppm/°C	
Oscillation frequency	f_{OSC}	$V_{OUT} = V_{OUT}(S) \times 0.95$		212.5	250	287.5	kHz	1
Max. duty ratio	MaxDuty	$V_{OUT} = V_{OUT}(S) \times 0.95$		70	78	85	%	
PWM/PFM switching duty ratio (S-8354)	PFMDuty	$V_{IN} = V_{OUT}(S) - 0.1$ V, no load		10	15	24		
Shutdown pin input voltage (for shutdown function built-in type)	V_{SH}	Oscillation measured at CONT pin		0.75	–	–	V	
	V_{SL1}	Stop of oscillation judged at CONT pin	When $V_{OUT} \geq 1.5$ V	–	–	0.3		
	V_{SL2}		When $V_{OUT} < 1.5$ V	–	–	0.2		
Shutdown pin input current (for shutdown function built-in type)	I_{SH}	Shutdown pin = $V_{OUT}(S) \times 0.95$		−0.1	–	0.1	µA	
	I_{SL}	Shutdown pin = 0 V		−0.1	–	0.1		
Soft start time	t_{SS}	–		1.8	3.6	7.2	ms	2
Efficiency	EFFI	–		–	85	–	%	

External parts
- Coil: CDRH6D28-220 of Sumida Corporation
- Diode: MA2Z748 (Schottky type) of Matsushita Electronic Components Co., Ltd.
- Capacitor: F93 (16 V, 22 µF tantalum type) of Nichicon Corporation

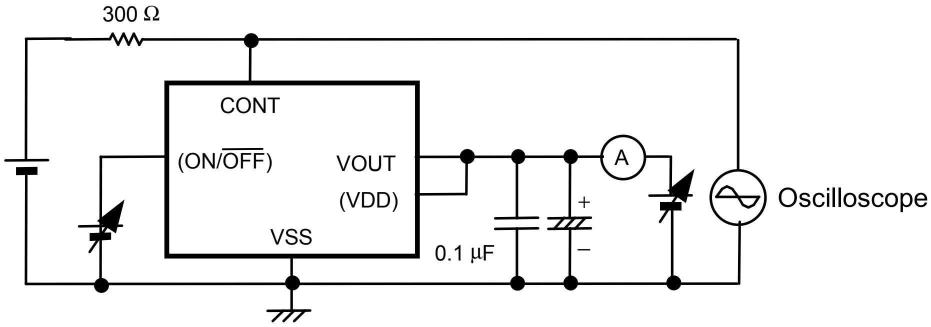
$V_{IN} = V_{OUT}(S) \times 0.6$ applied, $I_{OUT} = V_{OUT}(S)$ / 250 Ω

Shutdown function built-in type: ON/$\overline{\text{OFF}}$ pin is connected to V_{OUT}
V_{DD}/V_{OUT} separate type: VDD pin is connected to VOUT pin

Remarks
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:
Step-up operation is performed from V_{DD} = 0.8 V. However, 1.8 V ≤ V_{DD} < 10 V is recommended to stabilize the output voltage and oscillation frequency.
(V_{DD} ≥ 1.8 V must be applied for products with a set value of less than 1.9 V.)

■ Test Circuits

1.



2.

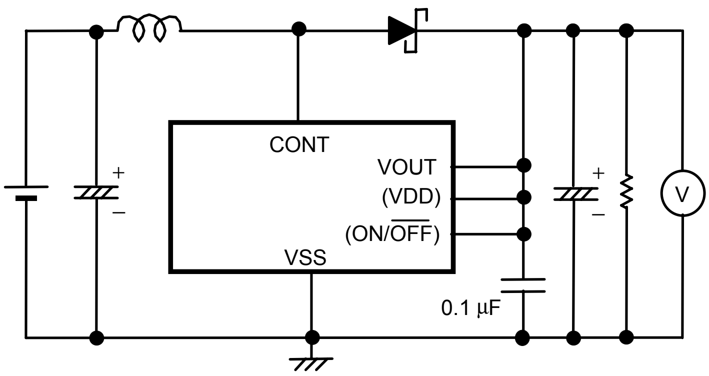


Figure 3. Test Circuits 1 and 2

■ Operation

Step-Up DC/DC Converter

The S-8353 Series is a DC/DC converter that uses a pulse width modulation method (PWM) and features low current consumption.
In the S-8353 Series, the switching frequency does not change, although the pulse width changes from 0% to 83% (78% for H and J Type) corresponding to each load current. The ripple voltage generated from switching can thus be removed easily using a filter because the switching frequency is constant.
The S-8354 Series is a DC/DC converter that automatically switches between a pulse width modulation method (PWM) and a pulse frequency modulation method (PFM), depending on the load current, and features low current consumption.
The S-8354 Series operates under PWM control with the pulse width duty changing from 15% to 83% (78% for H and J Type) when the output load current is high. On the other hand, when the output current is low, the S-8354 Series operates under PFM control with the pulse width duty fixed at 15%, and pulses are skipped according to the load current. The oscillator thus oscillates intermittently so that the resultant lower current consumption prevents a reduction in the efficiency when the load current is low. The switching point from PWM control to PFM control depends on the external devices (coil, diode, etc.), input voltage, and output voltage. This series is an especially efficient DC/DC converter at an output current of around 100 μA.
For this IC, a built-in soft start circuit controls the rush current and overshoot of the output voltage when the power is turned on or the ON/$\overline{\text{OFF}}$ pin is set to “H” level.

Shutdown pin: Stops or starts step-up operation.
(Only for SOT-23-5 package products of A and H types)

Setting the shutdown pin to “L” level stops operation of all the internal circuits and reduces the current consumption significantly.
DO NOT use the shutdown pin in a floating state because it has the structure shown in Figure 4 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 shutdown pin because applying such a voltage increases the current consumption. If the shutdown pin is not used, connect it to the VOUT pin.
The shutdown pin does not have hysteresis.

Shutdown Pin	CR Oscillation Circuit	Output Voltage
“H”	Operation	Fixed
“L”	Stop	≅ V_{IN}*

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

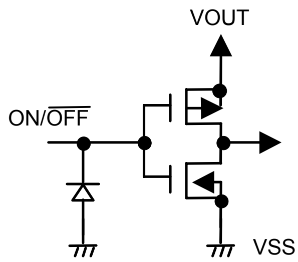


Figure 4. Shutdown Pin Structure

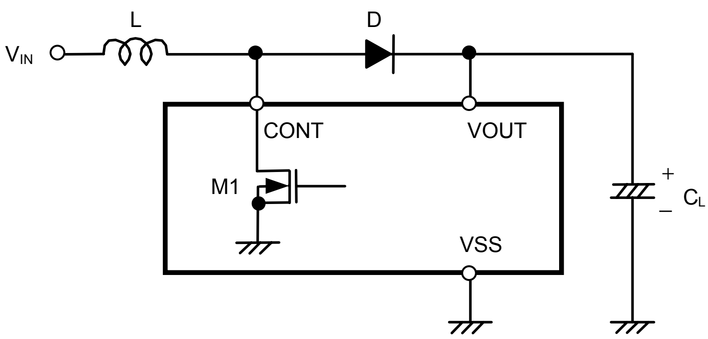


Figure 5. Step-Up Switching Regulator Circuit for Basic Equations

The following are the basic equations [(1) through (7)] of the step-up switching regulator (see **Figure 5**).

Voltage at CONT pin at the moment M1 is turned ON (current I_L flowing through L is zero), V_A:

$$V_A = V_S \quad \cdots\cdots \quad (1)$$

(V_S: Non-saturated voltage of M1)

The change in I_L over time:

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

Integration of equation (2) (I_L):

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

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}:

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

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:

$$V_L = (V_{OUT} + V_D) - V_{IN} \quad \cdots\cdots \quad (5)$$

(V_D: 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}:

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

Integration of equation (6) is as follows:

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

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:

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

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

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

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

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

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

Electric charge ΔQ_1 which is charged in C_L during t_1:

$$\Delta Q_1 = \int_0^{t_1} I_L dt = I_{PK} \bullet \int_0^{t_1} dt - \frac{V_{OUT} + V_D - V_{IN}}{L} \bullet \int_0^{t_1} t dt$$

$$= I_{PK} \bullet t_1 - \frac{V_{OUT} + V_D - V_{IN}}{L} \bullet \frac{1}{2} t_1^2 \qquad \text{(12)}$$

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

$$\Delta Q_1 = I_{PK} - \frac{1}{2}(I_{PK} - I_{OUT}) \bullet t_1 = \frac{I_{PK} + I_{OUT}}{2} \bullet t_1 \qquad \text{(13)}$$

A rise in voltage (V_{P-P}) due to ΔQ_1:

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

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

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

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

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

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

■ External Parts Selection for DC/DC Converter

The relationship between the major characteristics of the step-up circuit and the characteristic parameters of the external parts is shown in Figure 6.

<table>
<tr><th rowspan="2">For larger output current?</th><th colspan="2">For higher efficiency?</th><th rowspan="2">For smaller ripple voltage?</th></tr>
<tr><th>PFM Control</th><th>PWM Control</th></tr>
<tr><td colspan="2">Smaller inductance</td><td colspan="2">Larger inductance</td></tr>
<tr><td colspan="3">Smaller DC resistance of inductor</td><td></td></tr>
<tr><td>Larger output capacitance</td><td colspan="2"></td><td>Larger output capacitance</td></tr>
</table>

Figure 6. Relationship Between Major Characteristics of Step-Up Circuit and External Parts

1. Inductor

The inductance has a strong influence on the maximum output current (I_{OUT}) and efficiency (η).
The peak current (I_{PK}) increases by decreasing L and the stability of the circuit improves and I_{OUT} increases. If L is made even smaller, the efficiency falls causing a decline in the current drive capacity for the switching transistor, and I_{OUT} decreases.
The loss of I_{PK} by the switching transistor decreases by increasing L and the efficiency becomes maximum at a certain L value. Increasing L further decreases the efficiency due to the loss of coil DC resistance. I_{OUT} also decreases.
A higher oscillation frequency allows selection of a lower L value, making the coil smaller.
The recommended inductances are 47 to 220 μH for A, C, and D types, and 10 to 47 μH for H and J types.
Observe the allowable inductor current when choosing an inductor. Exceeding the allowable current of the inductor causes magnetic saturation, resulting in very low efficiency and destruction of the IC chip due to a large current.
Choose an inductor so that I_{PK} does not exceed the allowable current. I_{PK} in con-continuous mode is calculated from the following equation:

$$I_{PK} = \sqrt{\frac{2\,I_{OUT}\,(V_{OUT} + V_D - V_{IN})}{f_{OSC} \cdot L}}\ \text{(A)} \quad \cdots\cdots\cdots\cdots (17)$$

f_{osc} = oscillation frequency, $V_D \cong 0.4$ V.

2. Diode

Use an external diode that meets the following requirements:

- Low forward voltage: ($V_F < 0.3$ V)
- High switching speed: (50 ns max.)
- Reverse voltage: $V_{OUT} + V_F$ or more
- Rated current: I_{PK} or more

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 the case of a high output voltage or a high load current. The capacitor value should be at least 10 μF.
Select capacitor with an appropriate ESR (Equivalent Series Resistance) for stable output voltage. The stable range of voltage for this IC depends on the ESR. Although the inductance (L) is also a factor, an ESR of 30 mΩ to 500 mΩ maximizes the characteristics. However, the best ESR value may depend on the value of L, the capacitance, the wiring, and the applications (output load). Therefore, fully evaluate the ESR under the actual operating conditions to determine the best value.
Figure 11 of Application Circuits shows an example of a circuit that uses a ceramic capacitor and the external resistance (ESR) for reference.

4. V_{DD}/V_{OUT} Separate Types (D and J Types)

The D and J types are ideal for the following applications because the power pin for the IC chip and the VOUT pin for the output voltage are separated.

(1) When changing the output voltage with external resistance.
(2) When outputting a high voltage within the operating voltage (10 V).

Choose the products in the following table according to the applications (1) or (2) above.

Output Voltage V_{CC}	1.8 V ≤ V_{CC} < 5 V	5 V ≤ V_{CC} ≤ 10 V
S-835xx18	Yes	—
S-835xx50	—	Yes
Connection to VDD pin	V_{IN} or V_{CC}	V_{IN}

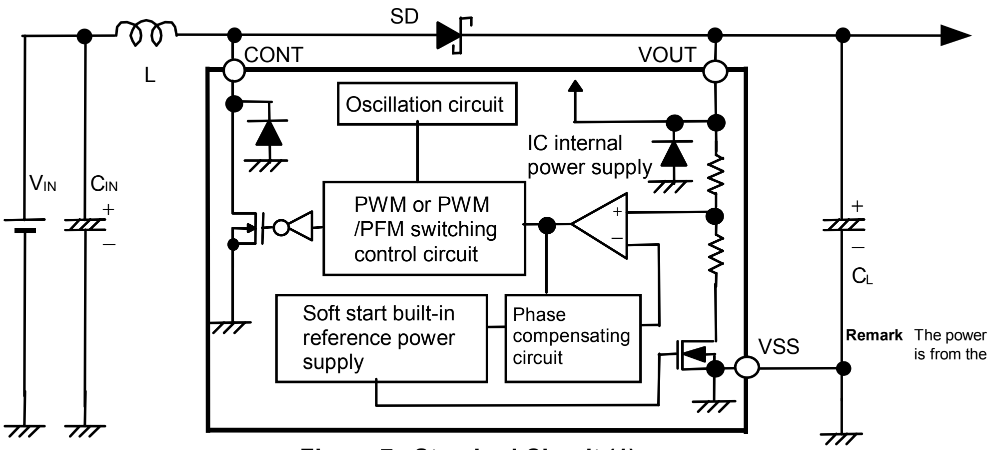
When using the above products, observe the following.

1) This IC starts a step-up operation at V_{DD} = 0.8 V, but set 1.8 ≤ V_{DD} ≤ 10 V to stabilize the output voltage and frequency of the oscillator. (Input a voltage of 1.8 V or more to the VDD pin for all the products with settings of less than 1.9 V.)
   An input voltage of 1.8 V or more at the VDD pin allows the connection of the VDD pin to either input power pin VIN or output power pin VOUT.
2) Choose external resistors R_A and R_B so that the output voltage is not affected, taking into consideration the impedance between the VOUT and VSS pins in the IC chip.
   The internal resistances between the VOUT and VSS pins are as follows.
   (1) S-835xx18 → 5.6 MΩ to 14.9 MΩ
   (2) S-835xx20 → 5.2 MΩ to 12.3 MΩ
   (3) S-835xx50 → 3.8 MΩ to 10.4 MΩ
3) Attach the capacitor (C_C) in parallel to the R_A resistor when unstable operation such as oscillation of the output voltage occurs. Calculate C_C from the following equation:

$$C_C(F) = \frac{1}{2 \bullet \pi \bullet R_A \bullet 20\text{ kHz}}$$

■ Standard Circuits

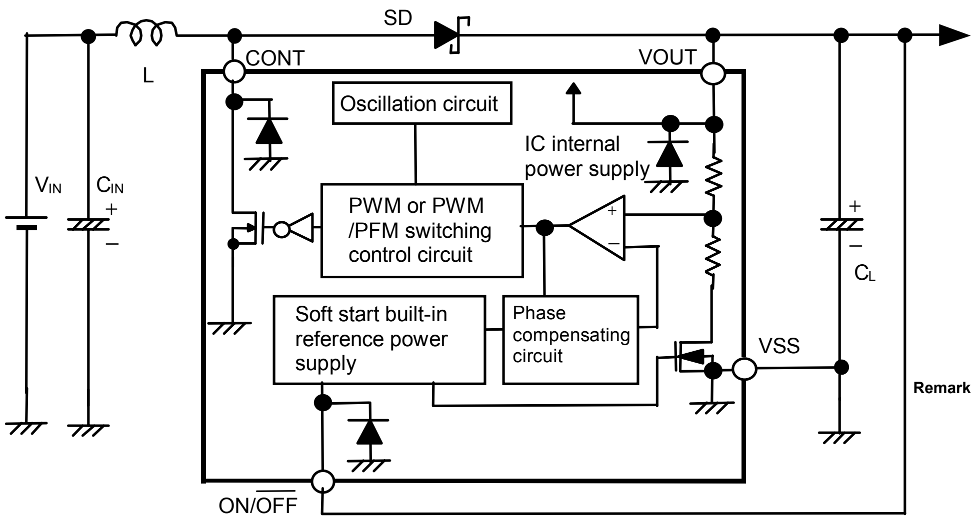
(1) S-8353AxxMA/UA, S-8353CxxMA, S-8353HxxMA/UA
S-8354AxxMA/UA, S-8354CxxMA, S-8354HxxMA/UA



Remark The power supply for the IC chip is from the VOUT pin.

Figure 7. Standard Circuit (1)

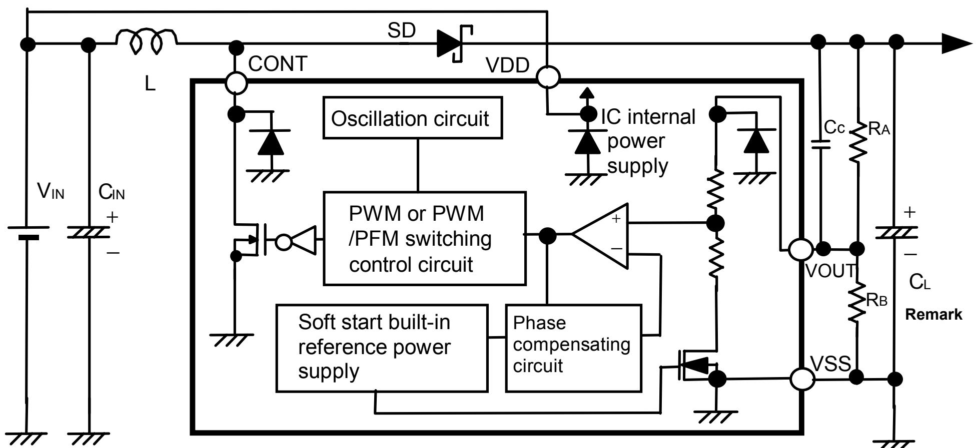
(2) S-8353AxxMC, S-8353HxxMC
S-8354AxxMC, S-8354HxxMC



Remark The power supply for the IC chip is from the VOUT pin.

Figure 8. Standard Circuit (2)

(3) S-8353DxxMC, S-8353JxxMC
S-8354DxxMC, S-8354JxxMC



Remark The power supply for the IC chip is from the VDD pin.

Figure 9. Standard Circuit (3)

■ Power Dissipation of Package

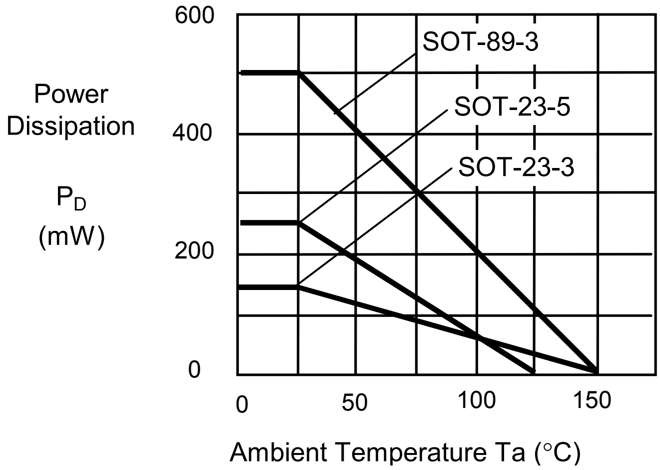


Figure 10. Power Dissipation of Package (Before Mounting)

■ Precautions

- Mount external capacitors, diodes, and coils as close as possible to the IC. Especially, mounting the output capacitor (capacitor between VDD and VSS for V_{DD}/V_{OUT} separate type) in the power supply line of the IC close to the IC can enable stable output characteristics. If it is impossible, it is recommended to mount and wire a ceramic capacitor of around 0.1 μF close to the IC.
- Unique ripple voltage and spike noise occur in switching regulators. Because they largely depend on the coil and the capacitor used, check those characteristics using an actually mounted model.
- Make sure 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. The recommended external part should be used wherever possible, but if this is not possible for some reason, contact an SII sales person.
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.
- Seiko Instruments Inc. assumes no responsibility for the way in which this IC is used on products created using this IC or for the specifications of that product, nor does Seiko Instruments Inc. assume any responsibility for any infringement of patents or copyrights by products that include this IC either in Japan or in other countries.

■ Application Circuits

Example of Ceramic Capacitor Application

When using a component with a small ESR, such as a ceramic capacitor, for the output capacitance, mount a resistor (R1) equivalent to the ESR in series with the ceramic capacitor (C_L) as shown in the following circuit diagram.
R1 differs depending on the L value, capacitance, wiring, and application (output load).
The following example shows a circuit using Rl = 100 mΩ, output voltage = 3.3 V, output load = 100 mA and its characteristics.

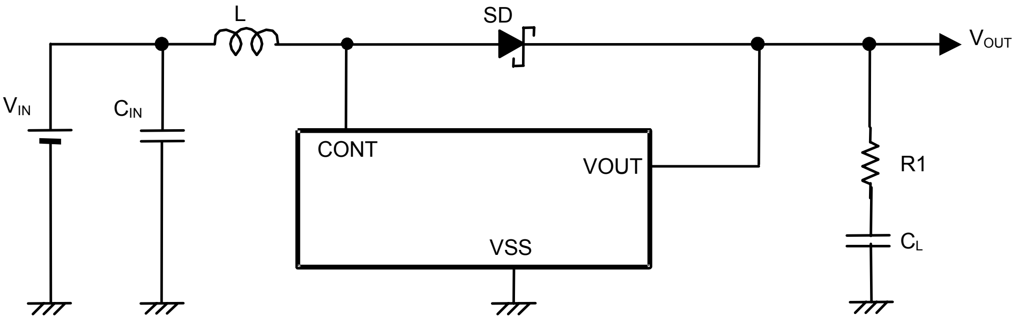


Figure 11. Circuit Using Ceramic Capacitor

IC	L Type Name	SD Type Name	C_L (Ceramic Capacitor)	R1	Output Characteristics
S-8353A33	CDRH5D28-101	MA2Z748	10 μF × 2	100 mΩ	(a), (b), (c)

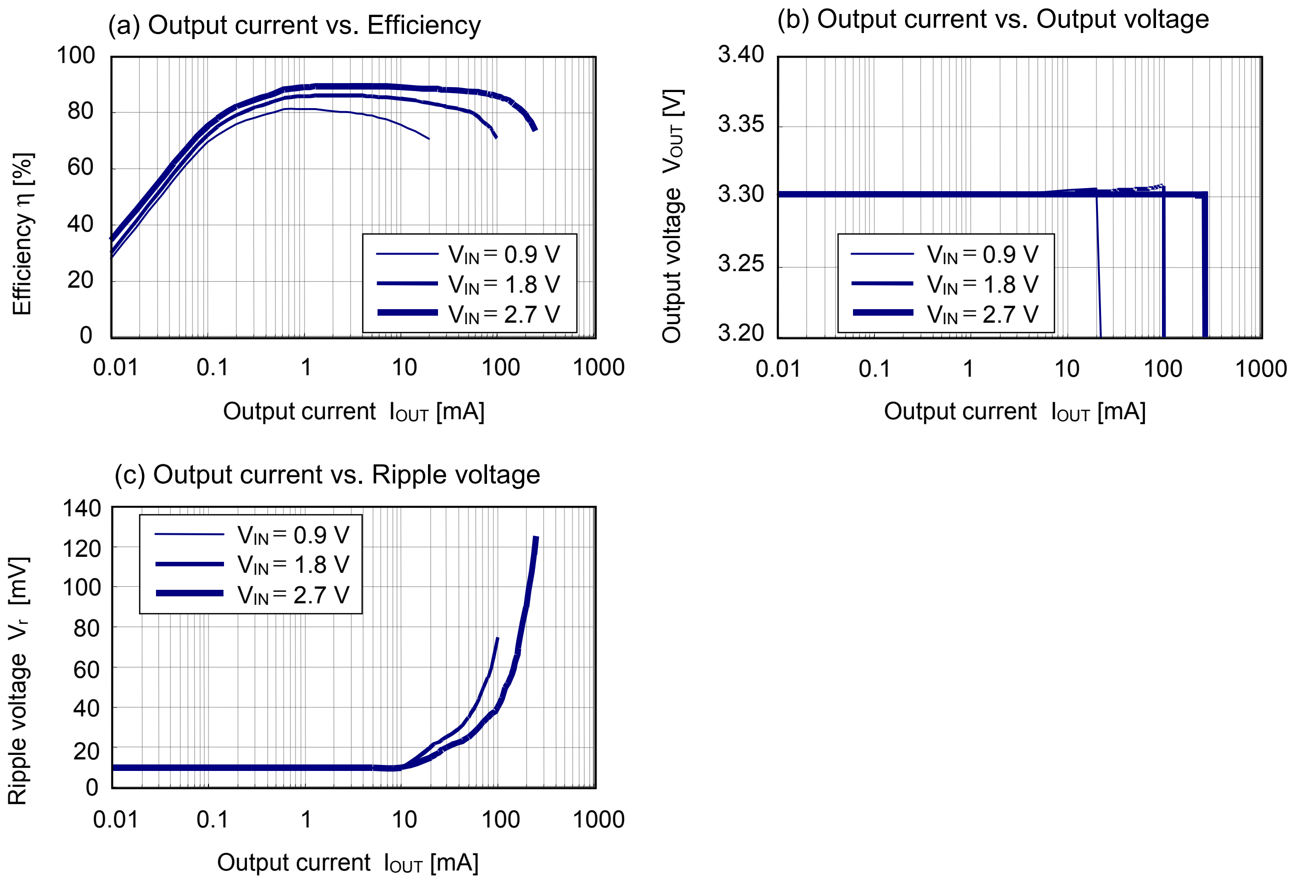
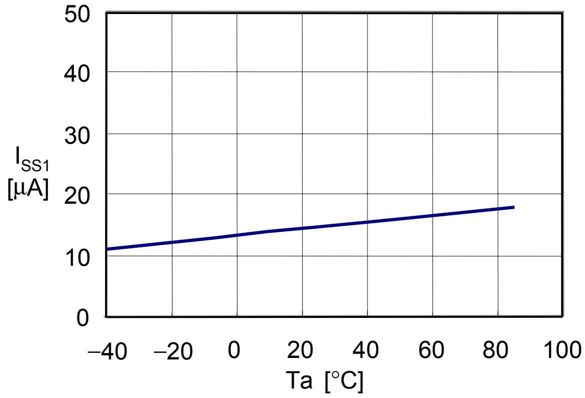


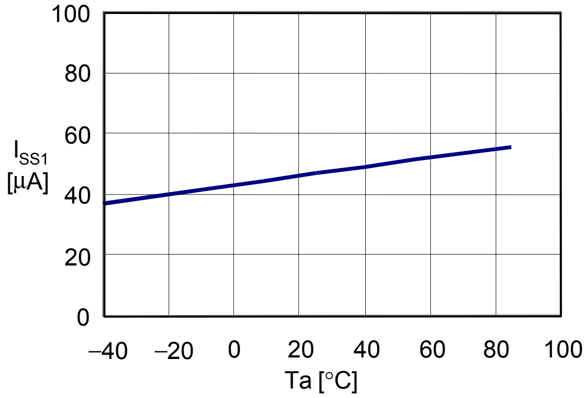
Figure 12. Ceramic Capacitor Circuit Output Characteristics

■ Examples of Major Temperature Characteristics (Ta = –40 to +85°C)

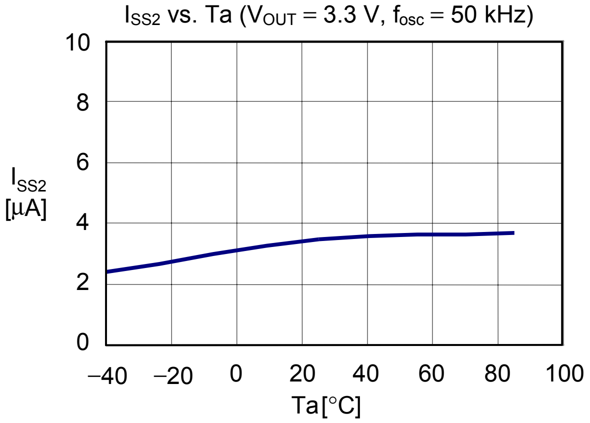
I_{SS1} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 50 kHz)



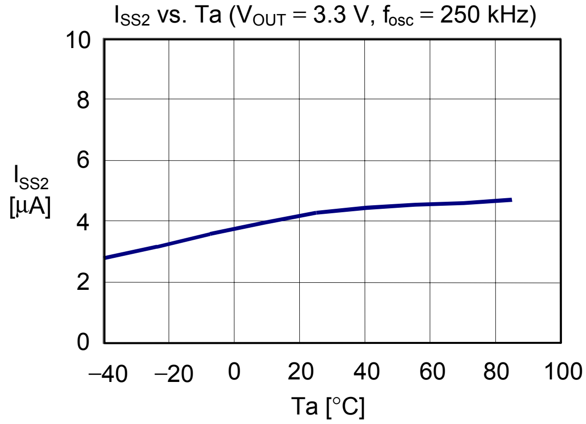
I_{SS1} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)



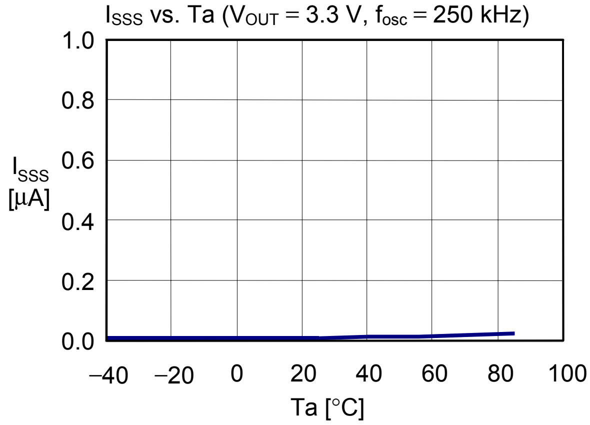
I_{SS2} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 50 kHz)



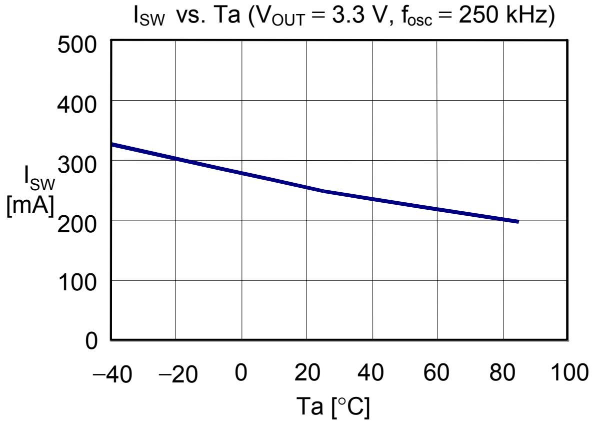
I_{SS2} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)



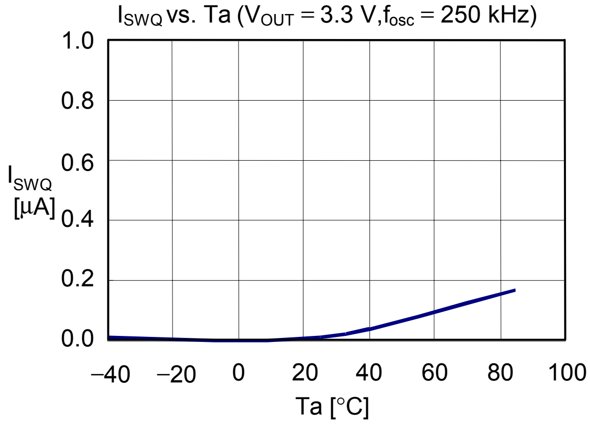
I_{SSS} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)

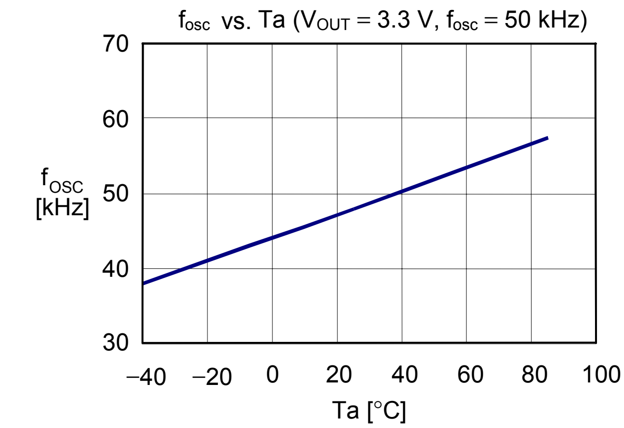


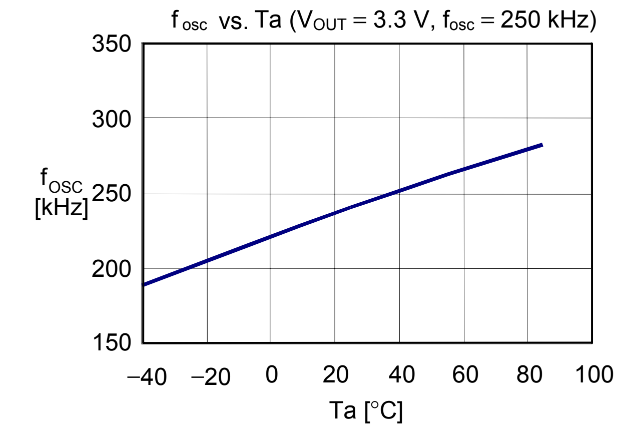
I_{SW} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)

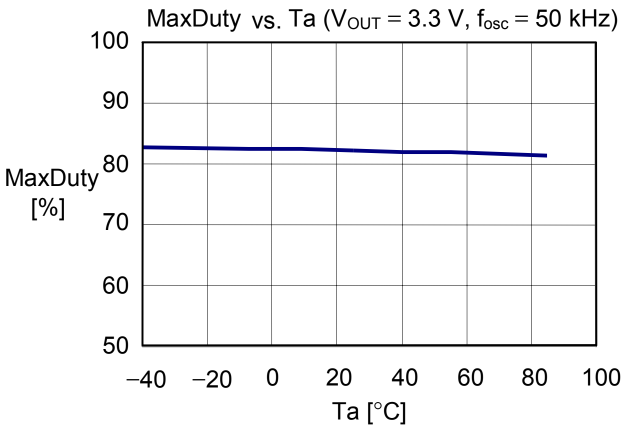


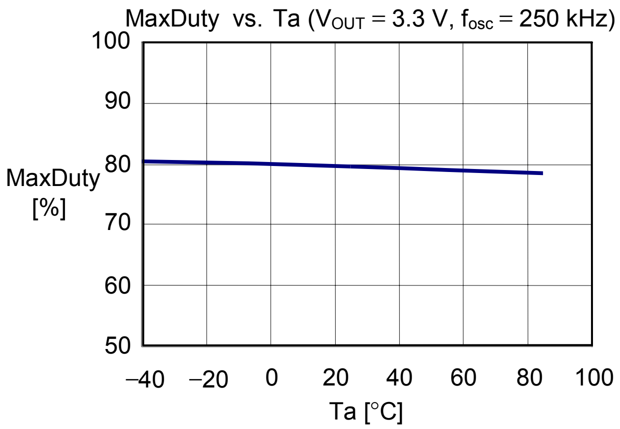
I_{SWQ} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)

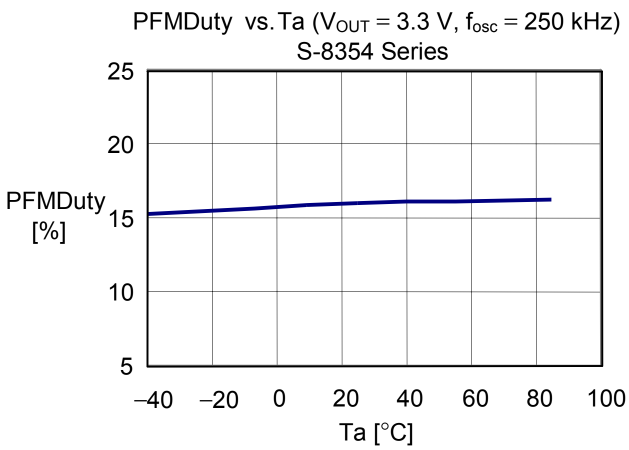


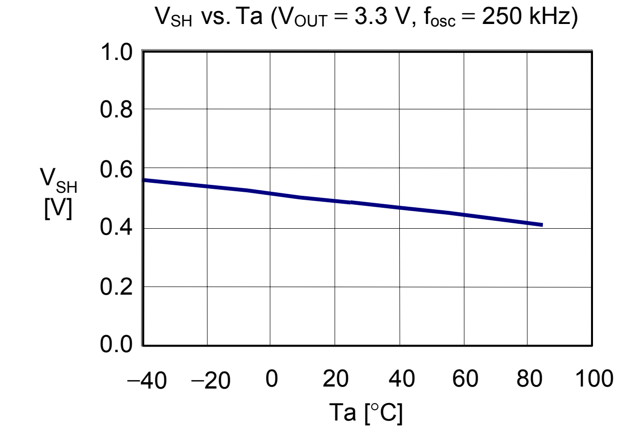

f_{osc} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 50 kHz)
f_{OSC} [kHz]
70
60
50
40
30
−40 −20 0 20 40 60 80 100
Ta [°C]

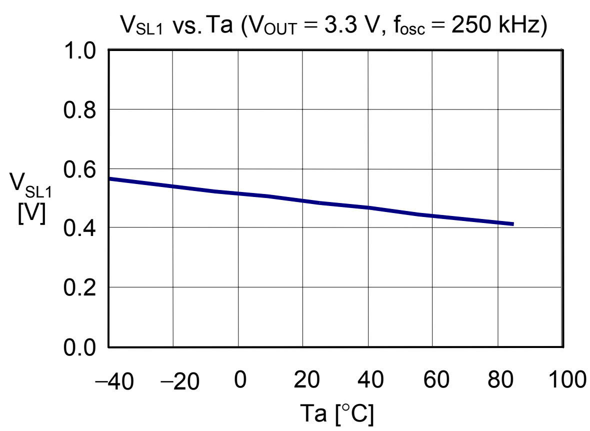

f_{osc} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)
f_{OSC} [kHz]
350
300
250
200
150
−40 −20 0 20 40 60 80 100
Ta [°C]

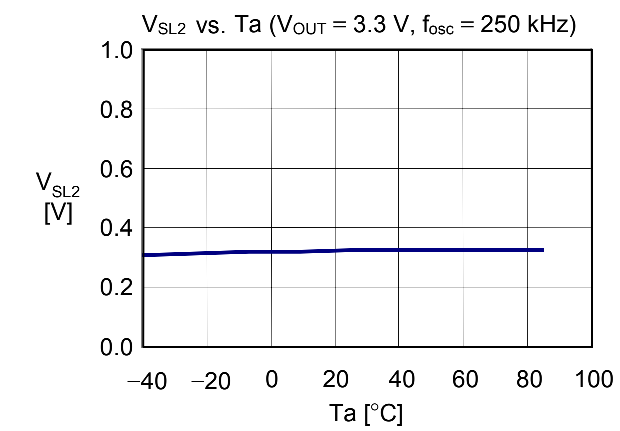

MaxDuty vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 50 kHz)
MaxDuty [%]
100
90
80
70
60
50
−40 −20 0 20 40 60 80 100
Ta [°C]

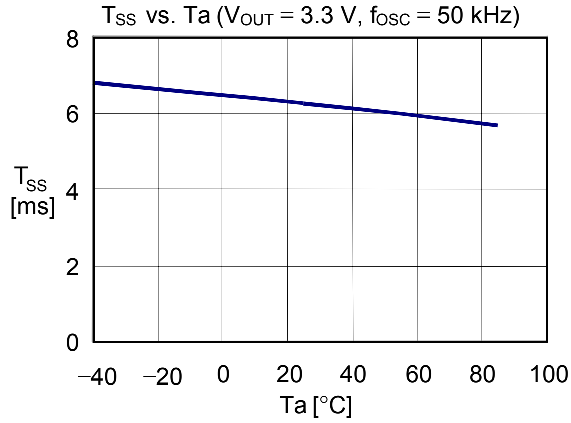

MaxDuty vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)
MaxDuty [%]
100
90
80
70
60
50
−40 −20 0 20 40 60 80 100
Ta [°C]

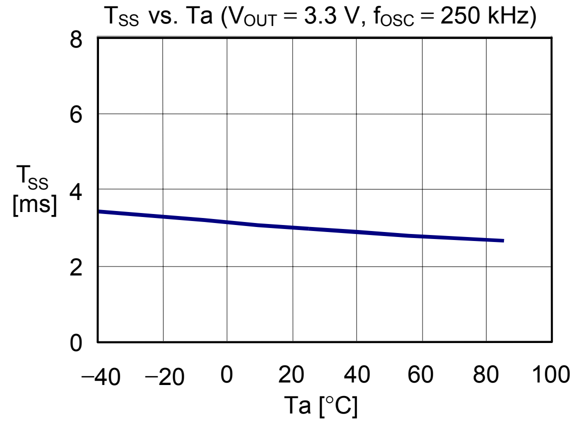

PFMDuty vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)
S-8354 Series
PFMDuty [%]
25
20
15
10
5
−40 −20 0 20 40 60 80 100
Ta [°C]

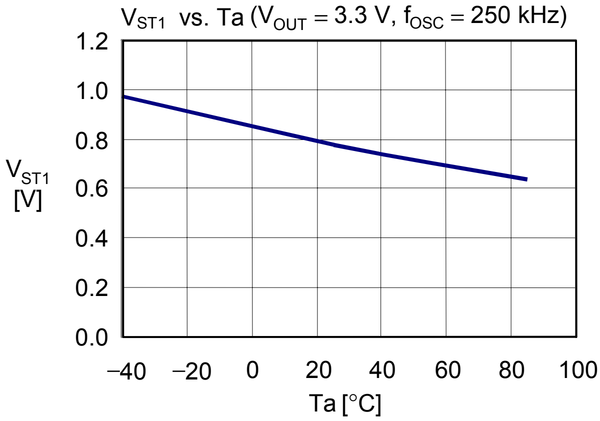

V_{SH} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)
V_{SH} [V]
1.0
0.8
0.6
0.4
0.2
0.0
−40 −20 0 20 40 60 80 100
Ta [°C]

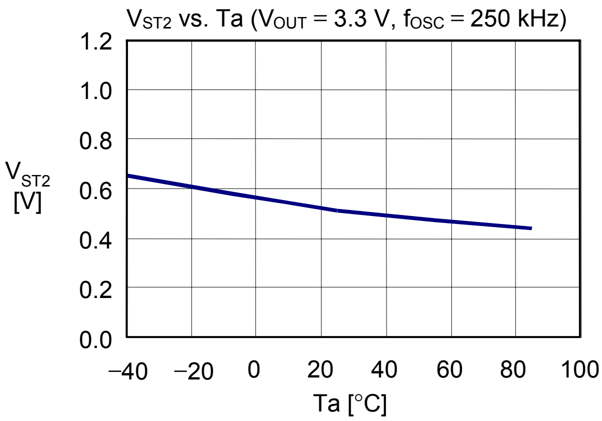

V_{SL1} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)
V_{SL1} [V]
1.0
0.8
0.6
0.4
0.2
0.0
−40 −20 0 20 40 60 80 100
Ta [°C]

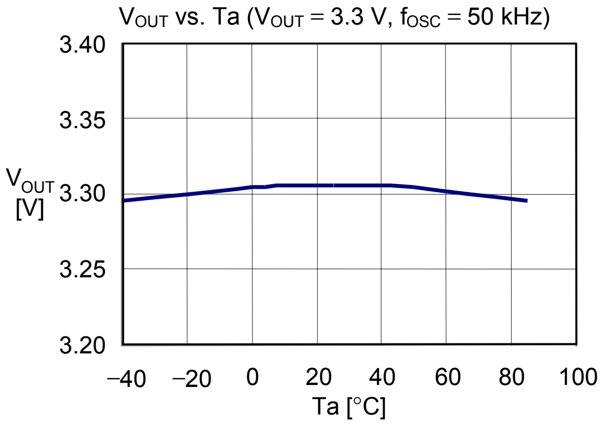

V_{SL2} vs. Ta (V_{OUT} = 3.3 V, f_{osc} = 250 kHz)
V_{SL2} [V]
1.0
0.8
0.6
0.4
0.2
0.0
−40 −20 0 20 40 60 80 100
Ta [°C]

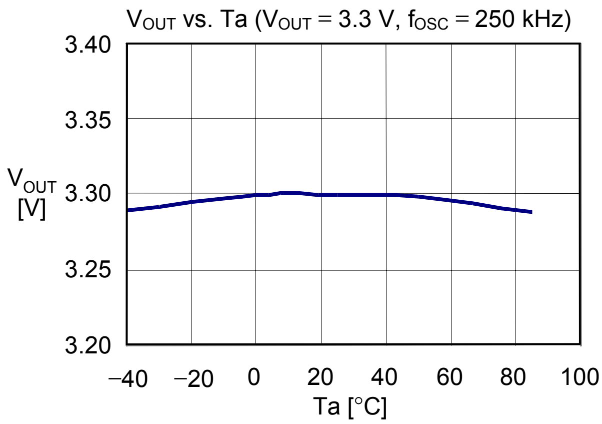

T_{SS} vs. Ta (V_{OUT} = 3.3 V, f_{OSC} = 50 kHz)
T_{SS} [ms]
Ta [°C]
8
6
4
2
0
−40
−20
0
20
40
60
80
100


T_{SS} vs. Ta (V_{OUT} = 3.3 V, f_{OSC} = 250 kHz)
T_{SS} [ms]
Ta [°C]
8
6
4
2
0
−40
−20
0
20
40
60
80
100


V_{ST1} vs. Ta (V_{OUT} = 3.3 V, f_{OSC} = 250 kHz)
V_{ST1} [V]
Ta [°C]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−40
−20
0
20
40
60
80
100

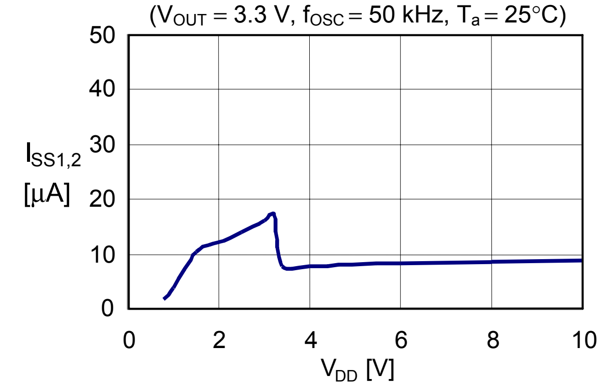

V_{ST2} vs. Ta (V_{OUT} = 3.3 V, f_{OSC} = 250 kHz)
V_{ST2} [V]
Ta [°C]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−40
−20
0
20
40
60
80
100


V_{OUT} vs. Ta (V_{OUT} = 3.3 V, f_{OSC} = 50 kHz)
V_{OUT} [V]
Ta [°C]
3.40
3.35
3.30
3.25
3.20
−40
−20
0
20
40
60
80
100

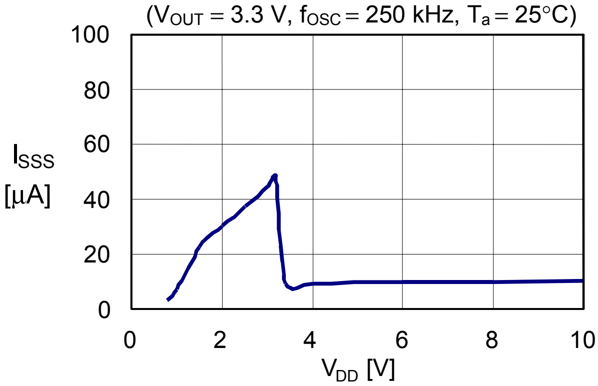

V_{OUT} vs. Ta (V_{OUT} = 3.3 V, f_{OSC} = 250 kHz)
V_{OUT} [V]
Ta [°C]
3.40
3.35
3.30
3.25
3.20
−40
−20
0
20
40
60
80
100

■ Examples of Major Power Supply Dependence Characteristics (Ta = 25°C)

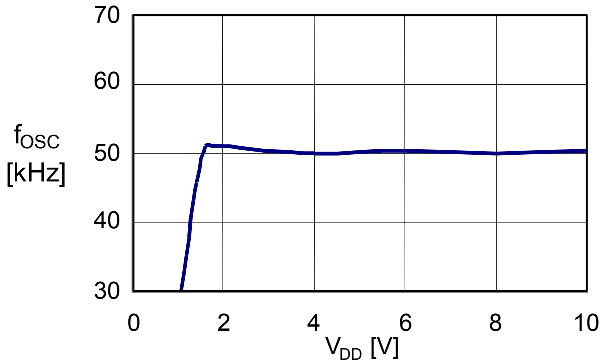
$I_{SS1,2}$ vs. V_{DD}
(V_{OUT} = 3.3 V, f_{OSC} = 50 kHz, T_a = 25°C)



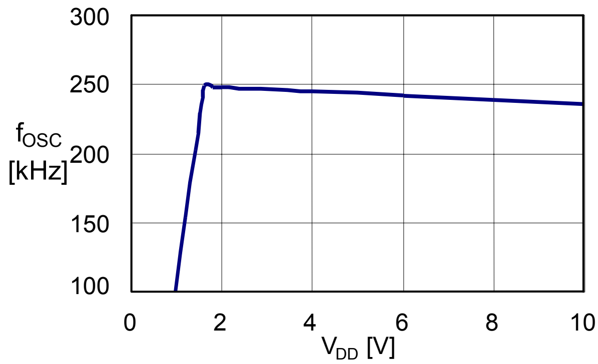
I_{SSS} vs. V_{DD}
(V_{OUT} = 3.3 V, f_{OSC} = 250 kHz, T_a = 25°C)



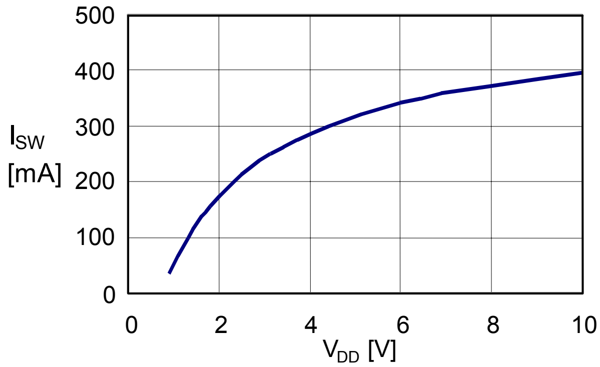
f_{OSC} vs. V_{DD} (f_{OSC} = 50 kHz)



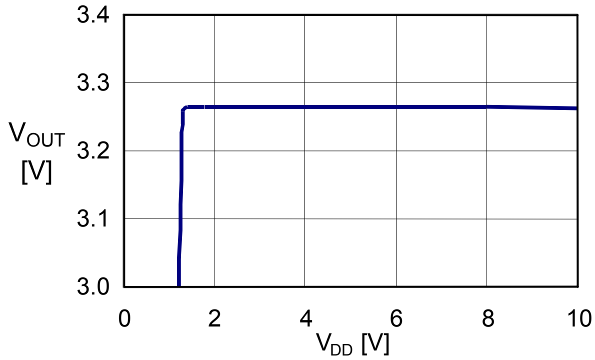
f_{OSC} vs. V_{DD} (f_{OSC} = 250 kHz)



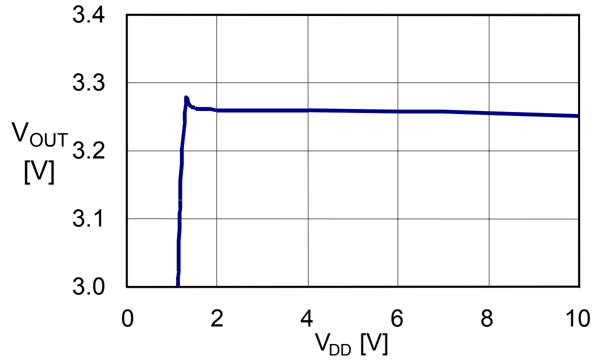
I_{SW} vs. V_{DD}



V_{OUT} vs. V_{DD}
(V_{OUT} = 3.3 V, f_{OSC} = 50 kHz, V_{DD} separate type)
V_{IN} = 1.98 V, I_{OUT} = 13.2 mA



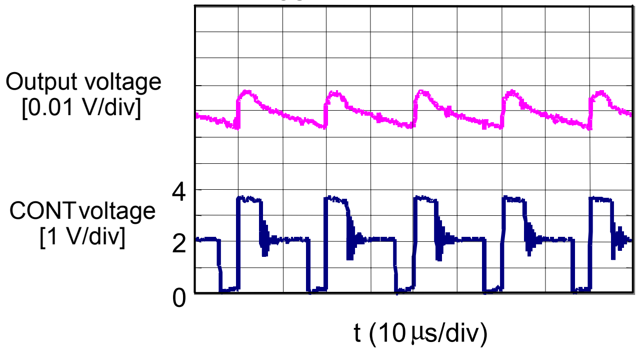
V_{OUT} vs. V_{DD}
(V_{OUT} = 3.3 V, f_{OSC} = 250 kHz, V_{DD} separate type)
V_{IN} = 1.98 V, I_{OUT} = 13.2 mA



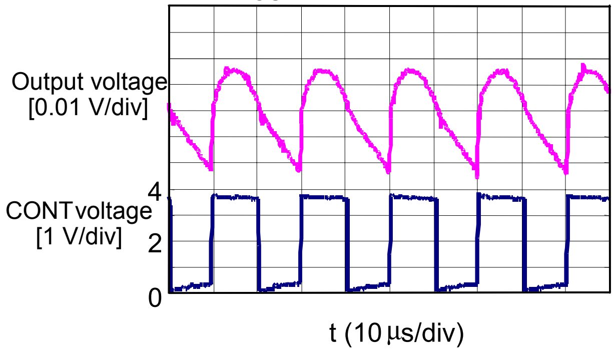
■ Output Waveforms

1. S-8353A33

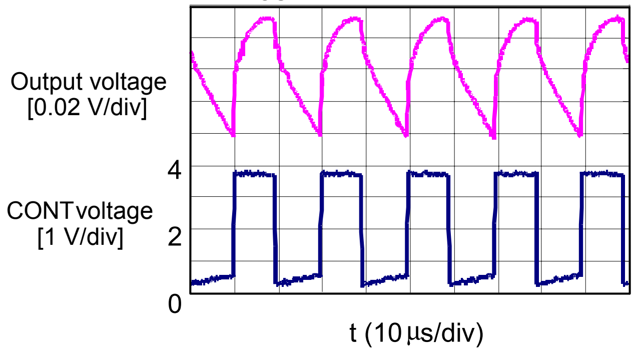
1. I_{OUT} = 10 mA V_{IN} = 1.98 V



2. I_{OUT} = 50 mA V_{IN} = 1.98 V

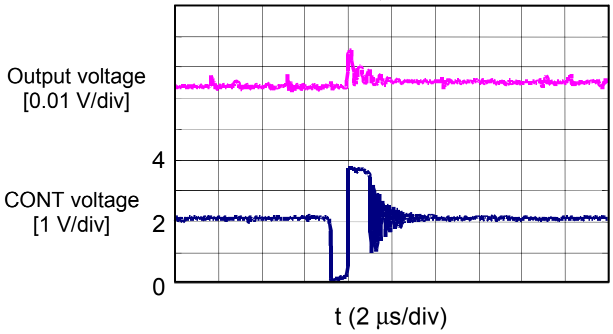


3. I_{OUT} = 100 mA V_{IN} = 1.98 V

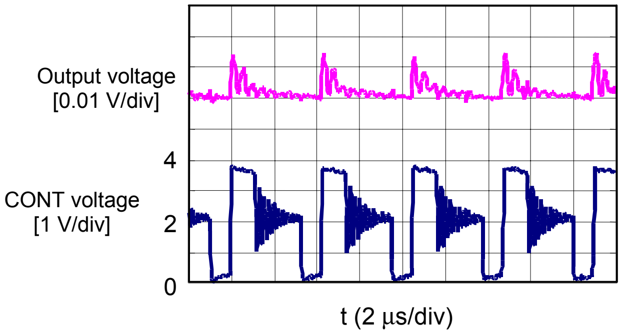


2. S-8354H33

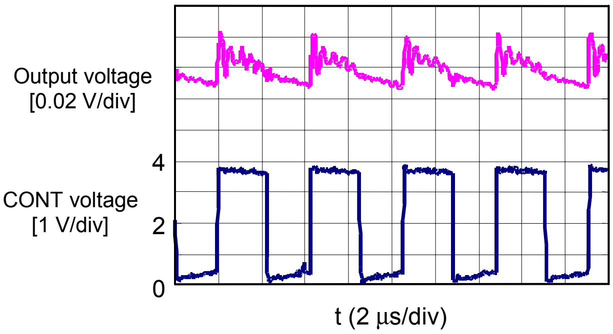
1. I_{OUT} = 100 µA V_{IN} = 1.98 V



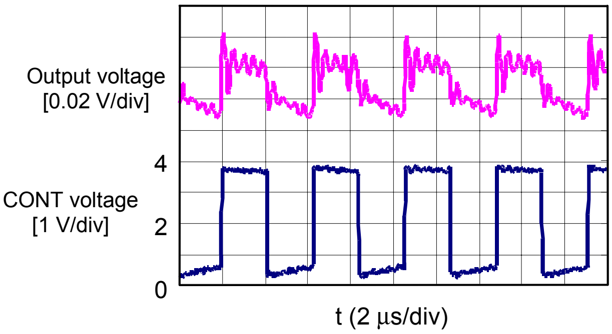
2. I_{OUT} = 10 mA V_{IN} = 1.98 V



3. I_{OUT} = 50 mA V_{IN} = 1.98 V

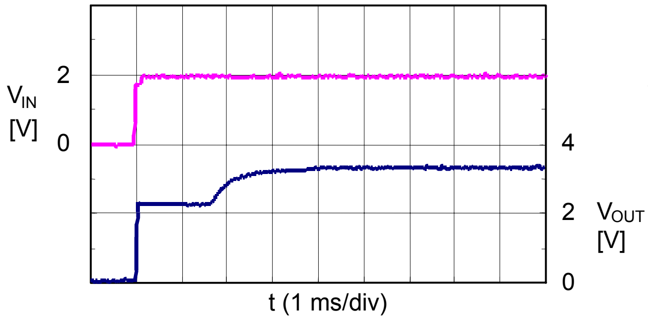


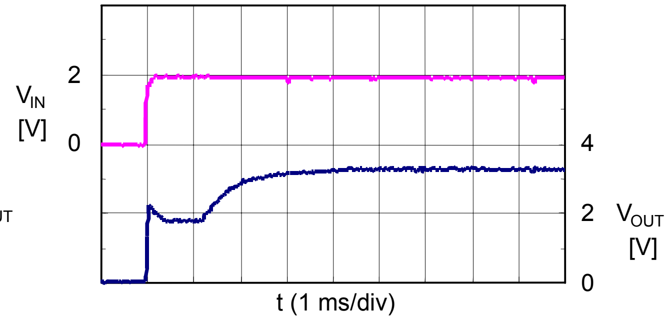
4. I_{OUT} = 100 mA V_{IN} = 1.98 V



■ Examples of Transient Response Characteristics (Ta = 25°C) (S-8354H33)

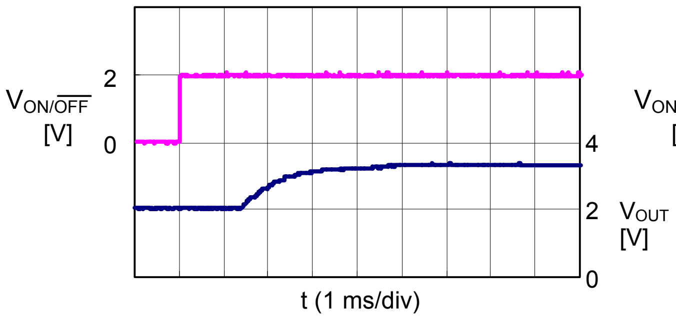
1. Power-On (V_{IN}; 0 V → 2.0 V)



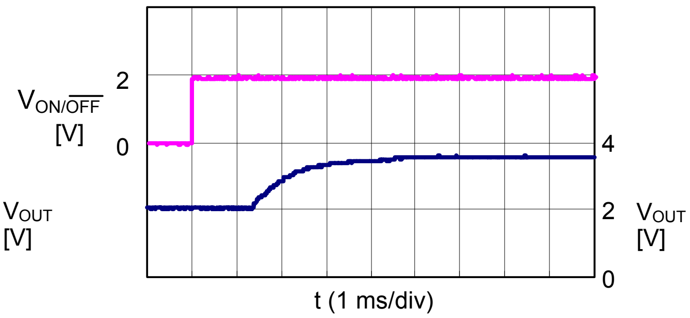


2. Shutdown Pin Response ($V_{ON/\overline{OFF}}$; 0 V → 2.0 V)

ON/$\overline{\text{OFF}}$ (250 kHz, I_{OUT} = 1 mA, V_{IN} = 2 V)



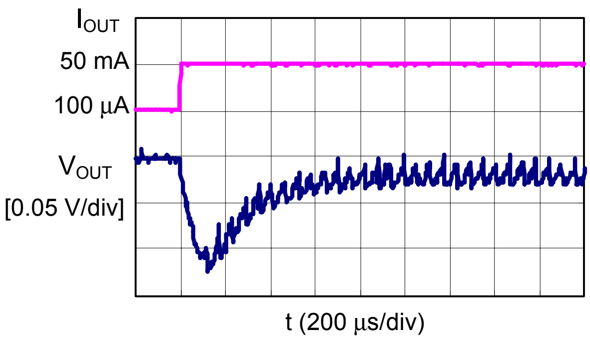
ON/$\overline{\text{OFF}}$ (250 kHz, I_{OUT} = 50 mA, V_{IN} = 2 V)



3. Load Fluctuations

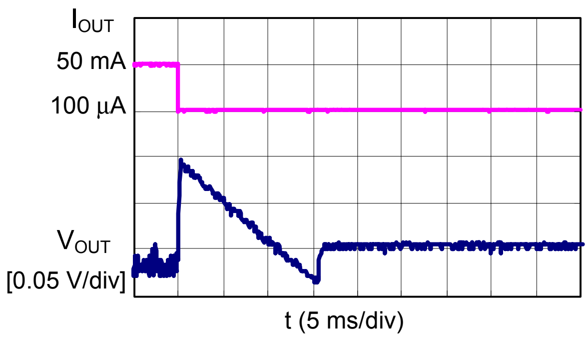
Load Fluctuation

(250 kHz, I_{OUT} ; 100 μA → 50 mA, V_{IN} = 1.98 V)



Load Fluctuation

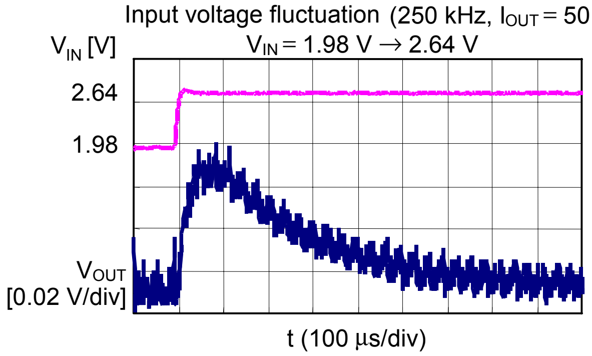
(250 kHz, I_{OUT} ; 50 mA → 100 μA, V_{IN} = 1.98 V)



4. Input Voltage Fluctuations

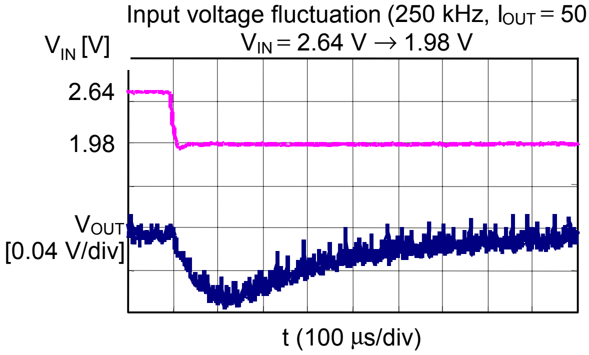
Input voltage fluctuation (250 kHz, I_{OUT} = 50 mA)

V_{IN} = 1.98 V → 2.64 V



Input voltage fluctuation (250 kHz, I_{OUT} = 50 mA)

V_{IN} = 2.64 V → 1.98 V



■ Reference Data

Reference data is provided to determine specific external components. Therefore, the following data shows the characteristics of the recommended external components selected for various applications.

1. Reference Data for External Components

Table 5. Efficiency vs. Output Characteristics and Output Voltage vs. Output Current Characteristics for External Components

No.	Product Name	Oscillation Frequency	Output Voltage	Control System	Inductor	Diode	Output Capacitor
1	S-8353H50MC	250 kHz	5.0 V	PWM	CDRH8D28-220	MA2Z748	F93 (16 V, 47 μF)
2	S-8353H50MC	250 kHz	5.0 V	PWM	CDRH5D28-220	MA2Z748	F93 (6.3 V, 22 μF)
3	S-8353H50MC	250 kHz	5.0 V	PWM	CXLP120-220	MA2Z748	F92 (6.3 V, 47 μF)
4	S-8354A50MC	50 kHz	5.0 V	PWM/PFM	CDRH8D28-101	MA2Z748	F93 (6.3 V, 22 μF)
5	S-8354A50MC	50 kHz	5.0 V	PWM/PFM	CXLP120-470	MA2Z748	F92 (6.3 V, 47 μF)
6	S-8353A50MC	50 kHz	5.0 V	PWM	CDRH8D28-101	MA2Z748	F93 (6.3 V, 22 μF)
7	S-8353A50MC	50 kHz	5.0 V	PWM	CXLP120-470	MA2Z748	F92 (6.3 V, 47 μF)
8	S-8353A33MC	50 kHz	3.3 V	PWM	CDRH8D28-101	MA2Z748	F93 (6.3 V, 22 μF)

The performance of the external components is shown below.

Table 6. Properties of External Components

Component	Product Name	Manufacturer	Characteristics
Inductor	CDRH8D28-220	Sumida Corporation	22 μH, DCR[*1] = 95 mΩ, Imax[*2] = 1.6 A, Component height = 3.0 mm
	CDRH8D28-101	Sumida Corporation	100 μH, DCR[*1] = 410 mΩ, Imax[*2] = 0.75 A, Component height = 3.0 mm
	CDRH5D28-220	Sumida Corporation	22 μH, DCR[*1] = 122 mΩ, Imax[*2] = 0.9 A, Component height = 3.0 mm
	CXLP120-220	Sumitomo Special Metals Co., Ltd.	22 μH, DCR[*1] = 590 mΩ, Imax[*2] = 0.55 A, Component height = 1.2 mm
	CXLP120-470	Sumitomo Special Metals Co., Ltd.	47 μH, DCR[*1] = 950 mΩ, Imax[*2] = 0.45 A, Component height = 1.2 mm
Diode	MA2Z748	Matsushita Electric Industrial Co., Ltd.	V_F[*3] = 0.4 V, I_F[*4] = 0.3 A
Capacitor	F93 (16 V, 47 μF)	Nichicon Corporation	
	F93 (6.3 V, 22 μF)	Nichicon Corporation	
	F92 (6.3 V, 47 μF)	Nichicon Corporation	

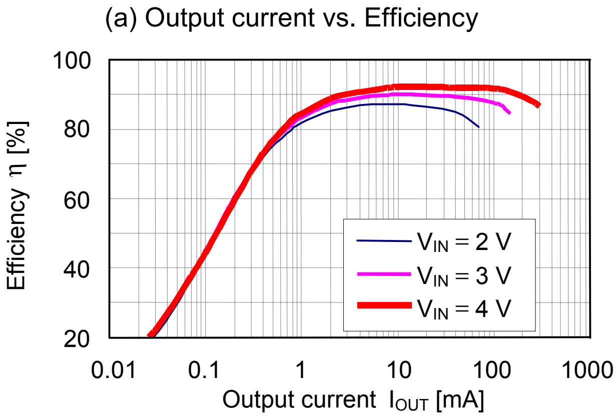
*1. DC resistance
*2. Maximum allowable current
*3. Forward voltage
*4. Forward current

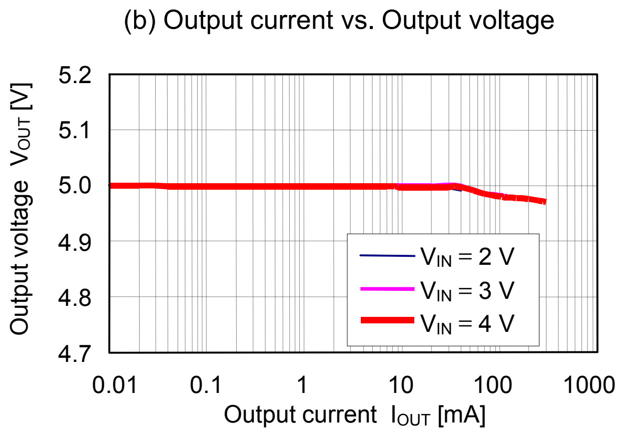
Caution The values shown in the characteristics column of Table 6 above are based on the materials provided by each manufacturer, however, consider the characteristics of the original materials when using the above products.

2. Reference Data 1

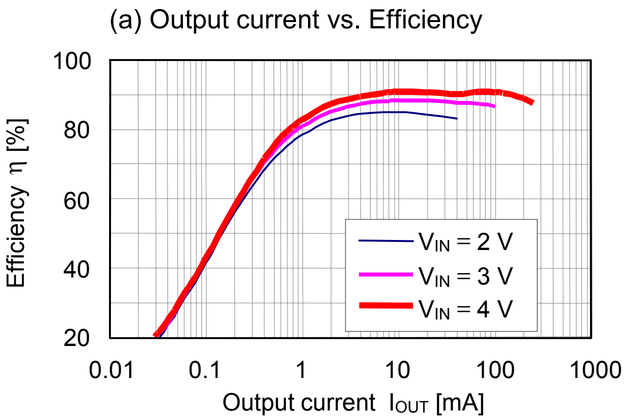
The following shows the actual (a) Output current vs. efficiency characteristics and (b) Output current vs. output voltage characteristics under the conditions of No. 1 to 8 in Table 5.

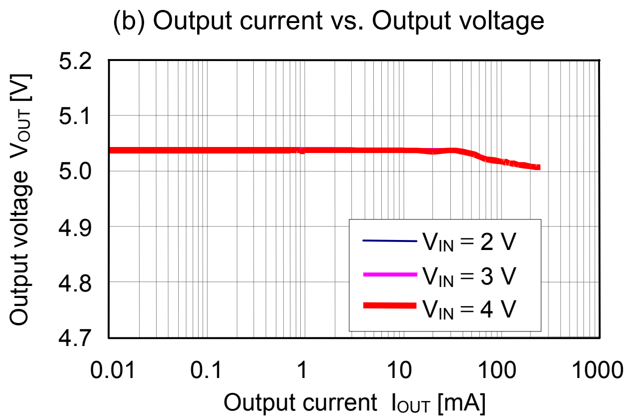
(1) S-8353H50MC



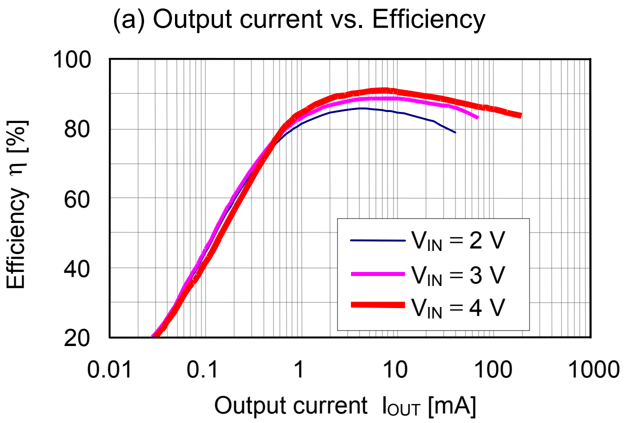


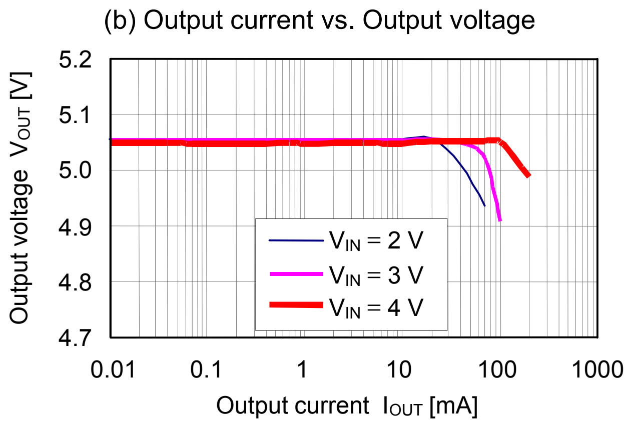
(2) S-8353H50MC





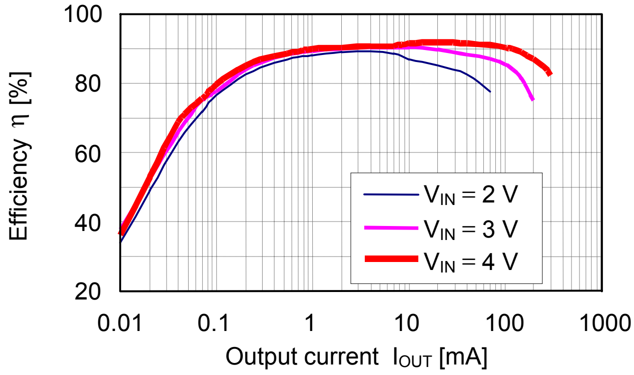
(3) S-8353H50MC



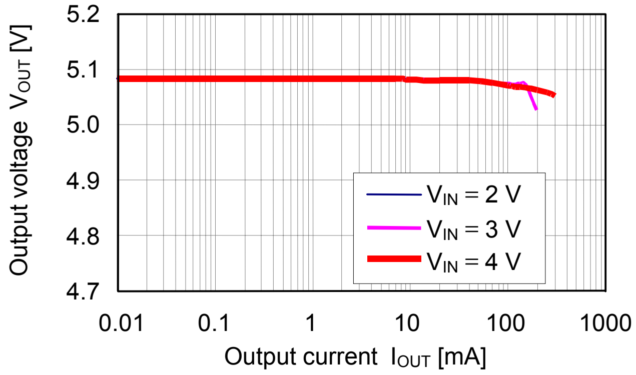


(4) S-8354A50MC

(a) Output current vs. Efficiency

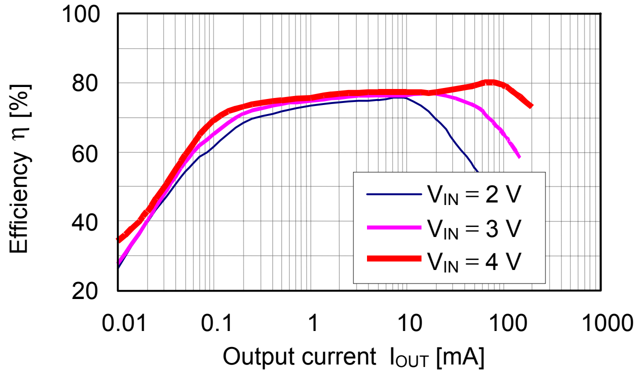


(b) Output current vs. Output voltage

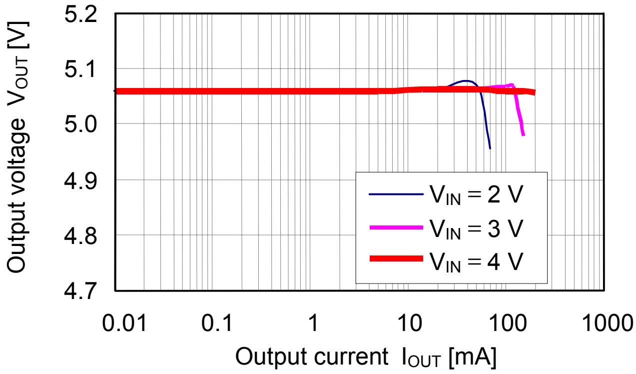


(5) S-8354A50MC

(a) Output current vs. Efficiency

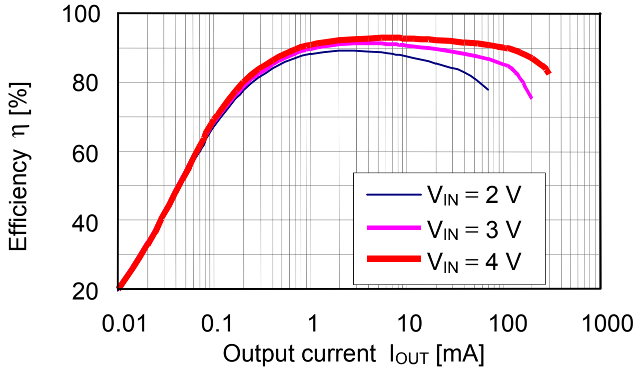


(b) Output current vs. Output voltage

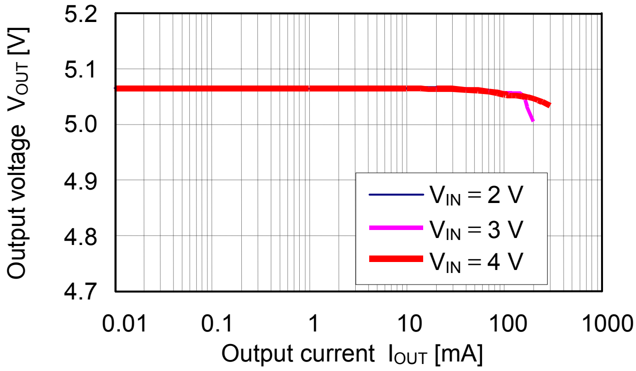


(6) S-8353A50MC

(a) Output current vs. Efficiency

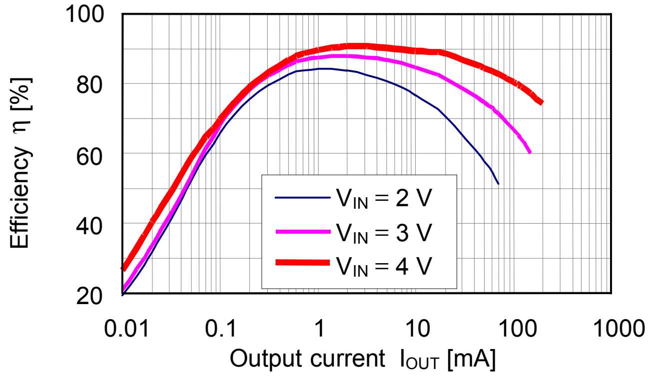


(b) Output current vs. Output voltage

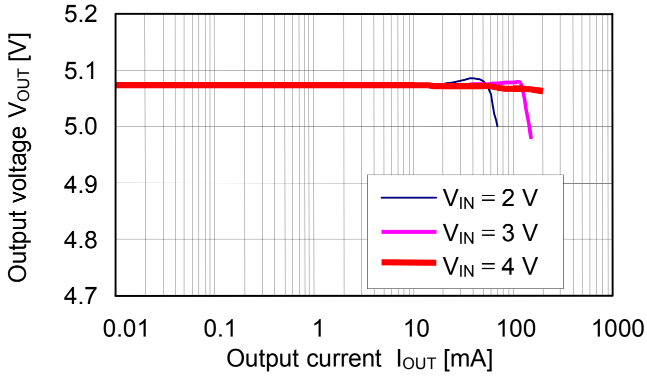


(7) S-8353A50MC

(a) Output current vs. Efficiency

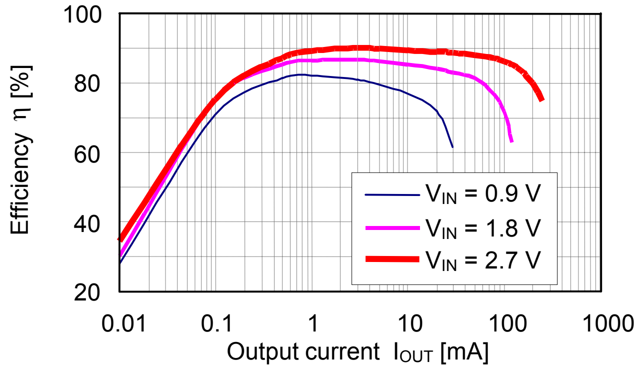


(b) Output current vs. Output voltage

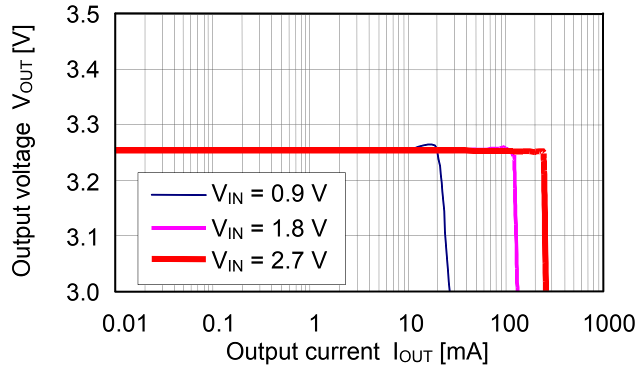


(8) S-8354A33MC

(a) Output current vs. Efficiency



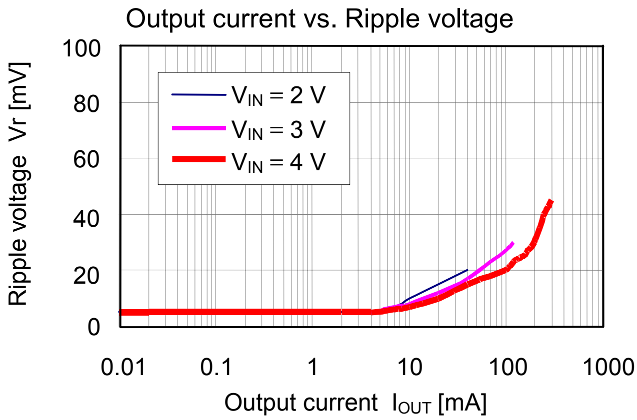
(b) Output current vs. Output voltage



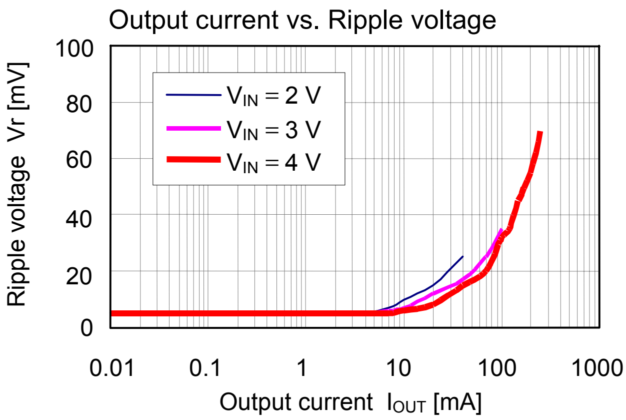
3. Reference Data 2

The following shows the actual output current vs. ripple voltage characteristics under the conditions of No. 1 to 8 in Table 5.

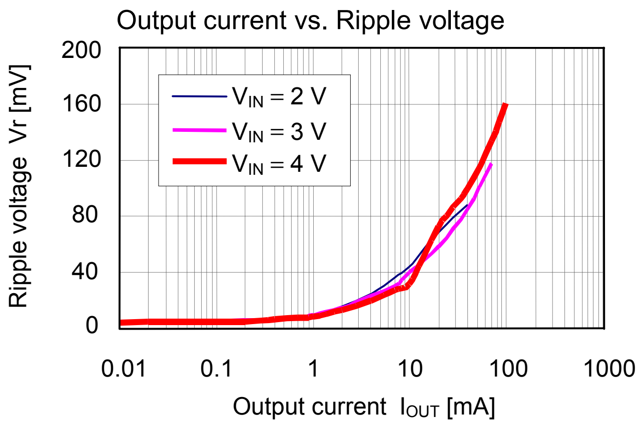
(1) S-8353H50MC



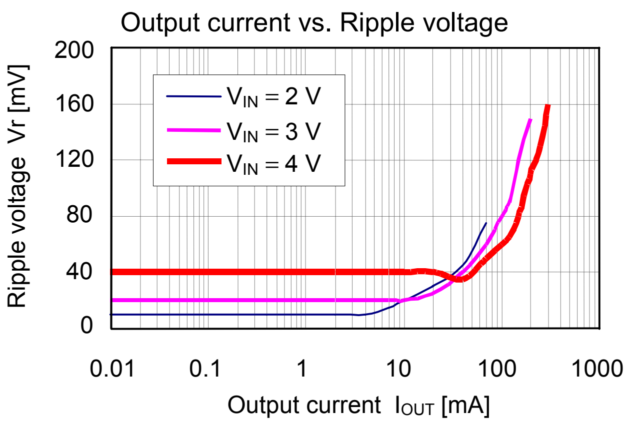
(2) S-8353H50MC



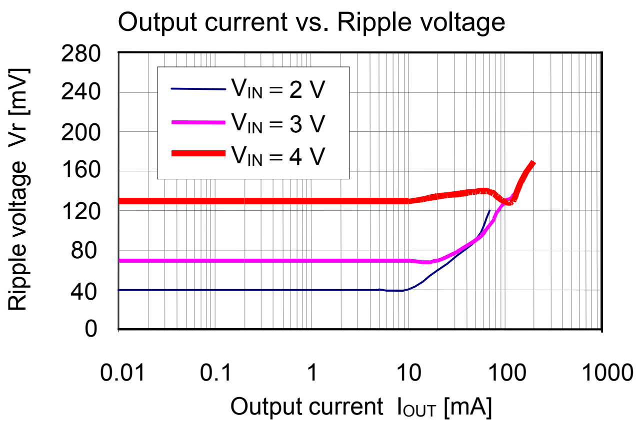
(3) S-8353H50MC



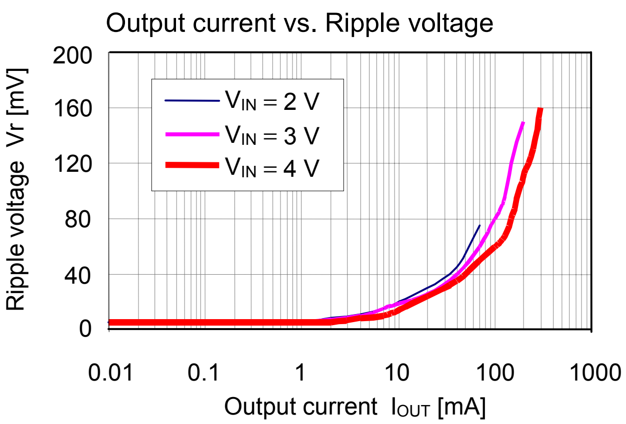
(4) S-8354A50MC



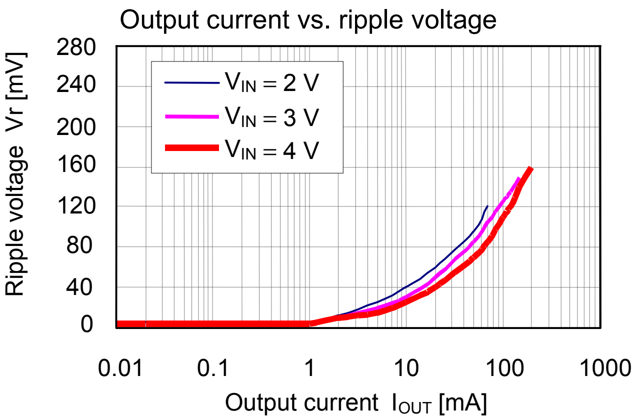
(5) S-8354A50MC



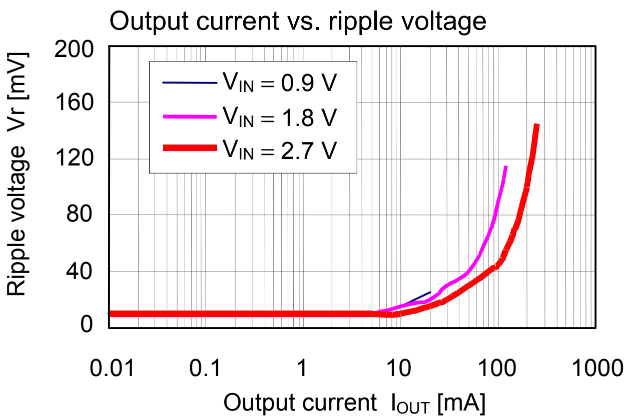
(6) S-8353A50MC



(7) S-8353A50MC



(8) S-8353A33MC

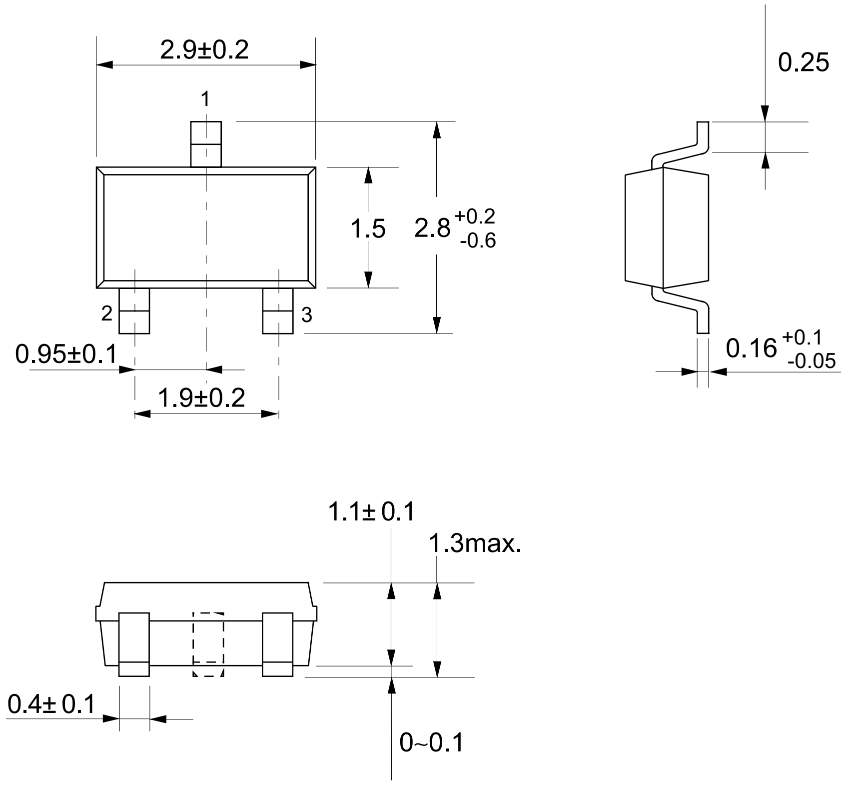


■ SOT-23-3

MP003-A 990531

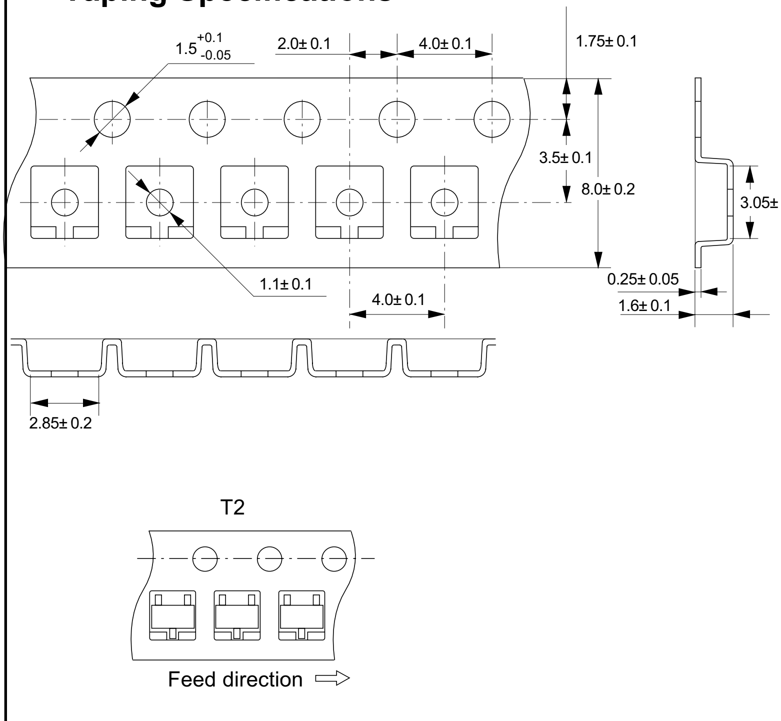
●Dimensions

Unit:mm



No.:MP003-A-P-SD-1.0

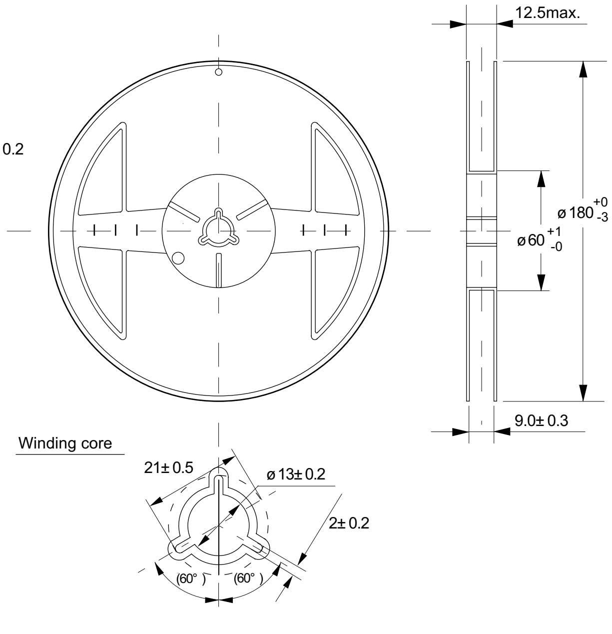
●Taping Specifications



No.:MP003-A-C-SD-1.0

●Reel Specifications

1 reel holds 3000 ICs.



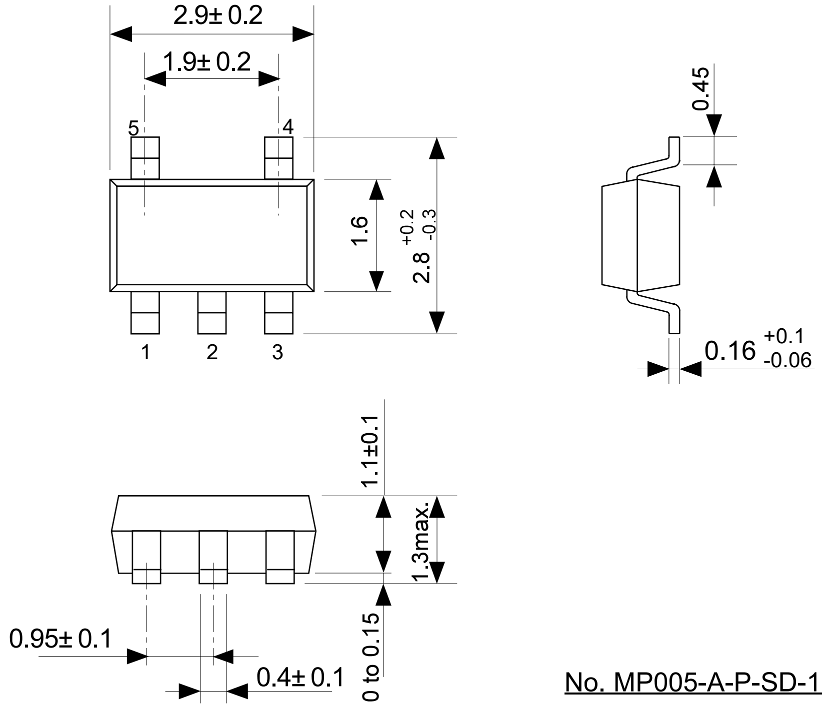
No.:MP003-A-R-SD-1.0

■ SOT-23-5

MP005-A 010907

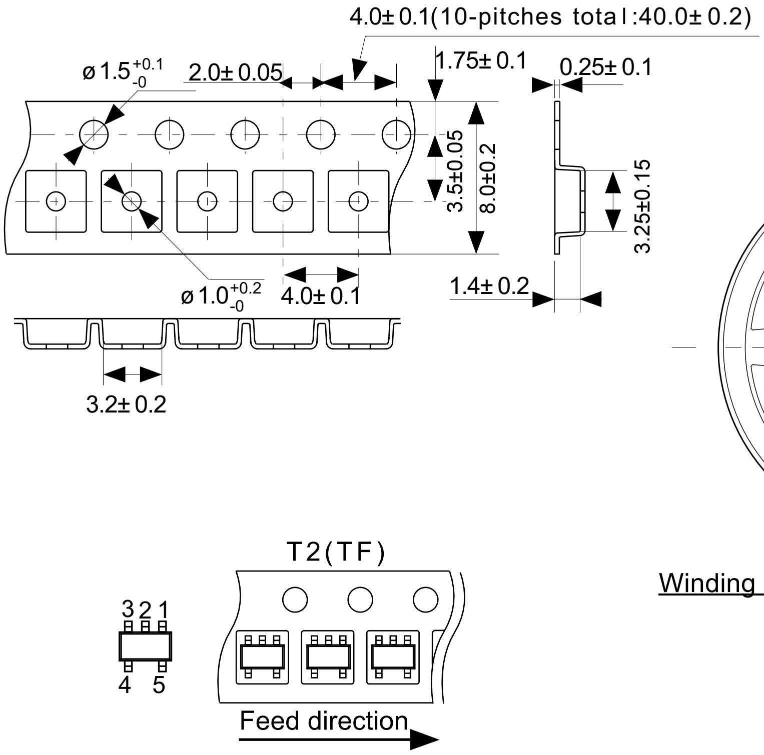
● Dimensions

Unit : mm



No. MP005-A-P-SD-1.1

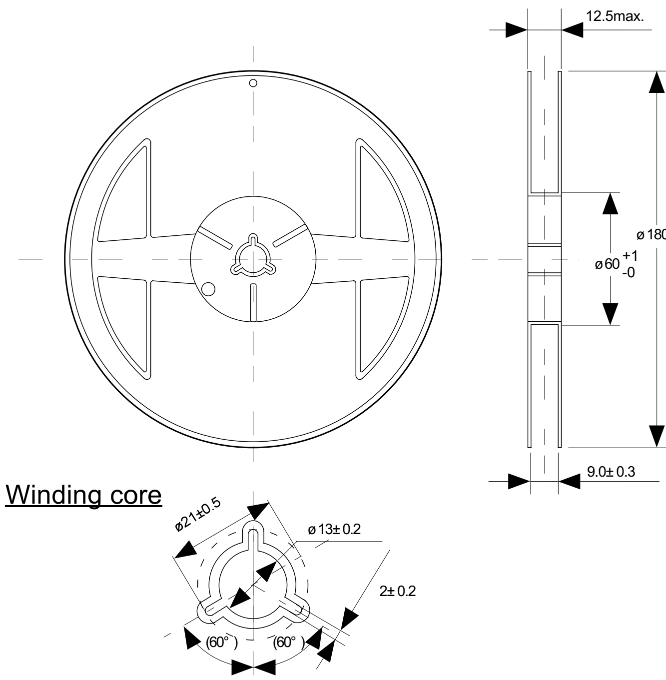
● Tape Specifications



No. : MP005-A-C-SD-2.0

● Reel Specifications

3000 pcs./reel



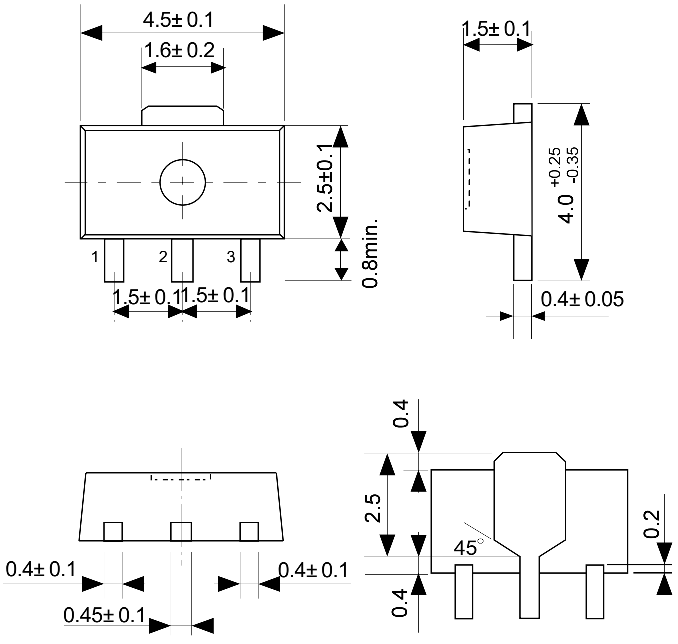
No. MP005-A-R-SD-1. 0

■ SOT-89-3

UP003-A Rev.1.0 020109

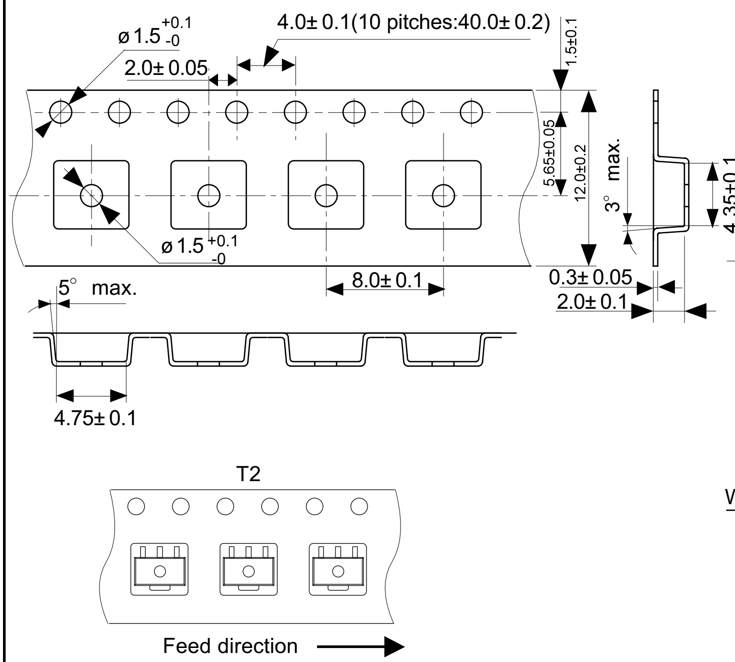
●Dimensions

Unit:mm



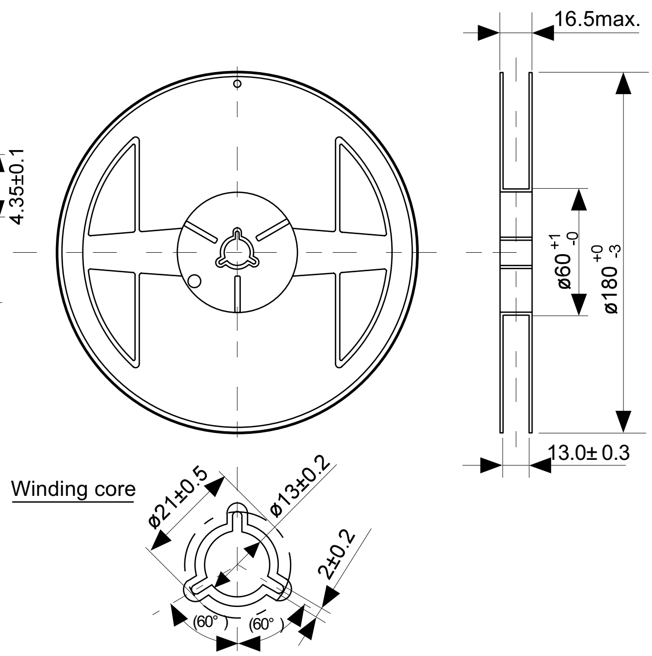
No. UP003-A-P-SD-1.0

●Taping Specifications



●Reel Specifications

1 reel holds 1000 ICs.



No. UP003-A-C-SD-1.0

No. UP003-A-R-SD-1.0