SMALL PACKAGE PWM/PFM CONTROL STEP-UP SWITCHING REGULATOR

S-8324/8328 Series

The S-8324/8328 is a series of CMOS PWM/PFM-control step-up switching regulators which mainly consist of a reference voltage source, an oscillation circuit, a power MOS FET (S-8324 Series) and an error amplifier. The new method PWM/PFM control circuit automatically switches the control method according to the current load, offering products of a wide range, high efficiency. A step-up switching regulator is constructed by externally connecting only a coil, a capacitor and a diode to the S-8324 Series. This feature, along with its small package and low current consumption, makes the S-8324 Series ideal for the power supply of portable equipment. For applications requiring a high output current, products used with an external transistor (S-8328 Series) are also available.

■ Features

- Low voltage operation:
  0.9 V (I_{OUT}=1 mA, 50 kHz and 100 kHz models)
- Low current consumption:
  During operation: 17.2 µA (typ.)
  (V_{OUT} = 3 V, 50 kHz)
  During shutdown: 0.5 µA (max.)
- Low Input current: 10.4 µA (typ.)
  (V_{OUT} = 3 V, 50 kHz, no load)
- Duty ratio:
  During PWM control: 15 to 83% typ.
  (15 to 78% for 250kHz model)
  During PFM control: 15 % typ.
- External parts: coil, diode, and capacitor only
  (a transistor is needed for the S-8328 Series.)
- Output voltage: accuracy of ±2.4%
- Oscillation frequency:
  30 kHz, 50 kHz, 100 kHz, and 250 kHz
- Software start function is built-in
- Shutdown function
- External transistor type is available (S-8328 Series)
- SOT-23-5 small plastic package
- SOT-23-3 small plastic package
- SOT-89-3 miniature power molded plastic package
- Step-down and invert type are also available.

■ Applications

- Power supplies for portable equipment such as pagers, handy calculators, and remote controllers
- Constant voltage power supplies for cameras, video equipment, and communications equipment
- Power supply for microcomputers

■ Block Diagram

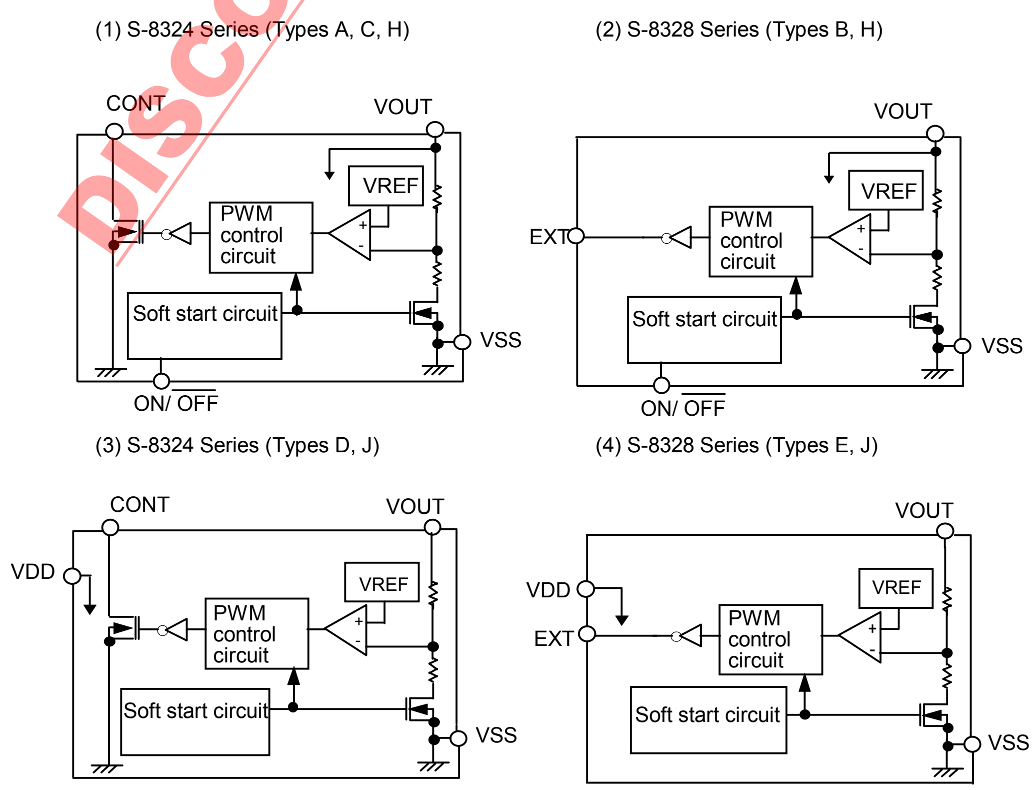


Figure 1 Block Diagram

■ Selection Guide

1. Product Name

S-832 x x xx xx - xxx - T2

- Tape Specification
- Product name (abbreviation)
- Package name (abbreviation)
  - MA : SOT-23-3 (without shutdown function)
  - MC : SOT-23-5 (with shutdown function, V_{DD}/V_{OUT} separate product)
  - UA : SOT-89-3 (without shutdown function)
- Output voltage (symbol) ×10
- Product category
  - A : Normal product, fosc=50 kHz (S-8324 only)
  - B : Normal product, fosc=100 kHz (S-8328 only)
  - C : For pagers, fosc=30 kHz (S-8324 only)
  - D : V_{DD}/V_{OUT} separate product, fosc=50 kHz (S-8324 only)
  - E : V_{DD}/V_{OUT} separate product, fosc=100 kHz (S-8328 only)
  - H : Normal product, fosc=250 kHz (S-8324/8)
  - J : V_{DD}/V_{OUT} separate product, fosc=250 kHz (S-8324/8)
- Power transistor
  - 4: Built-in PWM/PFM control switch.
  - 8: PWM/PFM control switch with an external transistor.

Product Name	Built In power transistor	with external power transistor	Switching frequency (KHz)	Shutdown function	V_{DD}/V_{OUT} separate type	Package	Application
S-8324AxxMC	Yes	—	50	Yes	—	SOT-23-5	With a shutdown function
S-8324AxxMA	Yes	—	50	—	—	SOT-23-3	without shutdown function
S-8324AxxUA	Yes	—	50	—	—	SOT-89-3	without shutdown function
S-8324DxxMC	Yes	—	50	—	Yes	SOT-23-5	For variable output voltage by step-up DC/DC converter and step-down inverted output DC/DC converter with an external resistor
S-8324CxxMA	Yes	—	30	—	—	SOT-23-3	For pagers
S-8324HxxMC	Yes	—	250	Yes	—	SOT-23-5	With a shutdown function
S-8324JxxMC	Yes	—	250	—	Yes	SOT-23-5	For variable output voltage by step-up DC/DC converter and step-down inverted output DC/DC converter with an external resistor
S-8328BxxMC	—	Yes	100	Yes	—	SOT-23-5	For large load current with shutdown function
S-8328BxxMA	—	Yes	100	—	—	SOT-23-3	For large load current without shutdown function
S-8328BxxUA	—	Yes	100	—	—	SOT-89-3	For large load current without shutdown function
S-8328ExxMC	—	Yes	100	—	Yes	SOT-23-5	For variable output voltage by step-up DC/DC converter with an external resistor
S-8328HxxMC	—	Yes	250	Yes	—	SOT-23-5	For large load current without shutdown function
S-8328JxxMC	—	Yes	250	—	Yes	SOT-23-5	For variable output voltage by step-up DC/DC converter with an external resistor

3. Product Name List

Output voltage (V)	S-8324AxxMC Series	S-8324AxxMA Series	S-8324AxxUA Series	S-8324CxxMA Series	S-8324DxxMC Series
2.0	—	—	—	—	S-8324D20MC-E2A-T2
2.5	S-8324A25MC-EOF-T2	S-8324A25MA-EOF-T2	S-8324A25UA-EOF-T2	S-8324C25MA-EQF-T2	—
2.7	S-8324A27MC-EOH-T2	S-8324A27MA-EOH-T2	S-8324A27UA-EOH-T2	S-8324C27MA-EQH-T2	—
2.8	S-8324A28MC-EOI-T2	—	S-8324A28UA-EOI-T2	—	—
3.0	S-8324A30MC-EOK-T2	S-8324A30MA-EOK-T2	S-8324A30UA-EOK-T2	S-8324C30MA-EQK-T2	S-8424D30MC-E2K-T2
3.3	S-8324A33MC-EON-T2	S-8324A33MA-EON-T2	S-8324A33UA-EON-T2	—	—
5.0	S-8324A50MC-EPE-T2	S-8324A50MA-EPE-T2	S-8324A50UA-EPE-T2	—	S-8324D50MC-E4E-T2

Output voltage (V)	S-8324HxxMC Series	S-8324JxxMC Series
2.5	—	S-8324J25MC-FUF-T2
3.0	S-8324H30MC-F6K-T2	S-8324J30MC-FUK-T2
3.3	S-8324H33MC-F6N-T2	S-8324J33MC-FUN-T2
5.0	S-8324H50MC-F7E-T2	S-8324J50MC-FVE-T2
5.2	S-8324H52MC-F7G-T2	—
5.3	S-8324H53MC-F7H-T2	—
5.4	S-8324H54MC-F7I-T2	—
5.5	S-8324H55MC-F7J-T2	—

Output voltage (V)	S-8328BxxMC Series	S-8328BxxMA Series	S-8328BxxUA Series	S-8328ExxMC Series
2.0	—	—	—	S-8328E20MC-EYA-T2
2.4	S-8328B24MC-EWE-T2	—	—	—
2.5	S-8328B25MC-EWF-T2	S-8328B25MA-EWF-T2	S-8328B25UA-EWF-T2	—
2.7	S-8328B27MC-EWH-T2	S-8328B27MA-EWH-T2	S-8328B27UA-EWH-T2	—
2.8	S-8328B28MC-EWI-T2	—	—	—
3.0	S-8328B30MC-EWK-T2	S-8328B30MA-EWK-T2	S-8328B30UA-EWK-T2	—
3.2	S-8328B32MC-EWM-T2	—	—	—
3.3	S-8328B33MC-EWN-T2	S-8328B33MA-EWN-T2	S-8328B33UA-EWN-T2	—
3.4	S-8328B34MC-EWO-T2	—	—	—
3.6	S-8328B36MC-EWQ-T2	—	—	—
3.8	S-8328B38MC-EWS-T2	—	—	—
4.9	S-8328B49MC-EXD-T2	—	—	—
5.0	S-8328B50MC-EXE-T2	S-8328B50MA-EXE-T2	S-8328B50UA-EXE-T2	S-8328E50MC-E9E-T2
5.1	S-8328B51MC-EXF-T2	—	—	—
5.2	S-8328B52MC-EXG-T2	—	—	—
5.4	S-8328B54MC-EXI-T2	—	—	—
5.5	S-8328B55MC-EXJ-T2	—	—	—

Output voltage (V)	S-8328HxxMC Series	S-8328JxxMA Series
2.5	S-8328H25MC-FYF-T2	S-8328J25MC-F2F-T2
3.0	S-8328H30MC-FYK-T2	S-8328J30MC-F2K-T2
3.2	S-8328H32MC-FYM-T2	—
3.3	S-8328H33MC-FYN-T2	S-8328J33MC-F2N-T2
5.0	S-8328H50MC-FZE-T2	S-8328J50MC-F3E-T2
5.5	S-8328H55MC-FZJ-T2	—

Consult our sales person for products with an output voltage other than specified above.

■ Pin Assignment

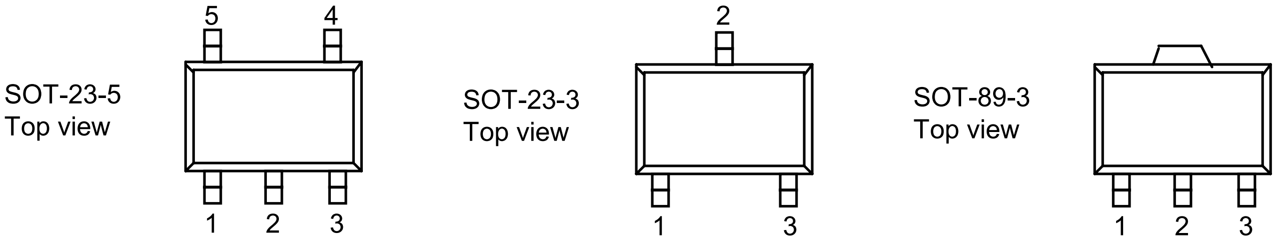


Figure 2

Product Names; S-8324AXxxMC / S-8328BxxMC
S-8324HxxMC / S-8328HxxMC
Package; SOT-23-5

Pin No.	Pin name	Functions
1	ON / $\overline{\text{OFF}}$	Shutdown pin "H": normal operation (stepping up operation) "L": stop stepping up (whole circuit stop)
2	VOUT	Output voltage pin and power supply pin
3	-	N.C. (Non Connection)
4	VSS	GND pin
5	CONT	External inductor connection pin (for S-8324 Series)
	EXT	External transistor connection pin (for S-8328 Series)

Product Names; S-8324DxxMC / S-8328ExxMC
S-8324JxxMC / S-8328JxxMC
Package; SOT-23-5

Pin No.	Pin name	Functions
1	VOUT	Output voltage pin
2	VDD	Power supply pin
3	-	N.C. (Non Connection)
4	VSS	GND pin
5	CONT	External inductor connection pin (for S-8324 Series)
	EXT	External transistor connection pin (for S-8328 Series)

Product Names; S-8324AXXMA/S-8324AxxUA / S-8324CxxMA
S-8328BxxMA / S-8328BxxUA
Packages; SOT-23-3, SOT-89-3

Pin No.	Pin name	Functions
1	VSS	GND pin
2	VOUT	Output voltage pin and power supply pin
3	CONT	External inductor connection pin (for S-8324 Series)
	EXT	External transistor connection pin (for S-8328 Series)

■ Absolute Maximum Ratings

Note: Although the IC contains protection circuit against static electricity, excessive static electricity or voltage which exceeds the limit of the protection circuit should not be applied to.

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol		Ratings	Unit
VOUT, VDD pin voltage	V_{OUT}, V_{DD}		V_{SS}+11	V
ON/$\overline{\text{OFF}}$ pin voltage	$V_{ON/\overline{OFF}}$		V_{ss}-0.3 to V_{SS}+11	V
CONT pin voltage	V_{CONT}		V_{SS}+11	V
CONT pin current	I_{CONT}		300	mA
EXT pin voltage	V_{EXT}		V_{ss}-0.3 to V_{OUT}+0.3	V
EXT pin current	I_{EXT}		±50	mA
Power dissipation	PD	SOT-89-3	500	mW
		SOT-23-5, SOT-23-3	150	
Operating temperature	T_{OPR}		-40 to +85	°C
Storage temperature	T_{STG}		-40 to +125	°C

■ Electrical Characteristics

1-1. S-8324AxxMC

(Unless otherwise specified: Ta=25 °C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}		S-8324A50MC	4.880	5.000	5.120	V	1
			S-8324A33MC	3.221	3.300	3.379		
			S-8324A30MC	2.928	3.000	3.072		
			S-8324A28MC	2.733	2.800	2.867		
			S-8324A27MC	2.635	2.700	2.765		
			S-8324A25MC	2.440	2.500	2.560		
Input voltage	V_{IN}			—	—	9		
Operation start voltage	V_{ST1}	I_{OUT}=1 mA		—	—	0.9		
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT} CONT pulled up to 5 V by 10 kΩ		—	—	0.8		2
Operation holding voltage	V_{HLD}	I_{OUT}=1 mA, Measured by decreasing V_{IN} voltage gradually		0.7	—	—		1
Input current at no load	I_{IN}	No load	S-8324A50MC	—	10.5	21.1	μA	—
			S-8324A33MC	—	10.4	20.8		
			S-8324A30MC	—	10.4	20.7		
			S-8324A28MC	—	10.5	21.0		
			S-8324A27MC	—	10.5	21.1		
			S-8324A25MC	—	10.5	21.0		
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8324A50MC	—	30.2	50.3		2
			S-8324A33MC	—	19.1	31.8		
			S-8324A30MC	—	17.2	28.7		
			S-8324A28MC	—	16.1	26.8		
			S-8324A27MC	—	15.5	25.9		
			S-8324A25MC	—	14.3	23.9		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8324A50MC	—	3.5	6.9		
			S-8324A33MC	—	3.3	6.5		
			S-8324A30MC	—	3.2	6.4		
			S-8324A28MC	—	3.2	6.4		
			S-8324A27MC	—	3.2	6.4		
			S-8324A25MC	—	3.2	6.3		
Current consumption during shutdown	I_{SSS}	$V_{ON/\overline{OFF}}$=0 V		—	—	0.5		
Switching current	I_{SW}	V_{CONT}=0.4 V	S-8324A50MC	114	182	—	mA	—
			S-8324A33MC	78	125	—		
			S-8324A30MC	78	125	—		
			S-8324A28MC	61	98	—		
			S-8324A27MC	61	98	—		
			S-8324A25MC	61	98	—		
Switching transistor leak current	I_{SWQ}	V_{OUT}= V_{CONT}=10 V		—	—	1.0	μA	
Line regulation	ΔV_{OUT1}	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV	1
Load regulation	ΔV_{OUT2}	I_{OUT}=10μA to I_{OUT}(below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\Delta V_{OUT}/\Delta Ta$	Ta=-40°C to +85°C	S-8324A50MC	—	±0.25	—	mV/°C	
			S-8324A33MC	—	±0.17	—		
			S-8324A30MC	—	±0.15	—		
			S-8324A28MC	—	±0.14	—		
			S-8324A27MC	—	±0.14	—		
			S-8324A25MC	—	±0.13	—		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		42.5	50	57.5	kHz	2
Max duty ratio	MaxDuty	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		75	83	90	%	
PWM/PFM control switch duty ratio	PFMDuty	V_{IN}= output voltage -0.1 V No load		5	15	24		1
Shutdown pin	V_{SH}	V_{OUT}=output voltage×0.95 Judged the oscillation at CONT pin		0.75	—	—	V	2
Input voltage (ON/OFF type)	V_{SL1}	V_{OUT}=output voltage×0.95	When V_{OUT}≥1.5 V	—	—	0.3		
	V_{SL2}	Judged the stop of oscillation at CONT pin	When V_{OUT}<1.5 V	—	—	0.2		
Soft start time	t_{SS}			3.0	6.0	12.0	ms	—
Efficiency	EFFI		S-8324A50MC	—	87	—	%	1
			S-8324A33MC	—	83	—		
			S-8324A30MC	—	83	—		
			S-8324A28MC	—	79	—		
			S-8324A27MC	—	79	—		
			S-8324A25MC	—	79	—		

External parts used:
- -Coil: CD54 (100 μH) of Sumida Corporation
- -Diode: MA720 (Schottky type) of Matsushita Electric Industrial Co., Ltd.
- -Capacitor: F93 (16 V, 22 μF, tantalum type) of Nichicon Corporation

Applied V_{IN}=output voltage×0.6, I_{OUT}=output voltage/250 Ω
The shutdown pin is connected to VOUT pin.

Note 1: The output voltage specified above is the typical value.

1-2. S-8324AxxMA, S-8324AxxUA, S-8324DxxMC

(Unless otherwise specified: Ta=25 °C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}		S-8324x50xx	4.880	5.000	5.120	V	1
			S-8324x33xx	3.221	3.300	3.379		
			S-8324x30xx	2.928	3.000	3.072		
			S-8324x27xx	2.635	2.700	2.765		
			S-8324x25xx	2.440	2.500	2.560		
			S-8324x20xx	1.952	2.000	2.048		
Input voltage	V_{IN}			—	—	9		
Operation start voltage	V_{ST1}	I_{OUT}=1 mA		—	—	0.9		
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT} CONT pulled up to 5 V by 10kΩ		—	—	0.8		2
Operation holding voltage	V_{HLD}	I_{OUT}=1 mA, Measured by decreasing V_{IN} voltage gradually		0.7	—	—		1
Input current at no load	I_{IN}	No load	S-8324x50xx	—	10.5	21.1	µA	—
			S-8324x33xx	—	10.4	20.8		
			S-8324x30xx	—	10.4	20.7		
			S-8324x27xx	—	10.5	21.1		
			S-8324x25xx	—	10.5	21.0		
			S-8324x20xx	—	10.8	21.5		
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8324x50xx	—	30.2	50.3		2
			S-8324x33xx	—	19.1	31.8		
			S-8324x30xx	—	17.2	28.7		
			S-8324x27xx	—	15.5	25.9		
			S-8324x25xx	—	14.3	23.9		
			S-8324x20xx	—	11.6	19.4		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8324x50xx	—	3.5	6.9		
			S-8324x33xx	—	3.3	6.5		
			S-8324x30xx	—	3.2	6.4		
			S-8324x27xx	—	3.2	6.4		
			S-8324x25xx	—	3.2	6.3		
			S-8324x20xx	—	3.1	6.2		
Switching current	I_{SW}	V_{CONT}=0.4 V	S-8324x50xx	114	182	—	mA	—
			S-8324x33xx	78	125	—		
			S-8324x30xx	78	125	—		
			S-8324x27xx	61	98	—		
			S-8324x25xx	61	98	—		
			S-8324x20xx	45	71	—		
Switching transistor leak current	I_{SWQ}	V_{OUT}= V_{CONT}=10 V		—	—	1.0	µA	
Line regulation	ΔV_{OUT1}	V_{IN}= output voltage ×0.4 to ×0.6		—	30	60	mV	1
Load regulation	ΔV_{OUT2}	I_{OUT}=10µA to I_{OUT} (below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\Delta V_{OUT}/\Delta Ta$	Ta=-40°C to +85°C	S-8324x50xx	—	±0.25	—	mV/°C	
			S-8324x33xx	—	±0.17	—		
			S-8324x30xx	—	±0.15	—		
			S-8324x27xx	—	±0.14	—		
			S-8324x25xx	—	±0.13	—		
			S-8324x20xx	—	±0.10	—		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		42.5	50	57.5	kHz	2
Max duty ratio	MaxDuty	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		75	83	90	%	
PWM/PFM control switch duty ratio	PFMDuty	V_{IN}= output voltage -0.1V No load		5	15	24		1
Soft start time	t_{SS}			3.0	6.0	12.0	ms	—
Efficiency	EFFI		S-8324x50xx	—	87	—	%	1
			S-8324x33xx	—	83	—		
			S-8324x30xx	—	83	—		
			S-8324x27xx	—	79	—		
			S-8324x25xx	—	79	—		
			S-8324x20xx	—	75	—		

External parts used:
- -Coil: CD54 (100 µH) of Sumida Corporation
- -Diode: MA720 (Schottky type) of Matsushita Electric Industrial Co., Ltd.
- -Capacitor: F93 (16 V, 22 µF, tantalum type) of Nichicon Corporation

Applied V_{IN}=output voltage×0.6, I_{OUT}=output voltage/250 Ω
The VDD pin is connected to VOUT pin for V_{DD}/V_{OUT} separate product.

Note 1: The output voltage specified above is the typical value.

Note 2: V_{DD}/V_{OUT} Separate products:
Boot operation is performed from V_{DD}=0.8 V.
However, 2.0 V or more voltage for V_{DD} is recommended to stabilize the output voltage and oscillation frequency.

1-3. S-8324CxxMA

(Unless otherwise specified: Ta=25 °C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}		S-8324C30MA	2.928	3.000	3.072	V	1
			S-8324C27MA	2.635	2.700	2.765		
			S-8324C25MA	2.440	2.500	2.560		
Input voltage	V_{IN}			—	—	9		
Operation start voltage	V_{ST1}	I_{OUT}=1 mA		—	—	0.9		
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT} CONT pulled up to 5 V by 10kΩ		—	—	0.8		2
Operation holding voltage	V_{HLD}	I_{OUT}=1 mA, Measured by decreasing V_{IN} voltage gradually		0.7	—	—		1
Input current at no load	I_{IN}	No load	S-8324C30MA	—	9.6	19.1	μA	—
			S-8324C27MA	—	9.5	19.1		
			S-8324C25MA	—	9.7	19.3		
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8324C30MA	—	11.6	19.3		2
			S-8324C27MA	—	10.5	17.5		
			S-8324C25MA	—	9.8	16.3		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8324C30MA	—	3.0	5.9		
			S-8324C27MA	—	2.9	5.8		
			S-8324C25MA	—	2.9	5.8		
Switching current	I_{SW}	V_{CONT}=0.4 V	S-8324C30MA	78	125	—	mA	—
			S-8324C27MA	61	98	—		
			S-8324C25MA	61	98	—		
Switching transistor leak current	I_{SWQ}	V_{OUT}= V_{CONT}=10 V		—	—	1.0	μA	
Line regulation	ΔV_{OUT1}	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV	1
Load regulation	ΔV_{OUT2}	I_{OUT}=10 μA to I_{OUT} (below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\Delta V_{OUT}/\Delta Ta$	Ta=-40°C to +85°C	S-8324C30MA	—	±0.15	—	mV/°C	
			S-8324C27MA	—	±0.14	—		
			S-8324C25MA	—	±0.13	—		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		25	30	35	kHz	2
Max duty ratio	MaxDuty	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		75	83	90	%	
PWM/PFM control switch duty ratio	PFMDuty	V_{IN}= output voltage -0.1 V No load		5	15	24		1
Soft start time	t_{SS}			3.0	6.0	12.0	ms	—
Efficiency	EFFI		S-8324C30MA	—	81	—	%	1
			S-8324C27MA	—	77	—		
			S-8324C25MA	—	77	—		

External parts used:
- -Coil: CD54 (100 μH) of Sumida Corporation
- -Diode: MA720 (Schottky type) of Matsushita Electric Industrial Co., Ltd.
- -Capacitor: F93 (16 V, 22 μF, tantalum type) of Nichicon Corporation

Applied V_{IN}=output voltage×0.6, I_{OUT}=output voltage/250 Ω

Note 1: The output voltage specified above is the typical value.

1-4. S-8324HxxMC

(Unless otherwise specified: Ta=25 °C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}		S-8324H33MC	3.221	3.300	3.379	V	1
			S-8324H50MC	4.880	5.000	5.120		
Input voltage	V_{IN}			—	—	9		
Operation start voltage	V_{ST1}	I_{OUT}=1 mA		—	—	1.4		
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT} CONT pulled up to 5 V by 10kΩ		—	—	1.3		2
Operation holding voltage	V_{HLD}	I_{OUT}=1 mA, Measured by decreasing V_{IN} voltage gradually		0.7	—	—		1
Input current at no load	I_{IN}	No load	S-8324H33MC	—	36.0	72.0	μA	—
			S-8324H50MC	—	38.4	76.9		
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8324H33MC	—	87.9	146.5		2
			S-8324H50MC	—	142.6	237.7		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8324H33MC	—	10.0	19.9		
			S-8324H50MC	—	10.2	20.3		
Current consumption during shutdown	I_{SSS}	$V_{ON/\overline{OFF}}$=0 V		—	—	0.5		
Switching current	I_{SW}	V_{CONT}=0.4 V	S-8324H33MC	78	125		mA	—
			S-8324H50MC	114	182			
Switching transistor leak current	I_{SWQ}	V_{OUT}= V_{CONT}=10 V		—	—	1.0	μA	
Line regulation	ΔV_{OUT1}	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV	1
Load regulation	ΔV_{OUT2}	I_{OUT}=10μA to I_{OUT}(below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\Delta V_{OUT}/\Delta Ta$	Ta=-40°C to +85°C	S-8324H33MC	—	±0.17	—	mV/°C	
			S-8324H50MC	—	±0.25	—		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		212.5	200	287.5	kHz	2
Max duty ratio	MaxDuty	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		70	78	85	%	
PWM/PFM control switch duty ratio	PFMDuty	V_{IN}= output voltage -0.1 V No load		5	15	24		1
Shutdown pin	V_{SH}	V_{OUT}=output voltage×0.95 Judged the oscillation at CONT pin		0.75	—	—	V	2
Input voltage (ON/OFF type)	V_{SL1}	V_{OUT}=output voltage×0.95	When V_{OUT}≥1.5 V	—	—	0.3		
	V_{SL2}	Judged the stop of oscillation at CONT pin	When V_{OUT}<1.5 V	—	—	0.2		
Soft start time	t_{SS}			1.8	3.6	7.2	ms	—
Efficiency	EFFI		S-8324H33MC	—	83	—	%	1
			S-8324H50MC	—	87	—		

External parts used:
- -Coil: CD54 (22 μH) of Sumida Corporation
- -Diode: MA720 (Schottky type) of Matsushita Electric Industrial Co., Ltd.
- -Capacitor: F93 (16 V, 22 μF, tantalum type) of Nichicon Corporation

Applied V_{IN}=output voltage×0.6, I_{OUT}=output voltage/250 Ω
The shutdown pin is connected to VOUT pin.

Note 1: The output voltage specified above is the typical value.

1-5. S-8324JxxMC

(Unless otherwise specified: Ta=25 °C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}		S-8324J25MC	2.440	2.500	2.560	V	1
			S-8324J50MC	4.880	5.000	5.120		
Input voltage	V_{IN}			—	—	9		
Operation start voltage	V_{ST1}	I_{OUT}=1 mA		—	—	1.4		
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT} CONTpulled up to 5 V by 10kΩ		—	—	1.3		2
Operation holding voltage	V_{HLD}	I_{OUT}=1 mA, Measured by decreasing V_{IN} voltage gradually		0.7	—	—		1
Input current at no load	I_{IN}	No load	S-8324J25MC	—	34.2	68.4	μA	—
			S-8324J50MC	—	38.4	76.9		
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8324J25MC	—	64.8	108.0		2
			S-8324J50MC	—	142.6	237.7		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8324J25MC	—	9.9	19.7		
			S-8324J50MC	—	10.2	20.3		
Switching current	I_{SW}	V_{CONT}=0.4 V	S-8324J25MC	61	98	—	mA	—
			S-8324J50MC	114	182	—		
Switching transistor leak current	I_{SWQ}	V_{OUT}= V_{CONT}=10 V		—	—	1.0	μA	
Line regulation	ΔV_{OUT1}	V_{IN}= output voltage ×0.4 to ×0.6		—	30	60	mV	1
Load regulation	ΔV_{OUT2}	I_{OUT}=10 μA to I_{OUT} (below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\Delta V_{OUT}/\Delta Ta$	Ta=-40°C to +85°C	S-8324J25MC	—	±0.13	—	mV/°C	
			S-8324J50MC	—	±0.25	—		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		212.5	250	287.5	kHz	2
Max duty ratio	MaxDuty	V_{OUT}=output voltage×0.95 Measured waveform at CONT pin		70	78	85	%	
PWM/PFM control switch duty ratio	PFMDuty	V_{IN}= output voltage -0.1 V No load		5	15	24		1
Soft start time	t_{SS}			1.8	3.6	7.2	ms	—
Efficiency	EFFI		S-8324J25MC	—	79	—	%	1
			S-8324J50MC	—	87	—		

External parts used:
- -Coil: CD54 (22 μH) of Sumida Corporation
- -Diode: MA720 (Schottky type) of Matsushita Electric Industrial Co., Ltd.
- -Capacitor: F93 (16 V, 22 μF, tantalum type) of Nichicon Corporation

Applied V_{IN}=output voltage×0.6, I_{OUT}=output voltage/250 Ω
The VDD pin is connected to VOUT pin for V_{DD}/V_{OUT} separate product.

Note 1: The output voltage specified above is the typical value.

Note 2: V_{DD}/V_{OUT} Separate products:
Boot operation is performed from V_{DD}=0.8 V.
However, 2.0 V or more voltage for V_{DD} is recommended to stabilize the output voltage and oscillation frequency.
However, accuracy of volutage is degrated to ±4% under the V_{DD} volutage between 2.0 V to 2.35 V.

2-1. S-8328BxxMC

(Unless otherwise specified: Ta=25 °C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}		S-8328B52MC	5.075	5.200	5.325	V	3
			S-8328B50MC	4.880	5.000	5.120		
			S-8328B38MC	3.709	3.800	3.891		
			S-8328B36MC	3.514	3.600	3.686		
			S-8328B33MC	3.221	3.300	3.379		
			S-8328B30MC	2.928	3.000	3.072		
			S-8328B27MC	2.635	2.700	2.765		
			S-8328B26MC	2.538	2.600	2.662		
			S-8328B25MC	2.440	2.500	2.560		
Input voltage	V_{IN}			—	—	9		
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		4
Operation holding voltage	V_{HLD}	I_{OUT}=1 mA, Measured by decreasing V_{IN} voltage gradually		0.7	—	—		3
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8328B52MC	—	39.3	65.5	µA	4
			S-8328B50MC	—	37.6	62.6		
			S-8328B38MC	—	27.6	46.0		
			S-8328B36MC	—	26.0	43.3		
			S-8328B33MC	—	23.7	39.5		
			S-8328B30MC	—	21.4	35.7		
			S-8328B27MC	—	19.2	32.0		
			S-8358B26MC	—	18.5	30.9		
			S-8328B25MC	—	17.8	29.7		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8328B52MC	—	4.2	8.3		
			S-8328B50MC	—	4.2	8.3		
			S-8328B38MC	—	4.0	8.0		
			S-8328B36MC	—	4.0	7.9		
			S-8328B33MC	—	4.0	7.9		
			S-8328B30MC	—	3.9	7.8		
			S-8328B27MC	—	3.9	7.7		
			S-8328B26MC	—	3.9	7.7		
			S-8328B25MC	—	3.9	7.7		
shutdown current	I_{SSS}	$V_{ON/\overline{OFF}}$=0 V		—	—	0.5		
EXT pin output current	I_{EXTH}	V_{EXT}=V_{OUT}-0.4 V	S-8328B52MC	-5.3	-8.0	—	mA	—
			S-8328B50MC	-5.3	-8.0	—		
			S-8328B38MC	-3.5	-5.3	—		
			S-8328B36MC	-3.5	-5.3	—		
			S-8328B33MC	-3.5	-5.3	—		
			S-8328B30MC	-3.5	-5.3	—		
			S-8328B27MC	-2.7	-4.0	—		
			S-8328B26MC	-2.7	-4.0	—		
			S-8328B25MC	-2.7	-4.0	—		
	I_{EXTL}	V_{EXT}=0.4 V	S-8328B52MC	10.7	16.0	—		
			S-8328B50MC	10.7	16.0	—		
			S-8328B38MC	7.0	10.5	—		
			S-8328B36MC	7.0	10.5	—		
			S-8328B33MC	7.0	10.5	—		
			S-8328B30MC	7.0	10.5	—		
			S-8328B27MC	5.3	8.0	—		
			S-8328B26MC	5.3	8.0	—		
			S-8328B25MC	5.3	8.0	—		
Line regulation	ΔV_{OUT1}	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV	3
Load regulation	ΔV_{OUT2}	I_{OUT}=10 µA to I_{OUT}(below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\Delta V_{OUT}/\Delta Ta$	Ta=-40°C to +85°C	S-8328B52MC	—	±0.26	—	mV/°C	
			S-8328B50MC	—	±0.25	—		
			S-8328B38MC	—	±0.19	—		
			S-8328B36MC	—	±0.18	—		
			S-8328B33MC	—	±0.17	—		
			S-8328B30MC	—	±0.15	—		
			S-8328B27MC	—	±0.14	—		
			S-8328B26MC	—	±0.13	—		
			S-8328B25MC	—	±0.13	—		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measured waveform at EXT pin		85	100	115	kHz	4
Max. duty ratio	MaxDuty	V_{OUT}=output voltage×0.95 Measured waveform at EXT pin		75	83	90	%	
PWM/PFM control switch duty ratio	PFMDuty	V_{IN}= output voltage -0.1 V No load		5	15	24		3
Shutdown pin Input voltage (ON/OFF type)	V_{SH}	V_{OUT}=output voltage×0.95 Judged the oscillation at EXT pin		0.75	—	—	V	4
	V_{SL1}	V_{OUT}=output voltage×0.95	When V_{OUT}≥1.5 V	—	—	0.3		
	V_{SL2}	Judged the stop of oscillation at EXT pin	When V_{OUT}<1.5 V	—	—	0.2		
Soft start time	t_{SS}			3.0	6.0	12.0	ms	—
Efficiency	EFFI		S-8328B52MC	—	88	—	%	3
			S-8328B50MC	—	88	—		
			S-8328B38MC	—	84	—		
			S-8328B36MC	—	84	—		
			S-8328B33MC	—	84	—		
			S-8328B30MC	—	84	—		
			S-8328B27MC	—	80	—		
			S-8328B26MC	—	80	—		
			S-8328B25MC	—	80	—		

External parts used:

- -Coil: CD54 (47 µH) of Sumida Corporation
- -Diode: MA720 (Schottky type) of Matsushita Electric Industrial Co., Ltd.
- -Capacitor: F93 (16 V, 47 µF, tantalum type) of Nichicon Corporation
- -Transistor: 2SD1628G of Sanyo Electric Co., Ltd.
- -Base resistor (Rb): 1.0 kΩ
- -Base capacitor (Cb): 2200 pF (ceramic)

Applied V_{IN}=output voltage×0.6, I_{OUT}=output voltage/50 Ω
The shutdown pin is connected to VOUT pin.

Note 1 : The output voltage specified above is the typical value.

2-2. S-8328BxxMA, S-8328BxxUA, S-8328ExxMC

(Unless otherwise specified: Ta=25 °C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}		S-8328x50xx	4.880	5.000	5.120	V	3
			S-8328x33xx	3.221	3.300	3.379		
			S-8328x30xx	2.928	3.000	3.072		
			S-8328x27xx	2.635	2.700	2.765		
			S-8328x25xx	2.440	2.500	2.560		
			S-8328x20xx	1.952	2.000	2.048		
Input voltage	V_{IN}			—	—	9		
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		4
Operation holding voltage	V_{HLD}	I_{OUT}=1 mA, Measured by decreasing V_{IN} voltage gradually		0.7	—	—		3
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8328x50xx	—	37.6	62.6	μA	4
			S-8328x33xx	—	23.7	39.5		
			S-8328x30xx	—	21.4	35.7		
			S-8328x27xx	—	19.2	32.0		
			S-8328x25xx	—	17.8	29.7		
			S-8328x20xx	—	14.5	24.1		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8328x50xx	—	4.2	8.3		
			S-8328x33xx	—	4.0	7.9		
			S-8328x30xx	—	3.9	7.8		
			S-8328x27xx	—	3.9	7.7		
			S-8328x25xx	—	3.9	7.7		
			S-8328x20xx	—	3.8	7.6		
EXT pin output current	I_{EXTH}	VEXT=V_{OUT}-0.4V	S-8328x50xx	-5.3	-8.0	—	mA	—
			S-8328x33xx	-3.5	-5.3	—		
			S-8328x30xx	-3.5	-5.3	—		
			S-8328x27xx	-2.7	-4.0	—		
			S-8328x25xx	-2.7	-4.0	—		
			S-8328x20xx	-1.9	-2.9	—		
	I_{EXTL}	VEXT=0.4V	S-8328x50xx	10.7	16.0	—		
			S-8328x33xx	7.0	10.5	—		
			S-8328x30xx	7.0	10.5	—		
			S-8328x27xx	5.3	8.0	—		
			S-8328x25xx	5.3	8.0	—		
			S-8328x20xx	3.8	5.7	—		
Line regulation	ΔV_{OUT1}	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV	3
Load regulation	ΔV_{OUT2}	I_{OUT}=10 μA to I_{OUT}(below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\Delta V_{OUT}/\Delta Ta$	Ta=-40°C to +85°C	S-8328X50XX	—	±0.25	—	mV/°C	
			S-8328X33XX	—	±0.17	—		
			S-8328X30XX	—	±0.15	—		
			S-8328X27XX	—	±0.14	—		
			S-8328X25XX	—	±0.13	—		
			S-8328X20XX	—	±0.10	—		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measured waveform at EXT pin		85	100	115	kHz	4
Max. duty ratio	MaxDuty	V_{OUT}=output voltage×0.95 Measured waveform at EXT pin		75	83	90	%	
PWM/PFM control switch duty ratio	PFMDuty	V_{IN}= output voltage -0.1V No load		5	15	24		3
Soft start time	tss			3.0	6.0	12.0	ms	—
Efficiency	EFFI		S-8328X50XX	—	88	—	%	3
			S-8328X33XX	—	84	—		
			S-8328X30XX	—	84	—		
			S-8328X27XX	—	80	—		
			S-8328X25XX	—	80	—		
			S-8328X20XX	—	76	—		

External parts used:

-Coil:	CD54 (47μH) of Sumida Corporation
-Diode:	MA720 (Schottky type) of Matsushita Electric Industrial Co., Ltd.
-Capacitor:	F93 (16 V, 47μF, tantalum type) of Nichicon Corporation
-Transistor:	2SD1628G of Sanyo Electric Co., Ltd.
-Base resistor (Rb):	1.0 KΩ
-Base capacitor (Cb):	2200 pF (ceramic)

Applied V_{IN}=output voltage×0.6, I_{OUT}=output voltage/50 Ω
The VDD pin is connected to VOUT pin for V_{DD}/V_{OUT} separate product.

Note 1: The output voltage specified above is the typical value.

Note 2: V_{DD}/V_{OUT} Separate products:
Boot operation is performed from V_{DD}=0.8 V.
However, 2.0 V or more voltage for V_{DD} is recommended to stabilize the output voltage and oscilation frequency.

2-3. S-8328HxxMC

(Unless otherwise specified: Ta=25 °C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}		S-8328H30MC	2.928	3.000	3.072	V	3
			S-8328H33MC	3.221	3.300	3.379		
			S-8328H50MC	4.880	5.000	5.120		
Input voltage	V_{IN}			—	—	9		
Operation start voltage	V_{ST1}	I_{OUT}=1 mA		—	—	1.4		
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT}		—	—	1.3		4
Operation holding voltage	V_{HLD}	I_{OUT}=1 mA, Measured by decreasing V_{IN} voltage gradually.		0.7	—	—		3
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8328H30MC	—	53.9	89.8	μA	4
			S-8328H33MC	—	59.4	99.0		
			S-8328H50MC	—	93.7	156.1		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8328H30MC	—	10.0	19.9		
			S-8328H33MC	—	10.0	19.9		
			S-8328H50MC	—	10.2	20.3		
Current consumption while shutdown	I_{SSS}	$V_{ON/\overline{OFF}}$=0 V		—	—	0.5		
EXT pin output current	I_{EXTH}	V_{EXT}=V_{OUT}-0.4 V	S-8328H30MC	-3.5	-5.3	—	mA	—
			S-8328H33MC	-3.5	-5.3	—		
			S-8328H50MC	-5.3	-8.0	—		
	I_{EXTL}	V_{EXT}=0.4 V	S-8328H30MC	7.0	10.5	—		
			S-8328H33MC	7.0	10.5	—		
			S-8328H50MC	10.7	16.0	—		
Line regulation	ΔV_{OUT1}	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV	3
Load regulation	ΔV_{OUT2}	I_{OUT}=10 μA to I_{OUT}(below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\Delta V_{OUT}/\Delta Ta$	Ta=-40°C to +85°C	S-8328H30MC	—	±0.15	—	mV/°C	
			S-8328H33MC	—	±0.17	—		
			S-8328H50MC	—	±0.25	—		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measure waveform at EXT pin		212.5	250	287.5	kHz	4
Max. duty ratio	MaxDuty	V_{OUT}=output voltage×0.95 Measure waveform at EXT pin		70	78	85	%	
PWM/PFM control switch duty ratio	PFMDuty	V_{IN}= output voltage -0.1 V No load		5	15	24		
Shutdown pin Input voltage (ON/OFF type)	V_{SH}	V_{OUT}=output voltage×0.95		0.75	—	—	V	
	V_{SL1}	V_{OUT}=output voltage×0.95	When V_{OUT}≥1.5 V	—	—	0.3		
	V_{SL2}		When V_{OUT}<1.5 V	—	—	0.2		
Soft start time	t_{SS}			1.5	3.0	6.0	ms	—
Efficiency	EFFI		S-8328H30MC	—	81	—	%	3
			S-8328H33MC	—	81	—		
			S-8328H50MC	—	85	—		

External parts used:
- Coil: CD54 (22 μH) of Sumida Corporation
- Diode: MA720 (Schottky type) of Matsushita Electric Industrial Co., Ltd.
- Capacitor: F93 (16 V, 47 μF, tantalum type) of Nichicon Corporation
- Transistor: NDS355AN of National Semiconductor

Applied V_{IN}=output voltage×0.6, I_{OUT}=output voltage/50 Ω
The shutdown pin is connected to VOUT pin.

Note 1: The output voltage specified above is the typical value.

2-4. S-8328JxxMC

(Unless otherwise specified: Ta=25 °C)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test circuit
Output voltage	V_{OUT}		S-8328J25MC	2.440	2.500	2.560	V	3
			S-8328J50MC	4.880	5.000	5.120		
Input voltage	V_{IN}			—	—	9		
Operation start voltage	V_{ST1}	I_{OUT}=1 mA		—	—	1.4		
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT}		—	—	1.3		4
Operation holding voltage	V_{HLD}	I_{OUT}=1 mA, Measured by decreasing V_{IN} voltage gradually B.		0.7	—	—		3
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8328J25MC	—	44.9	74.8	μA	4
			S-8328J50MC	—	93.7	156.1		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8328J25MC	—	9.9	19.7		
			S-8328J50MC	—	10.2	20.3		
EXT pin output current	I_{EXTH}	V_{EXT}=V_{OUT}-0.4 V	S-8328J25MC	-2.3	-4.0	—	mA	—
			S-8328J50MC	-5.3	-8.0	—		
	I_{EXTL}	V_{EXT}=-0.4 V	S-8328J25MC	5.3	8.0	—		
			S-8328J50MC	10.7	16.0	—		
Line regulation	ΔV_{OUT1}	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV	3
Load regulation	ΔV_{OUT2}	I_{OUT}=10 μA to I_{OUT}(below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\Delta V_{OUT}/\Delta Ta$	Ta=-40°C to +85°C	S-8328J25MC	—	±0.13	—	mV/°C	
			S-8328J50MC	—	±0.25	—		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measured waveform at EXT pin		212.5	250	287.5	kHz	4
Max. duty ratio	MaxDuty	V_{OUT}=output voltage×0.95 Measured waveform at EXT pin		70	78	85	%	
PWM/PFM control switch duty ratio	PFMDuty	V_{IN}= output voltage -0.1 V No load		5	15	24		
Soft start time	t_{SS}			1.5	3.0	6.0	ms	—
Efficiency	EFFI		S-8328J25MC	—	77	—	%	3
			S-8328J50MC	—	85	—		

External parts used:
- Coil: CD54 (22 μH) of Sumida Corporation
- Diode: MA720 (Schottky type) of Matsushita Electric Industrial Co., Ltd.
- Capacitor: F93 (16 V, 47 μF, tantalum type) of Nichicon Corporation
- Transistor: NDS355AN of National Semiconductor

Applied V_{IN}=output voltage×0.6, I_{OUT}=output voltage/50 Ω
The VDD pin is connected to VOUT pin for V_{DD}/V_{OUT} separate product.

Note 1: The output voltage specified above is the typical value.
Note 2: V_{DD}/V_{OUT} Separate products:
Boot operation is performed from V_{DD}=0.8 V.
However, 2.0 V or more for V_{DD} is recommended to stabilize the output voltage and oscillation frequency.
However, accuracy of volutage is degrated to ±4% under the V_{DD} voltage between 2.0 V to 2.35 V.

■ Test Circuits

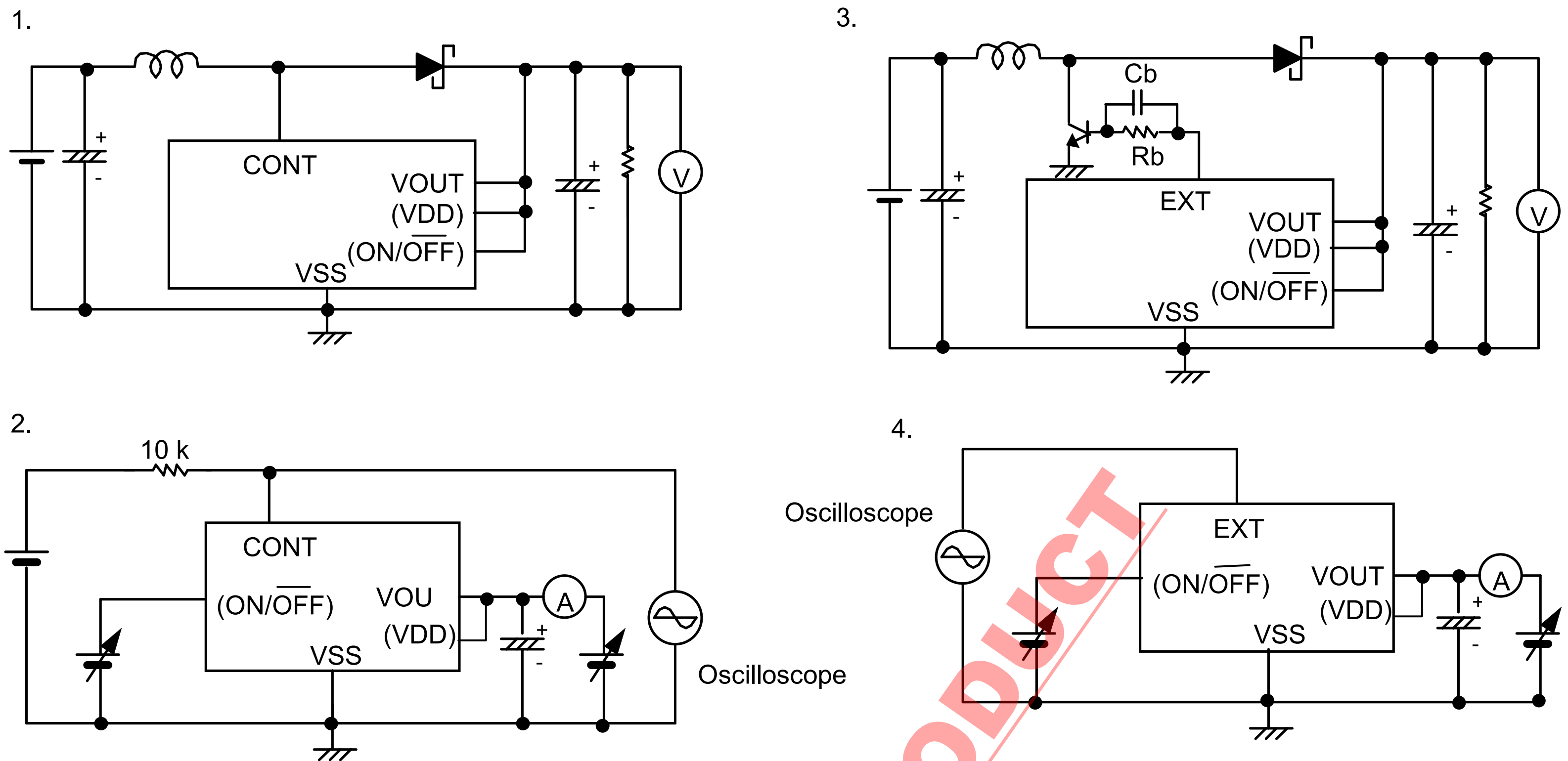


Figure 3

■ Operation

1. Step-Up DC/DC Converter

The S-8324/8328 series is a DC/DC converter using a pulse frequency modulation method (PFM) or a pulse width modulation method (PWM) which are switched automatically according to the load current with a low current consumption.

Especially in the region of 100μA output load current, a high-efficiency DC/DC converter is obtained.

In conventional fixed-duty type PFM DC/DC converters, pulses are skipped at low output load current, causing fluctuation in ripple frequency of the output voltage, with the result of increase in ripple voltage.

The S-8324/8328 series operates with the PWM control which changes the pulse width duty from 15% to 83%(78% for H, J types) in the region of large output load current.

The ripple voltage generated from switching can be removed easily through the filter because the switching frequency is constant.

The S-8324/8328 series operates with the PFM control which skips the pulse of the duty 15% pulth width and output that pulse to the switching transistor according to the load current.

From the above operation, the self current consumption is reduced from the blocking oscilation of the oscilation circuit, and a fall of efficiency can be protected in small load.

The switching point between PWM and PFM control differs according to the external elements (coil, diode and other), input voltage and output voltage.

See reference data about this.

Shutdown pin: Stops or starts step-up operation.

(Only for SOT-23-5 package products of A, B, and H Series.)

Turning the shutdown pin low stops operation of all the internal circuits and reduces current consumption significantly. Do NOT use the shutdown pin in floating state because it has a structure shown in Figure 4 and is not pulled up or pulled down internally. Do NOT apply voltage of between 0.3 V and 0.75 V to the shutdown pin because applying such voltage increases the current consumption. If the shutdown pin is not used, connect it to V_{OUT} (V_{DD} for D, E, J types) pin.

The shutdown pin doesn't have hysteresis.

Shutdown pin	CR oscillation circuit	Output voltage
“H”	Operation	Fixed
“L”	Stop	$\cong V_{IN}$*

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

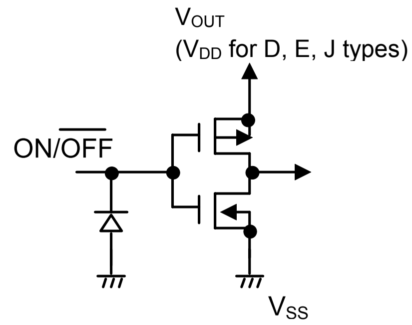


Figure 4

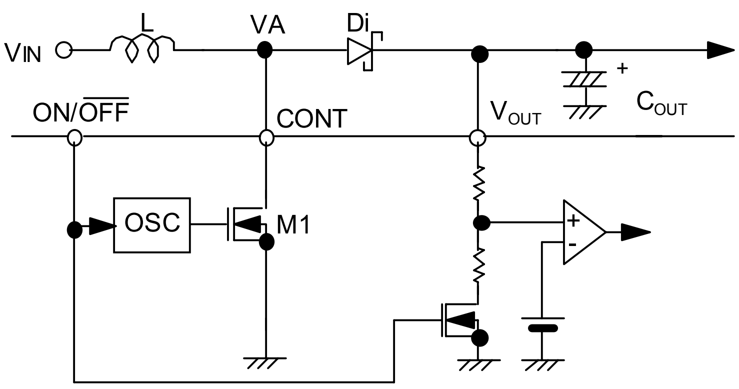


Figure 5

The following are basic equations [(1) through (7)] of the step-up switching regulator (see Figure 5.)
Voltage at CONT pin the moment M1 is turned ON (current I_L flowing through L is zero):

$$V_A = V_S \quad \text{.......................} \quad (1)$$

(V_S: Non-saturated voltage of M1)

The change in I_L over time:

$$\frac{dI_L}{d} = \frac{V_L}{L} = \frac{V_{IN} - V_S}{L} \quad \text{.......................} \quad (2)$$

Integration of the above equation (I_L):

$$I_L = \left(\frac{V_{IN} - V_S}{L}\right) \cdot t \quad \text{.......................} \quad (3)$$

I_L flows while M1 is turned ON (t_{ON}). The time of t_{ON} is determined by the oscillation frequency of the OSC.
The peak current (I_{PK}) after ton:

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

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

When M1 is turned OFF (t_{OFF}), the energy stored in L is transmitted through a diode to the output capacitor. Then reverse voltage (V_L) is generated.

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

(V_D: Diode forward voltage)

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

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

$$\frac{dI_L}{d} = \frac{V_L}{L} = \frac{V_{OUT} + V_D - V_{IN}}{L} \quad \text{.......................} \quad (6)$$

Integration of the above equation is as follows:

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

During t_{ON}, the energy is stored in L and is not transmitted to V_{OUT}. When receiving output current (I_{OUT}) from V_{OUT}, the energy of the capacitor (C_{OUT}) is consumed. As a result, the pin voltage of C_{OUT} 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_{OUT}, and the voltage of C_{OUT} rises drastically. V_{OUT} is a time function that indicates the maximum value (ripple voltage: $V_{P\text{-}P}$) when the current flowing through the diode into V_{OUT} and load current (I_{OUT}) match.
Next, the ripple voltage is found out 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:

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

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

After (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 ΔQ_1 which is charged in C_{OUT} during t1:

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

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

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

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

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

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

When taking into consideration I_{OUT} to be consumed during t1 and ESR (Equivalent Series Resistance) of C_{OUT}, namely R_{ESR}:

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

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

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

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

■ External Parts Selection for DC-DC Converter

The relationship between majorcharacteristics of the step-up circuit and characteristics parameters of the external parts are shown in Figure 6.

for large output current?	for high efficiency?		for small ripple voltage
	operation efficiency	stand-by efficiency	
small inductance	large inductance		
small DC resistance of inductor			
			large output capacitance
external switching transistor (small ON resistance)		built-in switching transistor	
small resistance of external resistor Rb when an external switching transistor is used		large resistance of external resistor Rb when an external switching transistor is used.	

Figure 6 Relationship between major character stics of the step-up circuit and external parts

1. Inductor

An inductance has strong influence on max. output current I_{OUT} and efficiency η.

Figure 7 shows I_{OUT} η characteristics for inductance of S-8324 and S-8328.

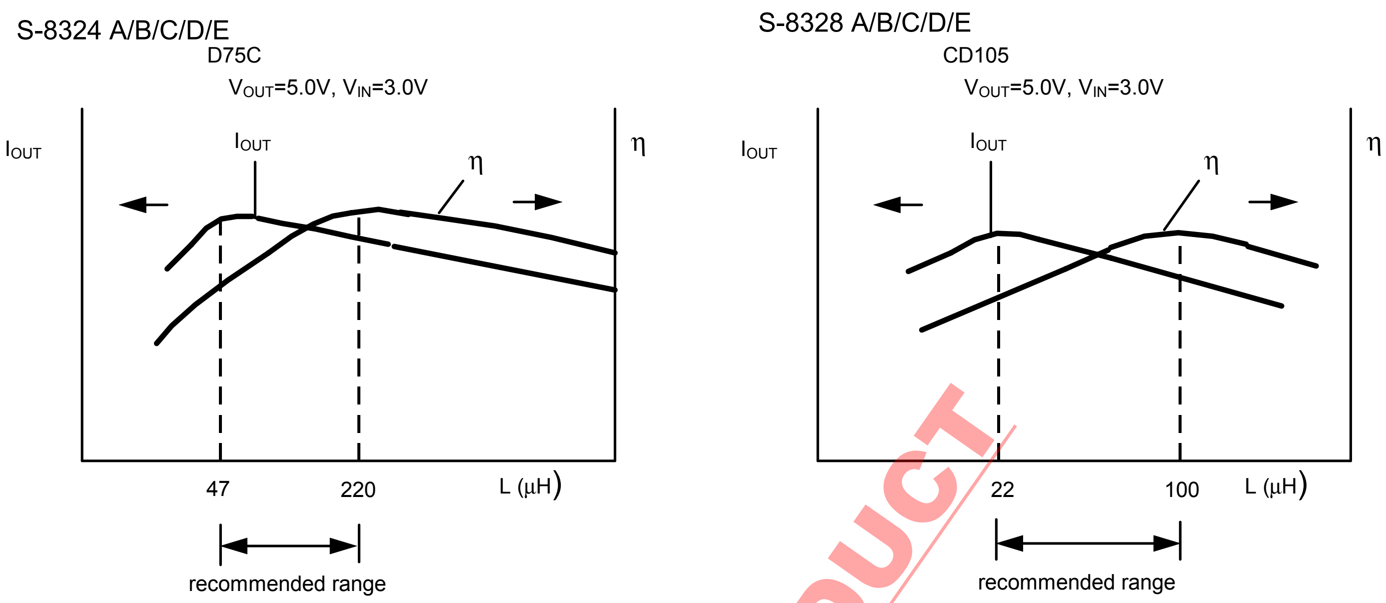


Figure 7

The peak current I_{PK} increases by decreasing L and I_{OUT} is at max. value at L value.

Further decreasing L decreases I_{OUT} due to the lack of the current driving capacity of the switching transistor.

The loss of I_{PK} by the switching transistor decreases by increasing L and the efficiency becomes max. at L value.

Further increasing L decreases efficiency due to the loss of the DC resistance of the coil.

47 to 220 µH inductor for S-8324 A/B/C/D/E and 22 to 100 µH inductor for S-8328 A/B/C/D/E, 10 to 22µH inductor for S-8324 H/J, and 4.7 to 10 µH inductor for S-8328 H/J are recommended.

Choose a value for L by refering to the reference data because the maximum output current is due to the input voltage in an actual case.

Choose an inductor so that the peak current I_{PK} does not exceed the allowable current.

Exceeding the allowable current of the inductor causes magnetic saturation, remarkable low efficiency and destruction of the IC chip due to a large current.

The peak current I_{PK} in uncontinuous mode is calculated from the following formula:

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

fosc: oscillation frequency

VD ≅ 0.4V

For instance, when you choose 100 µH at fosc=50 kHz for L using the S-8324A 50MC at the following conditions, I_{PK} is caluculated to 170 mA from the (17) formula.

- Input voltage V_{IN}=3 V
- Output voltage V_{OUT}=5 V
- Load current I_{OUT}=30 mA

The switching current limit circuit is not built into this IC chip.

I_{PK} current must be 500 mA or less.

2. Diode

Use an external diode that meets the following requirements:

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

3. Capacitors (C_{IN}, C_{OUT})

A capacitor at 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. The capacitor value should be around 10 μF.

A capacitor at the output side (C_{OUT}) is used for smoothing the ripple voltage. Therefore select a capacitor with a small ESR (Equivalent Series Resistance) and a large capacitance. The capacitor value should be 10 μF min. A tantalum electrolytic capacitor and an organic semiconductor capacitor are especially recommended because of their superior low-temperature characteristic and leakage current characteristic.

4. External transistor (S-8328 Series)

For the S-8328 Series, connecting an external transistor increases the output current. A bipolar (NPN) transistor or an enhancement (N-channel) MOS FET transistor can be used as external transistor.

4.1. Bipolar (NPN) transistor

A circuit example using a bipolar transistor (NPN), Sanyo 2SD1628G (h_{FE}=280 to 560) is shown in Figure 11. The h_{FE} value and the Rb value determine the driving capacity to increase the output current using a bipolar transistor. A peripheral circuit example of the transistor is shown in Figure 8.

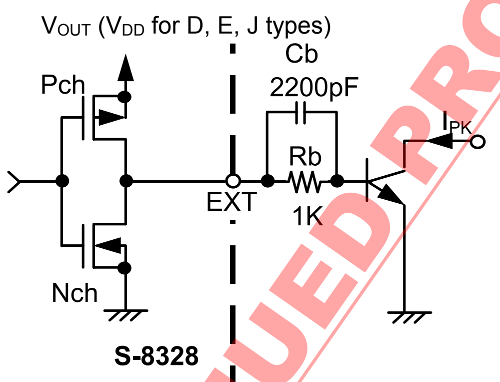


Figure 8 External transistor peripheral

1 kΩ is recommended for Rb. Rb is caluculated from the following formula:

$$Rb=\frac{V_{OUT}-0.7}{Ib}-\frac{0.4}{|I_{EXTH}|} \quad \left(Rb=\frac{V_{DD}-0.7}{Ib}-\frac{0.4}{|I_{EXTH}|} \text{ for D, E, J types}\right)$$

$Ib=I_{PK}/h_{FE}$

A small Rb increases output current, however, the efficiency decreases.

The current flows pulsating and there is voltage drop due to wiring resistance in an actual circuit, therefore optimum Rb value should be determined by experiment.

A speed-up capacitor connected in parallel with Rb resistance as shown in Figure 9 decreases the switching loss and improves the efficiency.

Cb is caluculated from the following formula:

$$Cb \leq \frac{1}{2\pi \times Rb \times f_{OSC} \times 0.7}$$

However, in practice, the optimum Cb value also varies with the characteristics of the bipolar transistor to be employed. Therefore, determine the optimum value through experiments.

4.2. Enhancement MOS FET Type

Figure 9 is a circuit example using NEC 2SK1959 MOS FET transistor (N-channel).

For a MOS FET, an N-channel power MOS FET should be used. 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.

Depending on which MOS FET you use in your device, there is a chance of a current overrun at power ON.

Thoroughly test all settings with your device before deciding on which one to use. Also, try to use a MOS FET with the gate capacitance of 300 pF or less.

Since the ON resistor of the MOS FET might affect the output amperage as well as the efficiency, the threshold voltage should be low. When the output voltage is as low as 2.0V the same as in the S-8328E20, the circuit operates only when the MOS FET has the threshold voltage lower than 2.0V.

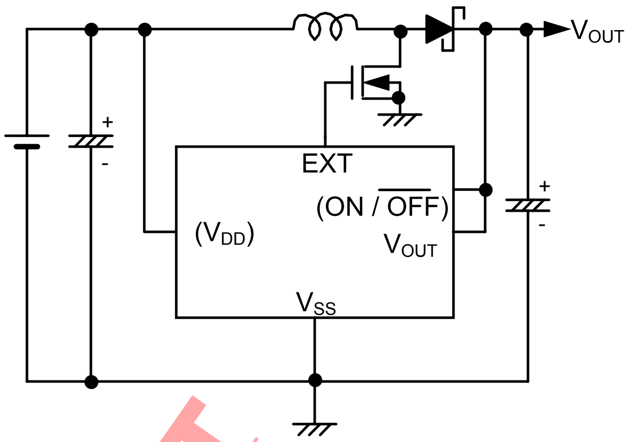


Figure 9 Circuit example using 2SK1959

5. Others (S-8324D/J and S-8328E/J only)

The S-8324D/J and S-8328E/J are applicable to the following uses because the power pin for IC chip and Vout pin for output voltage are separated:

① When changing the output voltage with an external resistance.

② When outputing the high voltage such as +12 V or 15 V.

③ When making the step-down DC/DC converter.

④ When making the inverted DC/DC converter.

Choose the products in the following table according to applications for ① to ③.

Use	Step-up					Step-down			
Output voltage V_{CC}	$2V \le V_{CC} < 3V$	$3V \le V_{CC} < 5V$	$5V \le V_{CC} < 9V$	$9V \le V_{CC}$	Ref. circuit	$2V \le V_{CC} < 3V$	$3V \le V_{CC} < 5V$	$5V \le V_{CC} < 9V$	Ref. circuit
S-8324D20	○	—	—	—	Std. circuit (5)	○	—	—	Appl. circuit 3
S-8324D30	—	○	—	—	Std. circuit (5)	—	○	—	Appl. circuit 3
S-8324D50	—	—	○	—	Std. circuit (5)	—	—	○	Appl. circuit 3
S-8324J25	—	○	—	—	Std. circuit (5)	—	—	—	—
S-8324J50	—	—	○	—	Std. circuit (5)	—	—	—	—
S-8328E20	○	○	○	○	Std. circuit (6)	—	—	—	—
S-8328E50	—	—	○	○	Std. circuit (6)	—	—	—	—
S-8328J25	—	○	○	○	Std. circuit (6)	—	—	—	—
S-8328J50	—	—	○	○	Std. circuit (6)	—	—	—	—
Connection to V_{DD} pin	V_{IN} or V_{CC}	V_{IN} or V_{CC}	V_{IN} or V_{CC}	V_{IN}	—	V_{IN}	V_{IN}	V_{IN}	—

The operational precautions are follows:

I. This IC starts to oscillate and step up operation at V_{DD}=0.8V(1.3V for J-type) but frequency of the oscillator does not stabilize.

Input the voltage from 2 V to 9 V for V_{DD} pin to get the stabilized output voltage and oscilation frequency.

The input voltage from 2 V to 9 V for V_{DD} pin allows the connection of V_{DD} pin to both input power pin V_{IN} and output power pin Vout.

II. Choose external resistors R_A and R_B not to affect to the output voltage with the consideration of the impedance between V_{OUT} and V_{SS} pins in the IC chip.

Internal resistance between V_{OUT} and V_{SS} pins are as follows:

① S-8324D20, S-8324J20, and S-8328E20: 3.0 MΩ to 19.6 MΩ

② S-8324J25, S-8328J25: 3.9 MΩ to 22.5 MΩ

③ S-8324D30: 3.3 MΩ to 22.6 MΩ

④ S-8324D50, S-8324J50, S-8328E50, and 8328J50: 2.1 MΩ to 19.1 MΩ

III. Attach the capacitor "C_C" in parallel to R_A resistance when the oscilation of the output voltage occurs.

Caluculate "C_C" from the following formula:

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

IV. When the device is used with an external resistance in the output voltages-variable mode, a large ripple voltage having a frequency lower than that of the switching frequency may appear as an output, if the load current is large, depending on the circuit patterns on the evaluation board and other factors (the interval is several times or a few tens times as large as the switching interval (4μs), see waves in Figure 10). Be sure to check the circuit patterns on your board in advance for practical use.

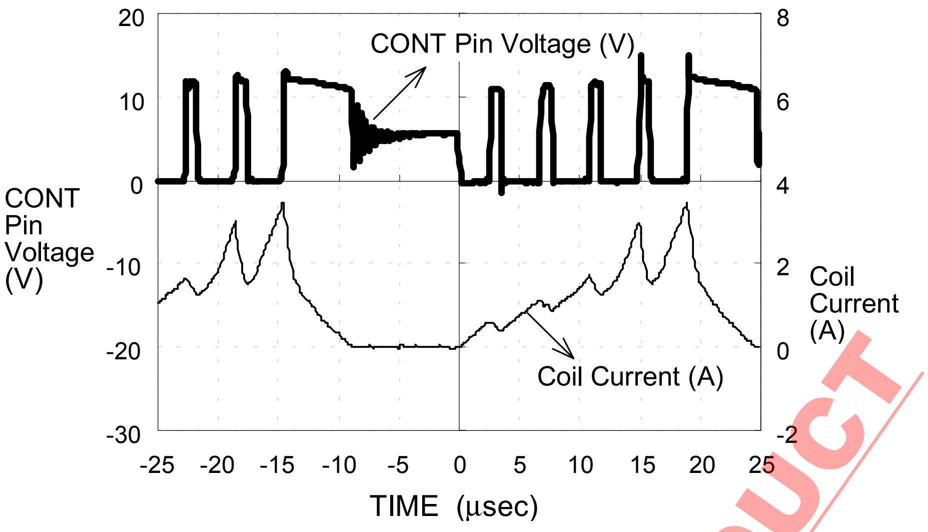
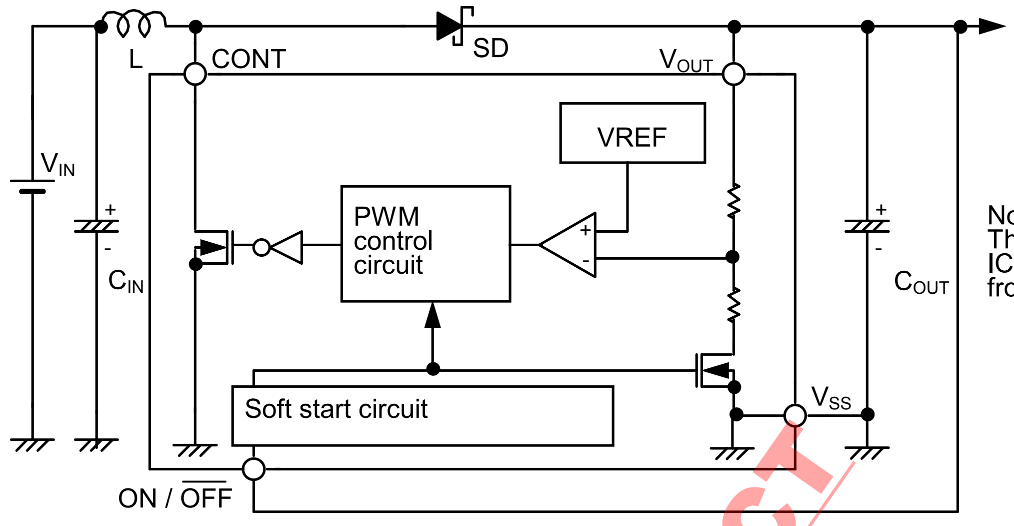


Figure 10

■ Standard Circuits

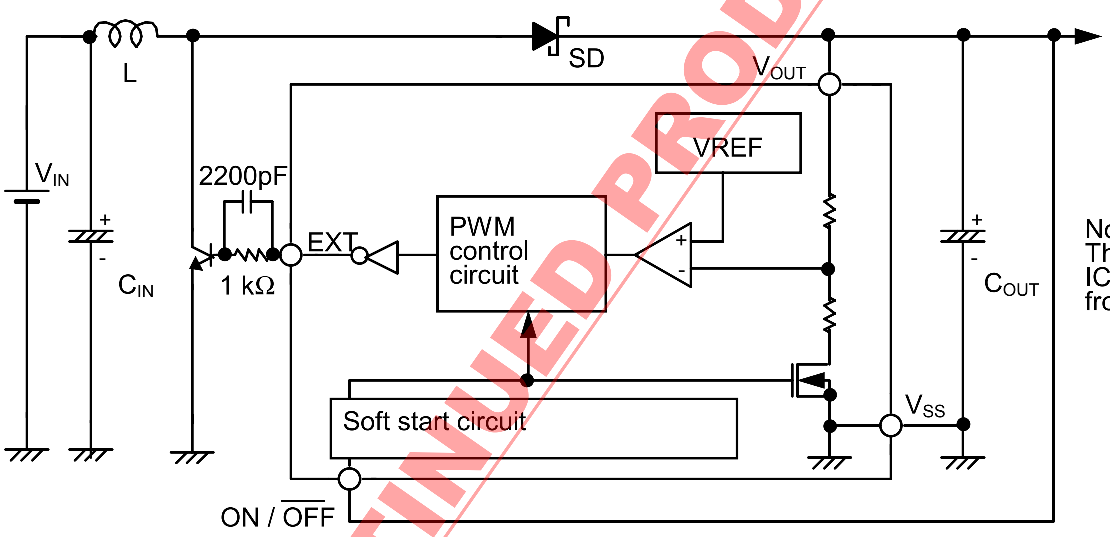
(1) S-8324AXXMC



Note:
The power supply for IC chip is supplied from V_{OUT} pin.

Figure 11

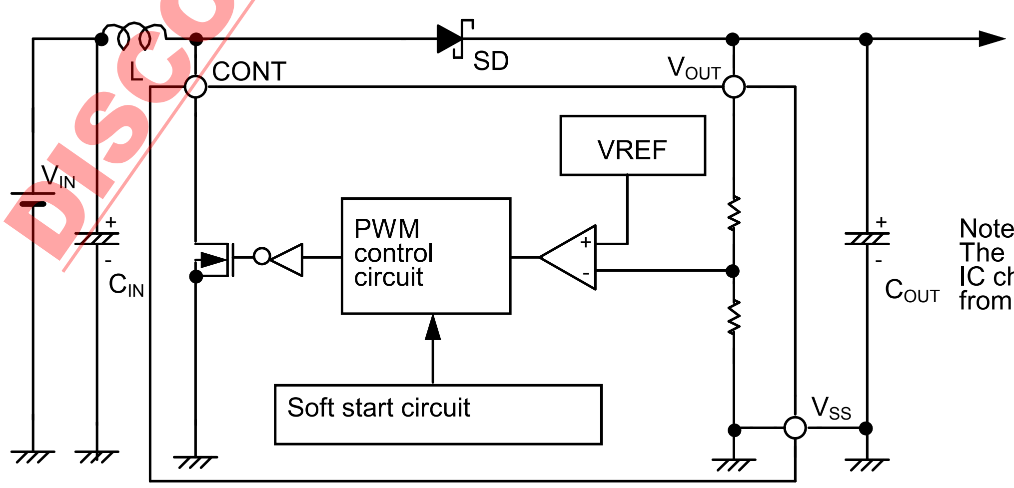
(2) S-8328BXXMC
S-8328HXXMC



Note:
The power supply for IC chip is supplied from V_{OUT} pin.

Figure 12

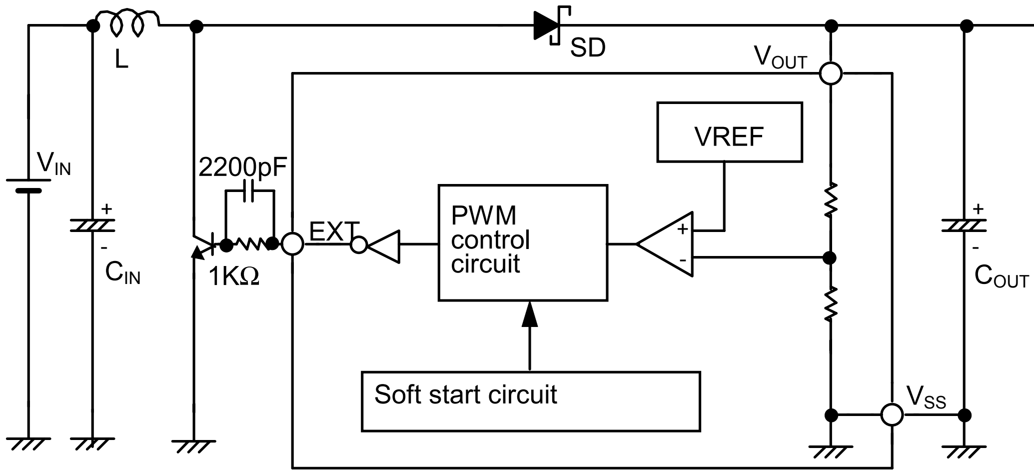
(3) S-8324AXXMA
S-8324AXXUA
S-8324CXXMA



Note:
The power supply for IC chip is supplied from V_{OUT} pin.

Figure 13

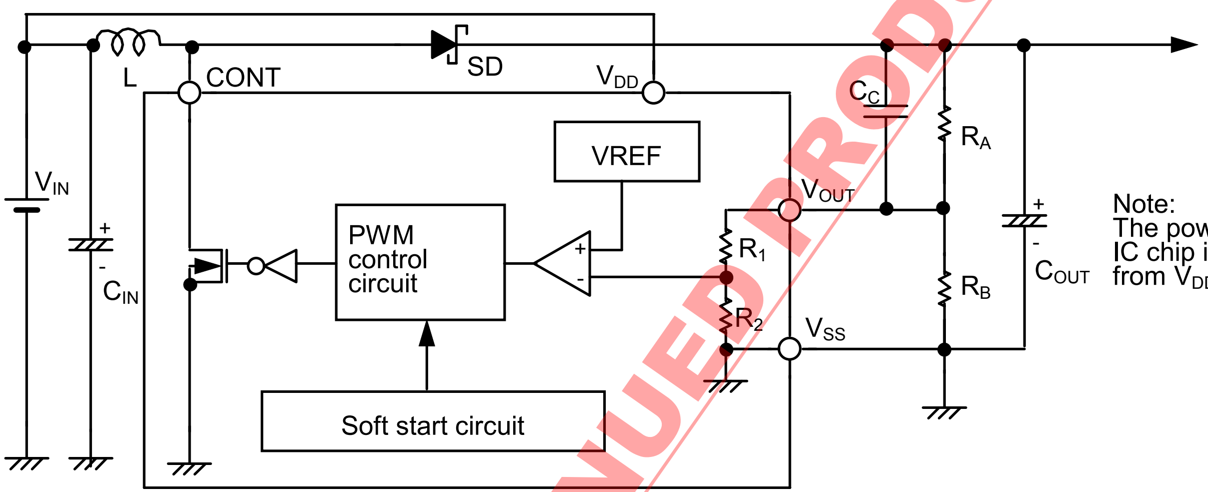
(4) S-8328BXXMA
S-8328BXXUA



Note:
The power supply for IC chip is supplied from V_{OUT} pin.

Figure 14

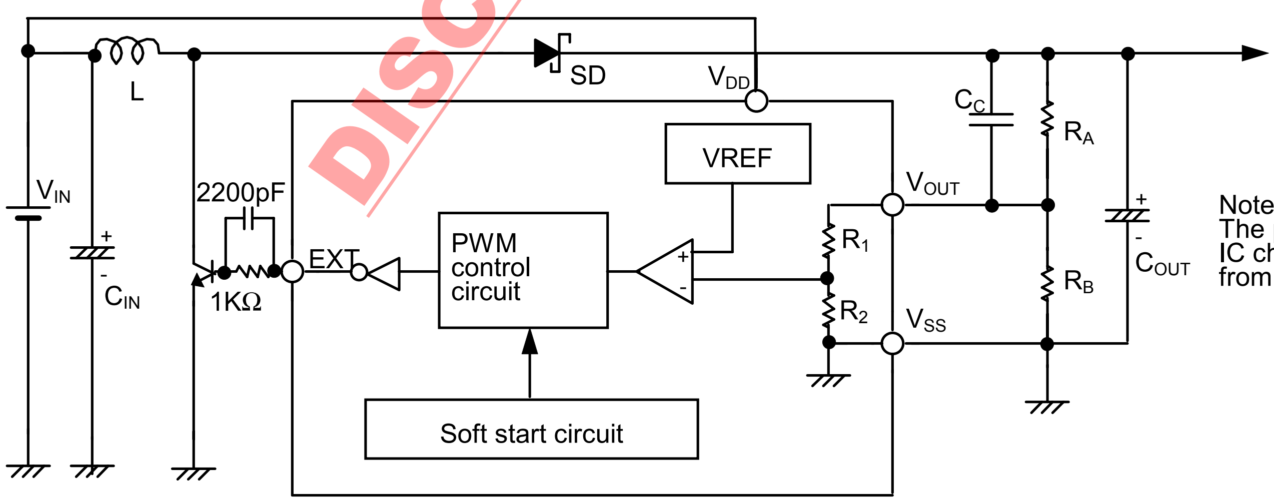
(5) S-8324DXXMC (Output voltage adjustment circuit with external resistors)
S-8324JXXMC



Note:
The power supply for IC chip is supplied from V_{DD} pin.

Figure 15

(6) S-8328EXXMC (Output voltage adjustment circuit with external resistors)
S-8328JXXMC



Note:
The power supply for IC chip is supplied from V_{DD} pin.

Figure 16

(7) S-8328JXXMC

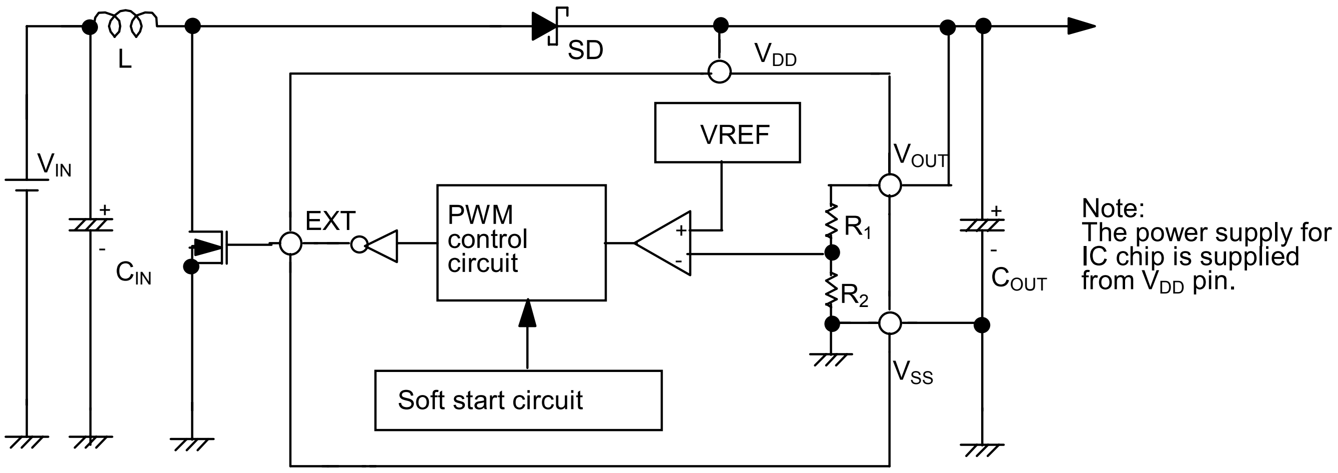


Figure 17

(8) S-8328HXXMC

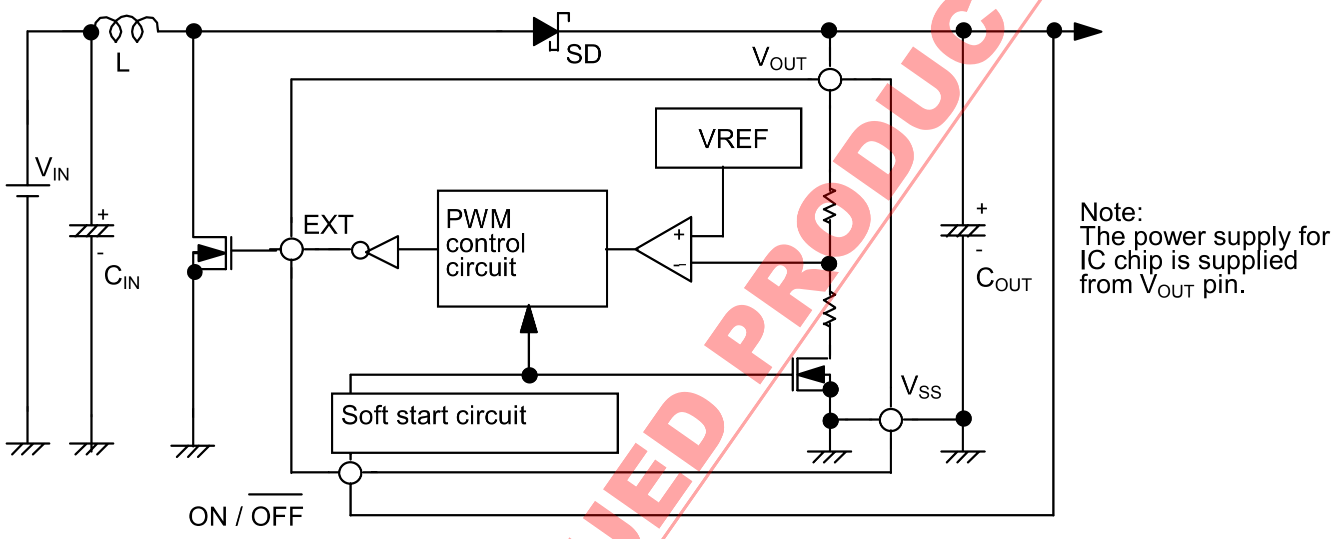


Figure 18

■ Precautions

- Mount external capacitors, a diode, and a coil as near as possible to the IC.
- Ripple voltage and spike noise occur in switching regulators. Because they largely depend on the coil and the capacitor used, check them using an actually mounted model.
- The performance of this IC varies depending on the PCB patterns, peripheral circuits or external parts. Thoroughly test all settings with your device. Also, try to use recommended external parts. If not, contact your local SII Sales Office.
- Seiko Instruments shall not be responsible for any patent infringement by products including S-8324/8328 Series in connection with the method of using S-8324/8328 Series in such products, the specification of such products, or the country of destination thereof.
- Make sure dissipation of the switching transistor (especially at a high temperatures) does not exceed the allowable power dissipation of the package.

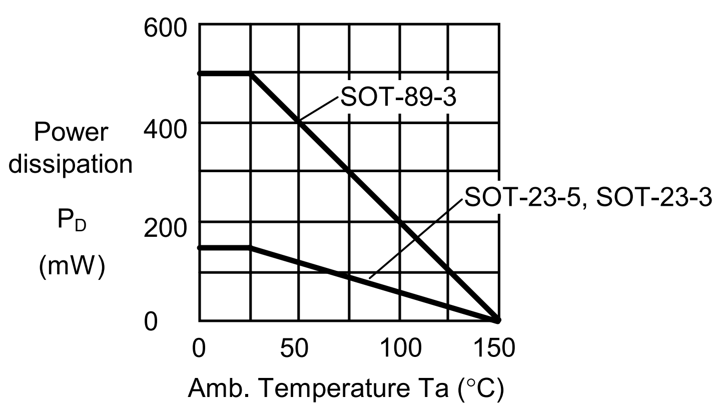


Figure 19 Power dissipation of the package (before mounting)

■ Application Circuits

1. Backup Circuit

Reduces the backup battery voltage from 3 V to 1.5 V (from 2 cells to 1 cell).

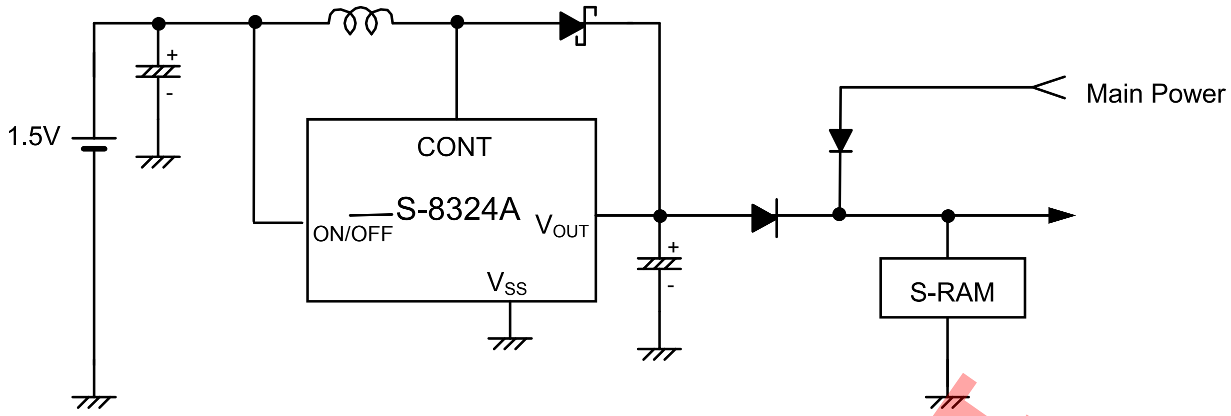


Figure 20

2. 5V/Backup Change

The S-8324A/8328B is provided with a power OFF function, where V_{OUT} becomes approx. V_{IN}-0.6V. This characteriistic allows the backup voltage of the microcomputer to be supplied with low current consumption.

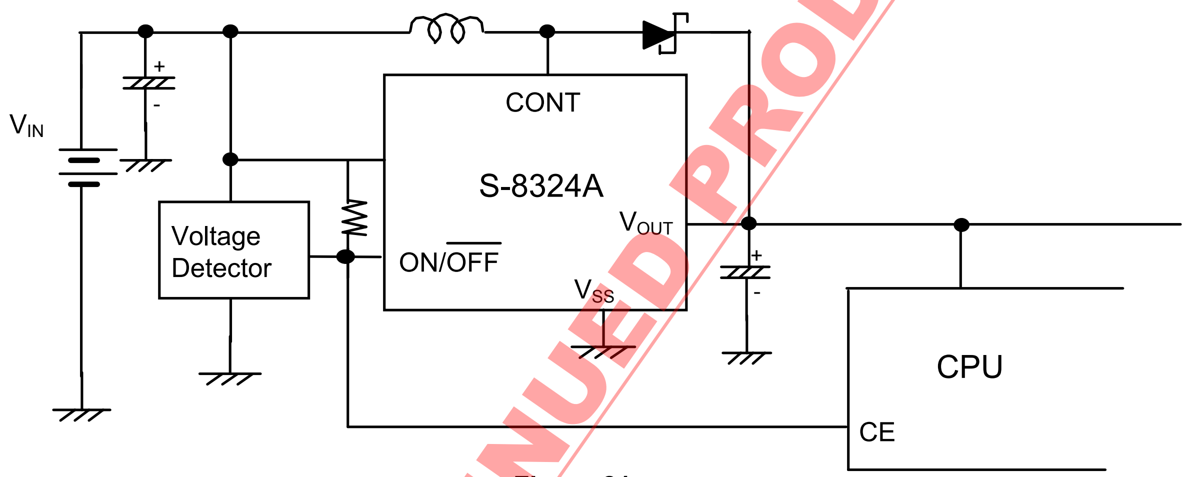


Figure 21

3. Step-down DC/DC converter

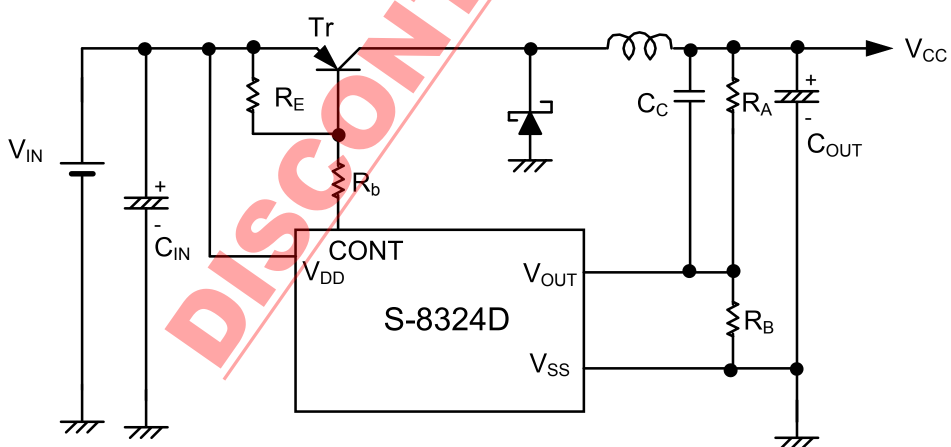


Figure 22

The start circuit is not needed because the power supply is supplied from V_{DD} to the IC.

The maximum input voltage for V_{DD} is 9 V.

DO NOT mount R_A and R_B resistors when V_{CC} is 2V for S-8324D20MC, 3V for S-8324D30MC, and 5V for S-8324D50MC.

The external resistor Rb must be 60Ω or more and R_E must be 6kΩ or less. A large value for R_E raises efficiency due to the reduction of reactive current for R_E and R_b.

Too large value of R_E lowers efficiency due to the large switching loss of the external transistor (Tr). Choose a suitable value of R_E under the operating conditions.

4. PDA/Digital Camera Power Supply

The following are a circuit example and its characteristics showing a 3-V system drive (3V/200mA) powered by 4 secondary Nicd batteries (3.6 to 4.8V), 2 lithium-ion batteries (4.8 to 8.8V) or 4 alkaline-manganese batteries (3.6 to 6.0V).

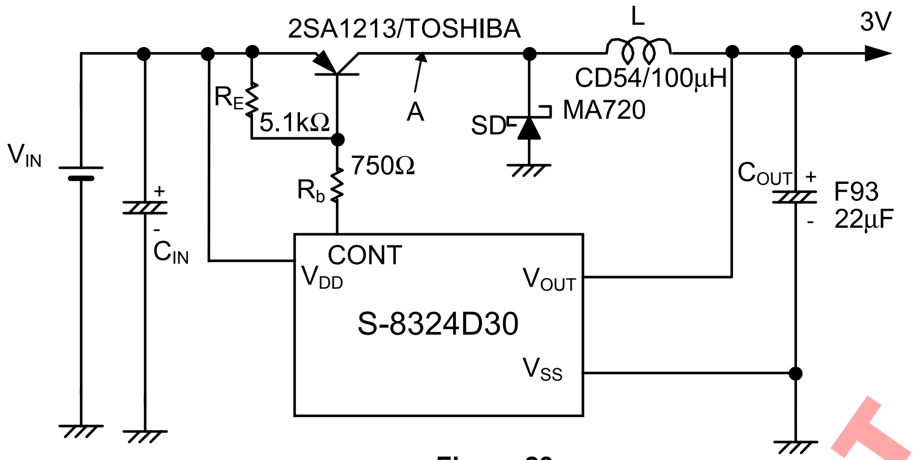


Figure 23

(a) Output Current - Output Voltage

(b) Output Current - Efficiency

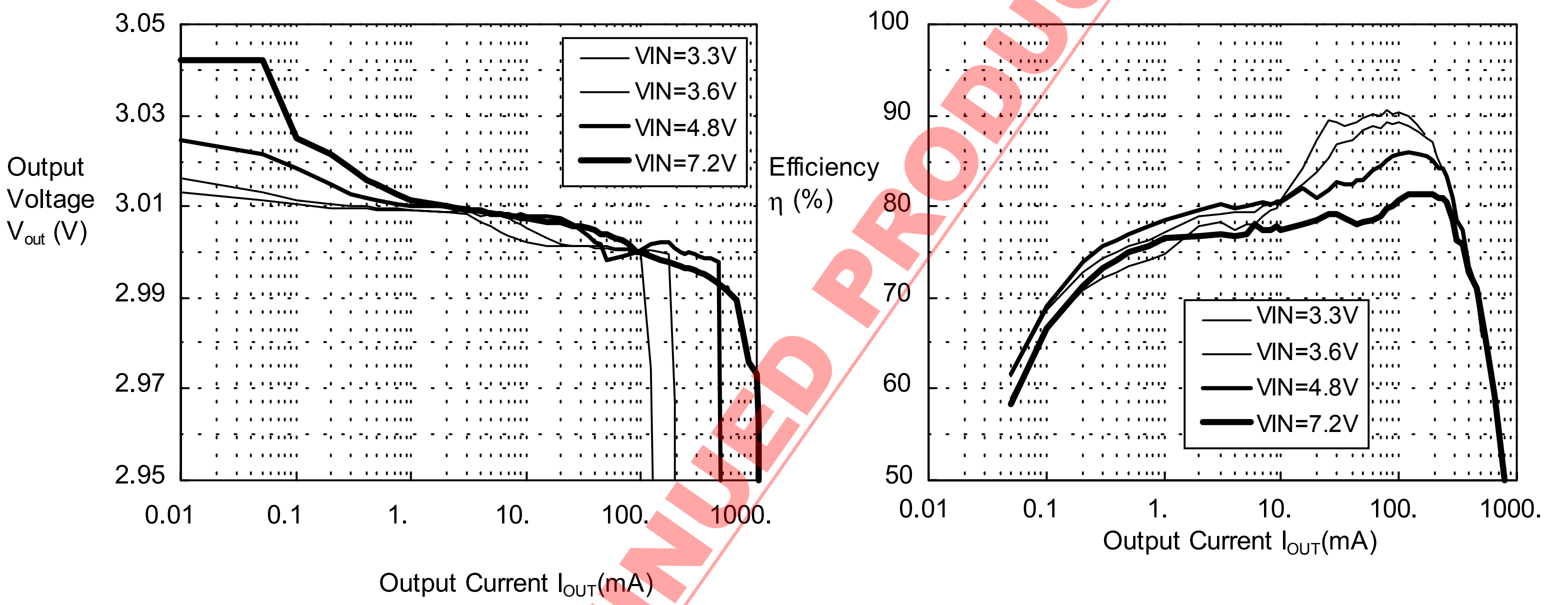


Figure 24

(c) Ripple Characteristics

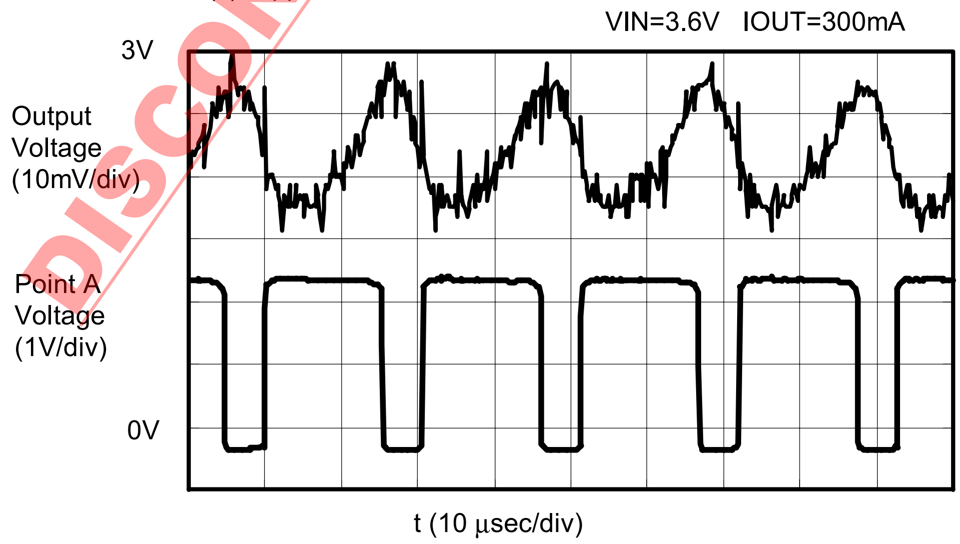


Figure 25

5. Voltage Inverting Type DC/DC Converter

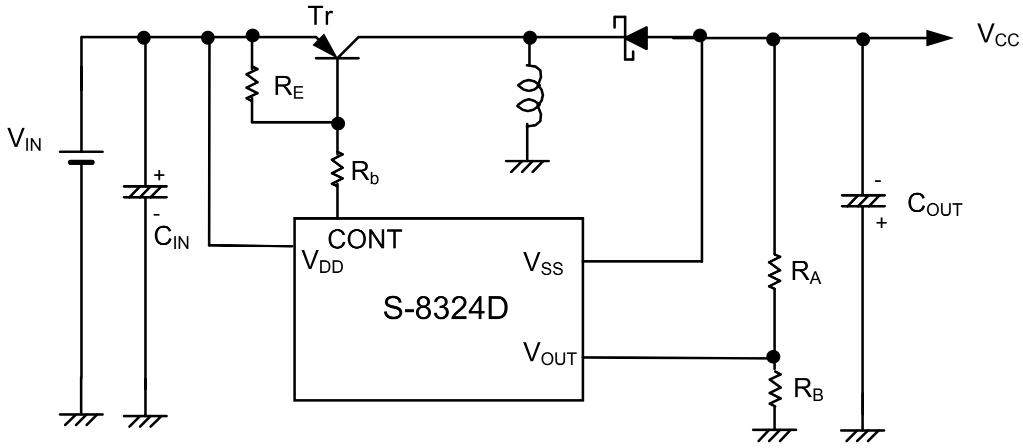


Figure 26

The Start circuit is not needed because the power is supplied from V_{DD} to the IC. Set V_{IN} to 9V-|V_{CC}| or less.

When V_{CC} is -2 V, - 3 V and - 5 V, use the S-8324D20MC, the S-8324D30MC and the S-8324D50MC respectively. Always connect V_{OUT} to GND without attaching R_A, R_B.

Set R_b to 60Ω or more and R_E to 6 kΩ or less. The larger R_E, the smaller the reactive current through R_E and R_b, allowing the efficiency to be improved. On the other hand, the switching loss of the Tr becomes large and consequently the efficiency will be worsend. Select R_E to ensure high efficiency under operating conditions.

6. Power Supply for GaAs and MR Head

The following are an application negative power supply circuit for GaAs and MR head, and its characteristics when -3V (-3V ±10%) and -5V (-5V ±10%) are used for the applied power. Set V_{IN} to 9V-|V_{CC}| or less.

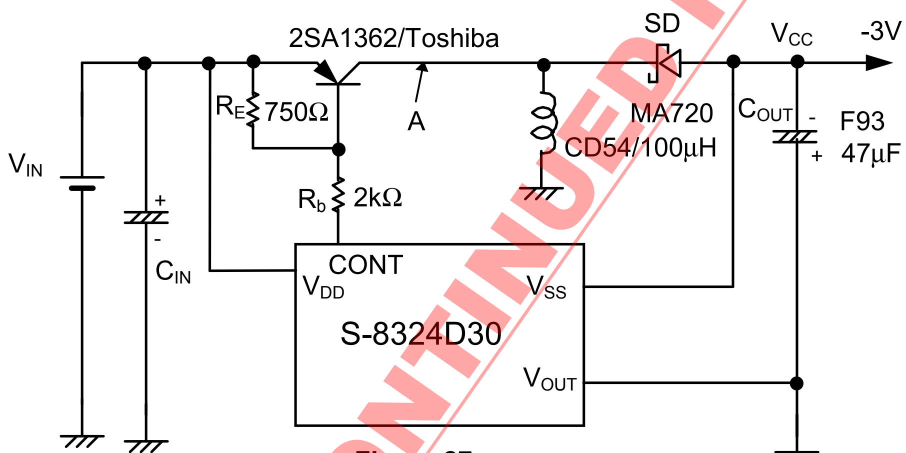


Figure 27

(a) Output Current - Output Voltage (b) Output Current - Efficiency

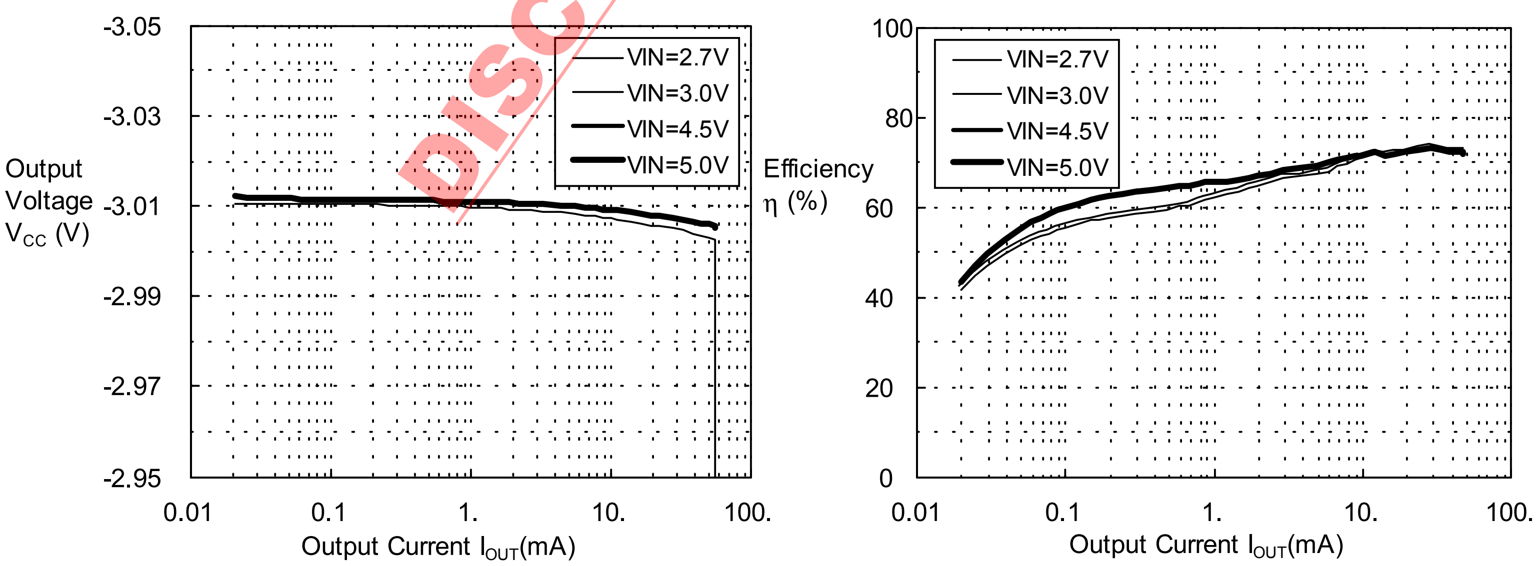


Figure 28

(c) Ripple Characteristics

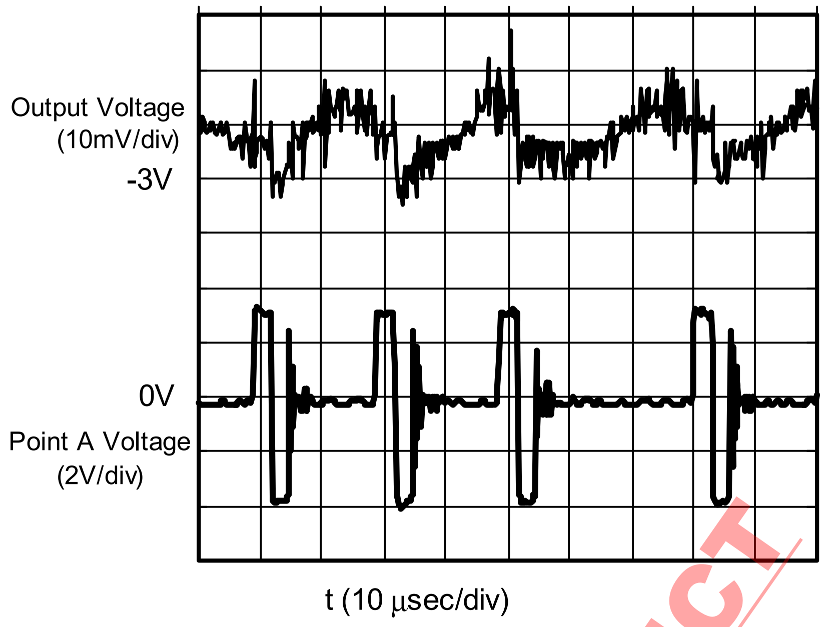


Figure 29

When output current I_{OUT} exceeds 50 mA, the current capacitance in the external transistor 2SA1362 becomes in short supply and the IC may be broken. Select a large current capacitance transistor.

The start circuit is not needed because the power supply is supplied from V_{DD} to the IC. Set Vin to 9 V - $|V_{CC}|$ or less.

The output voltage cannot be changed with external resistors.

Set R_b to 60Ω or more and R_E to 6 kΩ or less. The larger R_E, the smaller the reactive current through R_E and R_b, allowing the efficiency to be improved. On the other hand, the switching loss of the Tr becomes large and consequently the efficiency will be worsened. Select R_E to ensure high efficiency under operating conditions.

7. LCD Power Supply (Standard circuit (6))

The following are an application power supply circuit (30V/5mA) for intermidiate and large size LCD, and its characteristics when 3V (3V±10%) and 5V (5V±10%) are used for the applied power.

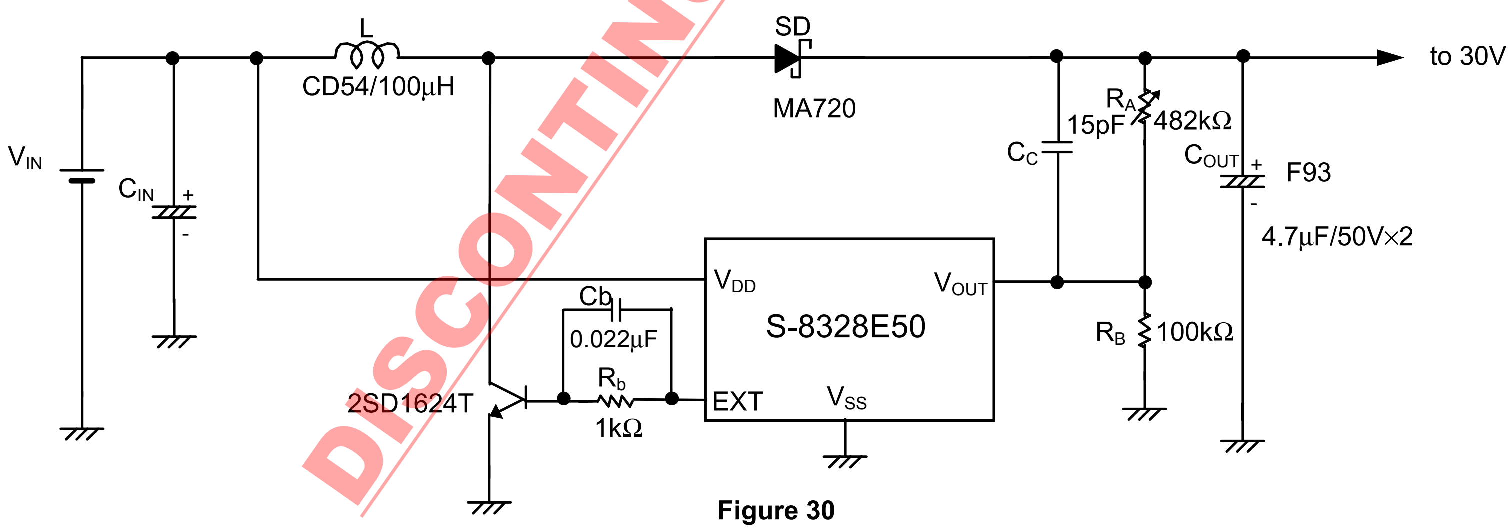


Figure 30

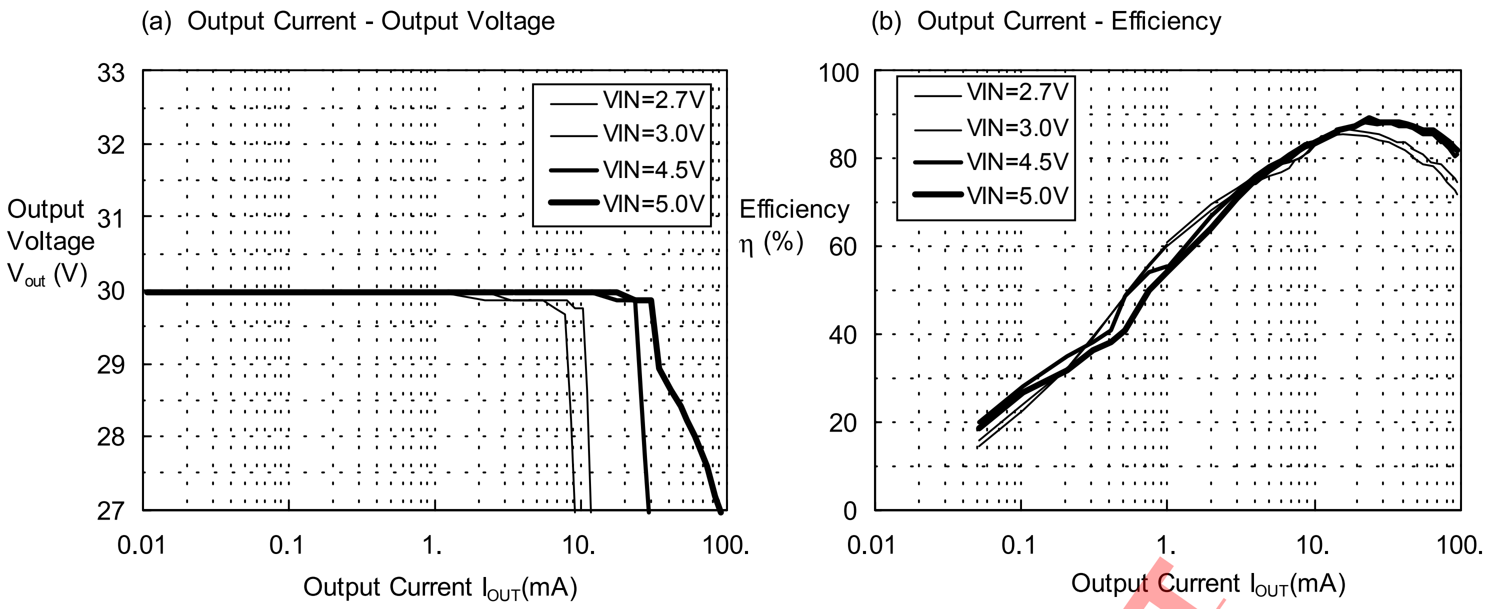


Figure 31

8. Flash Memory Power Supply

The following are a circuit example and its characteristics for a 5 V Flash Memory, 16 Mbit (5V/120mA) on a single lithium battery (2.4 V to 4.4 V).

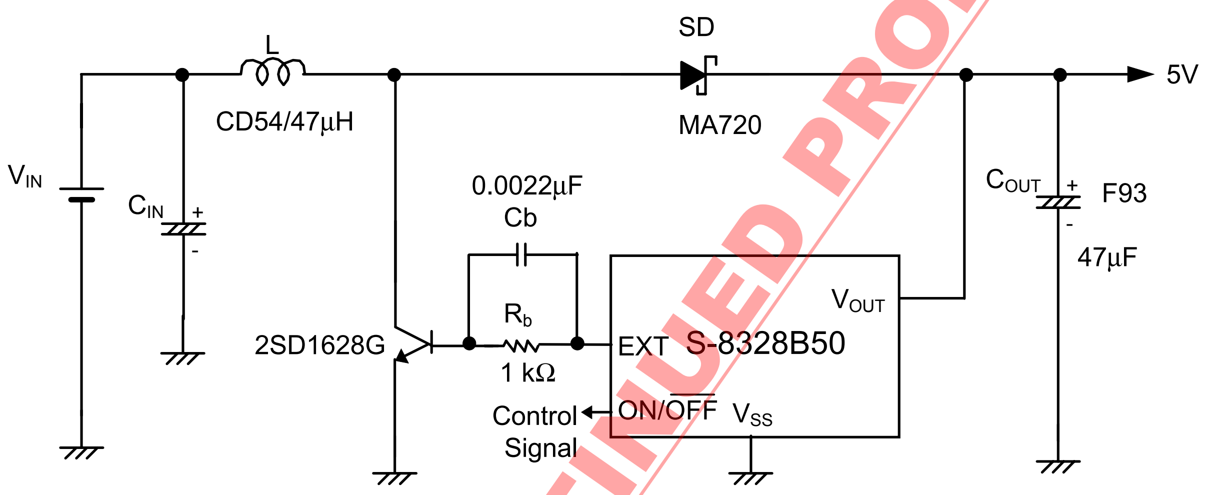


Figure 32

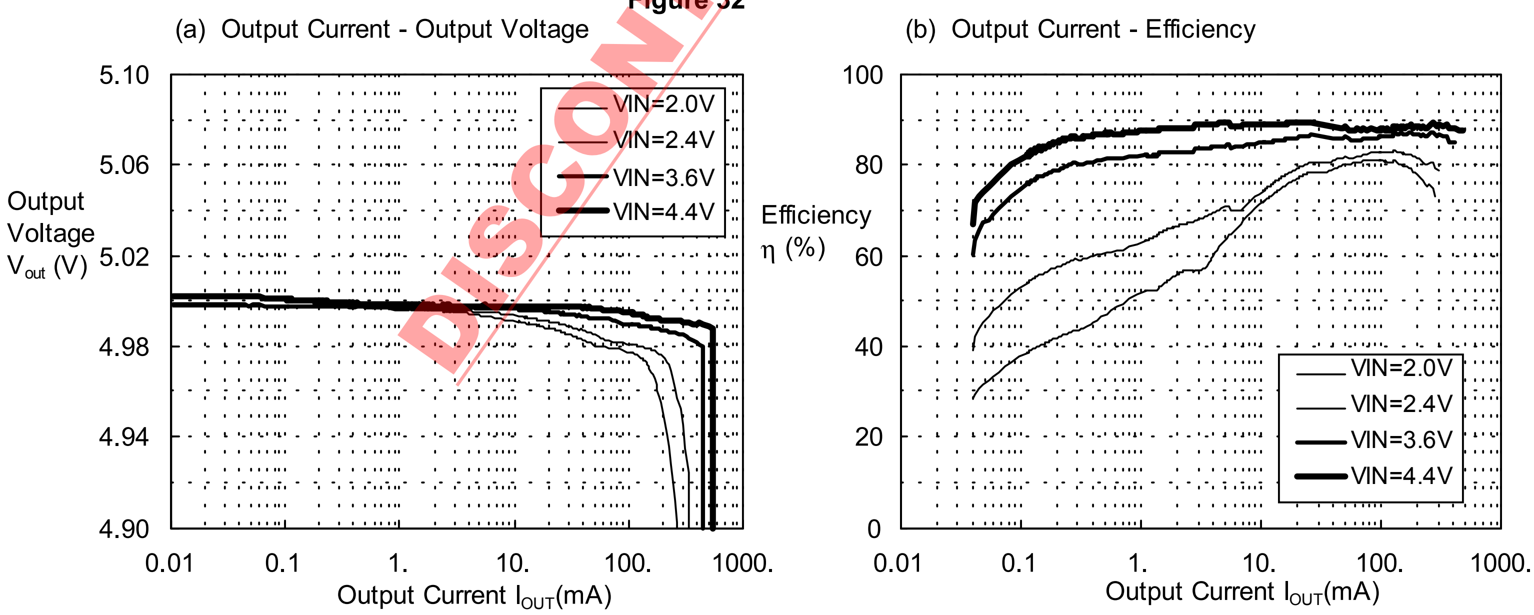


Figure 33

9. Power Supply for CCD

The follows are a circuit example and its characteristics for CCD power supply (+15, -5.5V/10mA) powered by 4 alkaline-manganese batteries (3.6-6.0V), used for digital still cameras and others.

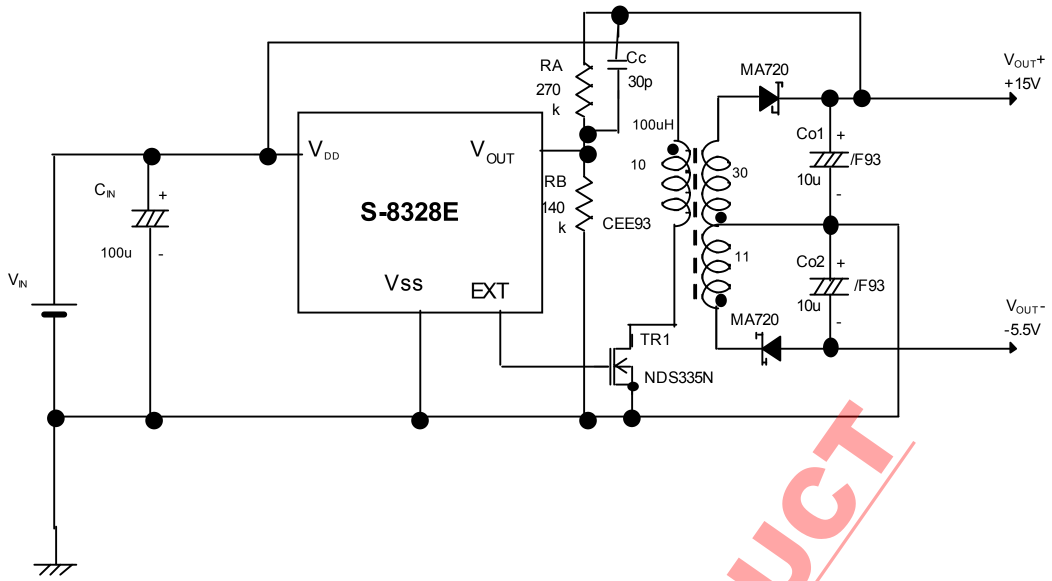
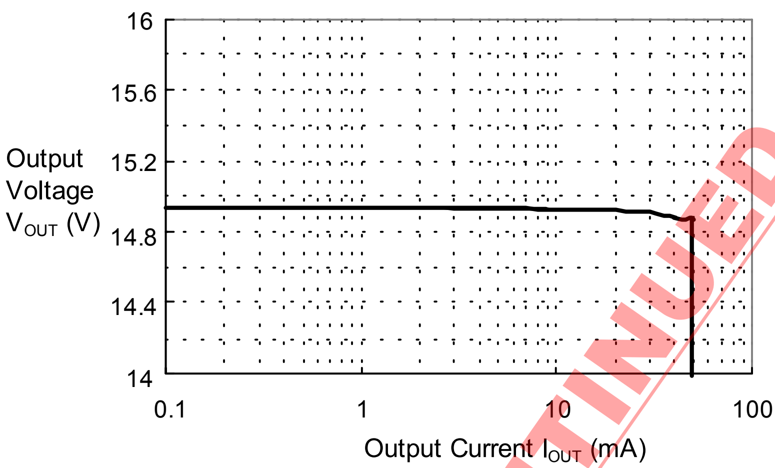
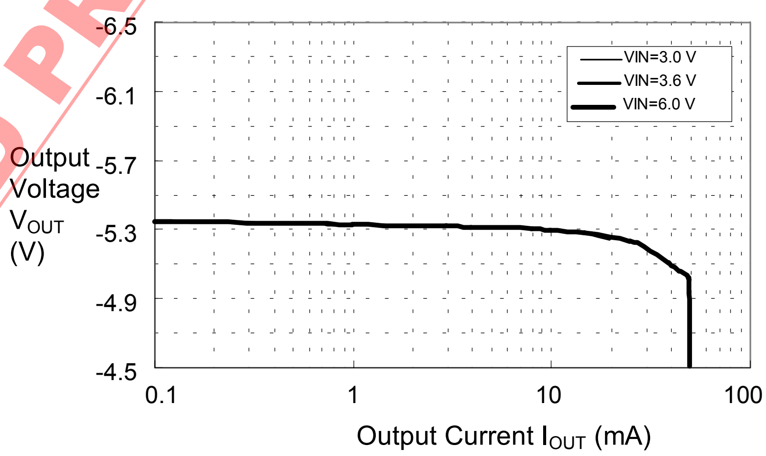


Figure 34

(a) Output Current - Output Voltage (positive output)



(b) Output Current - Output Voltage (negative output)



(c) Output Current - Efficiency

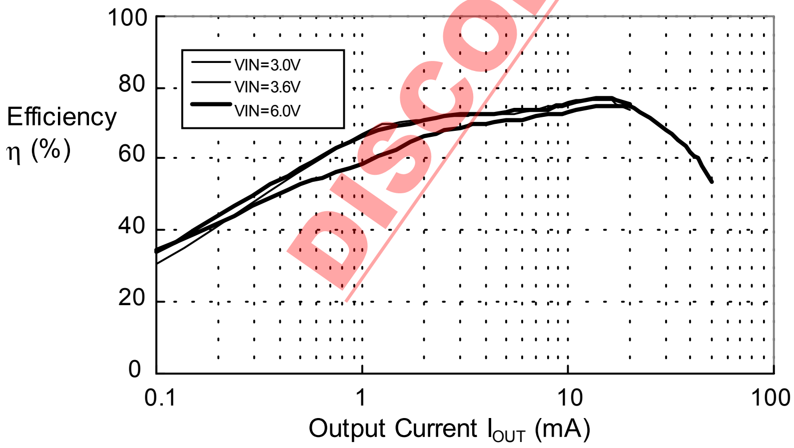
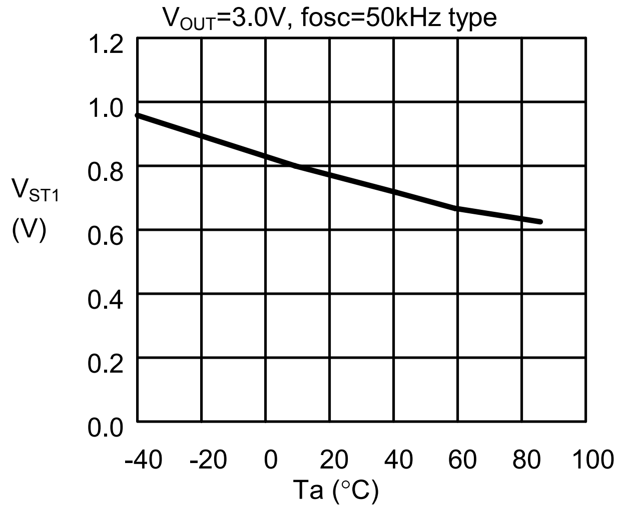


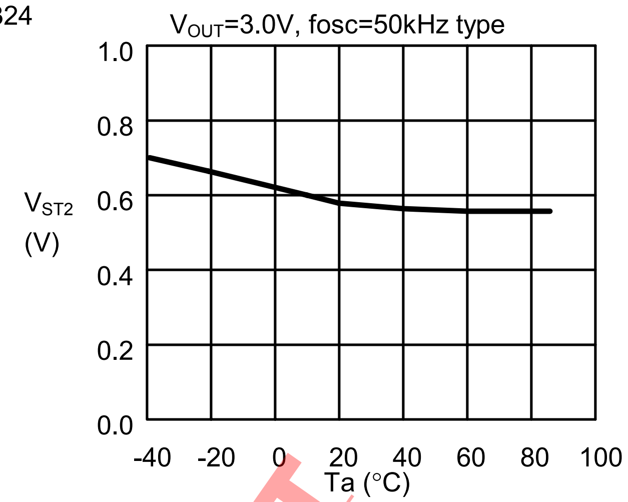
Figure 35

■ Temperature Characteristics

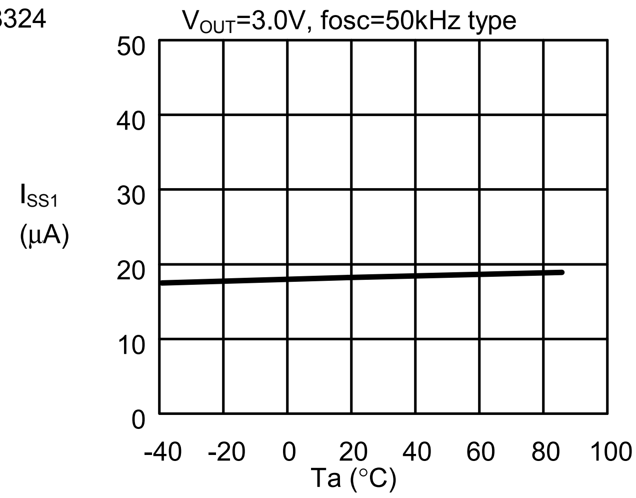
V_{ST1} - Ta
S-8324



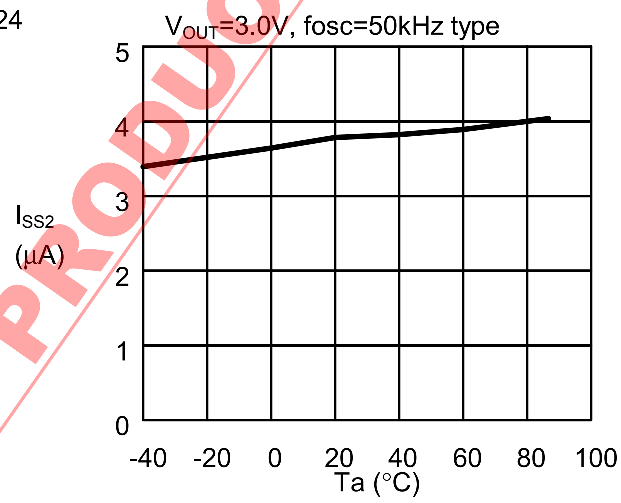
V_{ST2} - Ta
S-8324



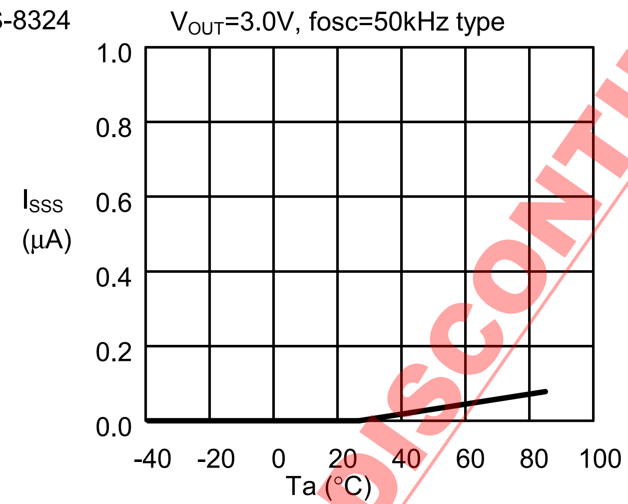
I_{SS1} - Ta
S-8324



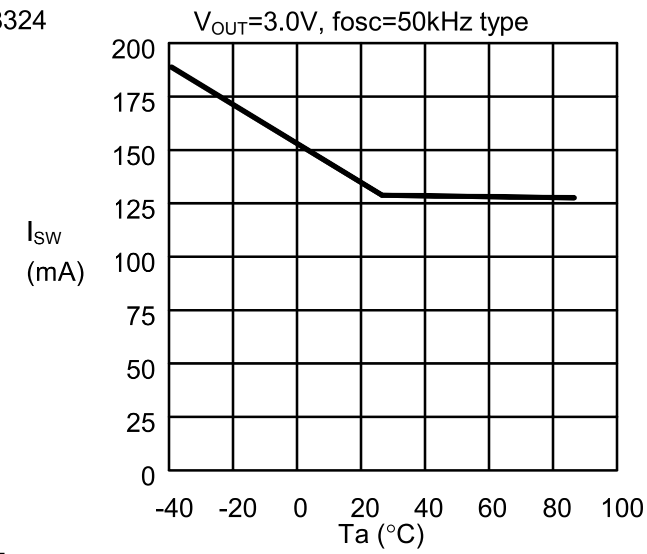
I_{SS2} - Ta
S-8324



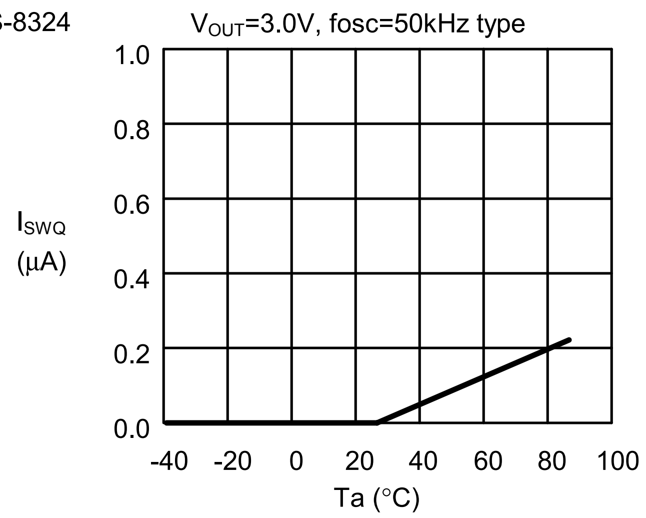
I_{SSS} - Ta
S-8324



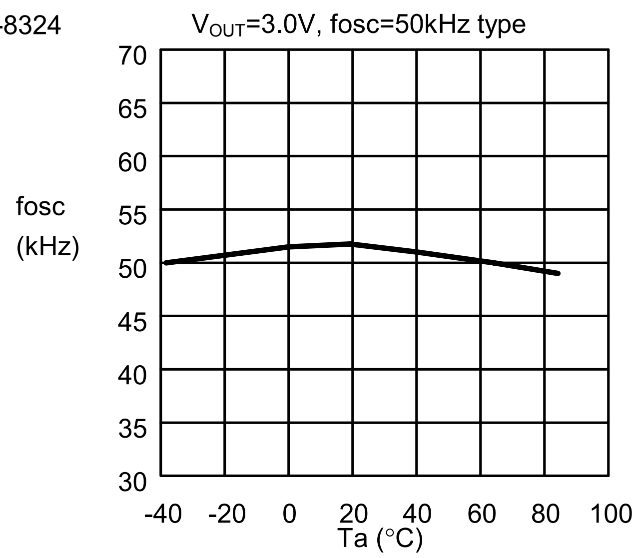
I_{SW} - Ta
S-8324



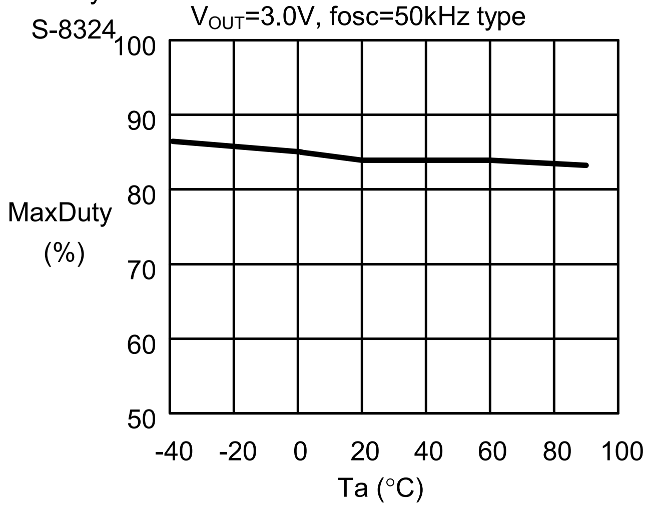
I_{SWQ} - Ta
S-8324



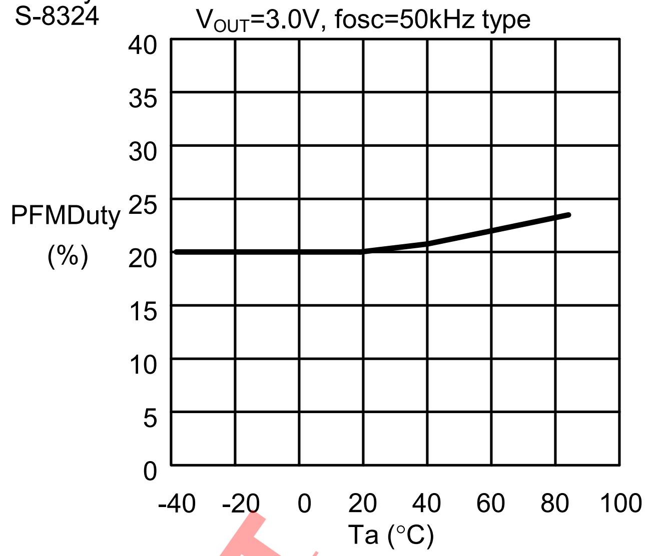
f_{osc} - Ta
S-8324



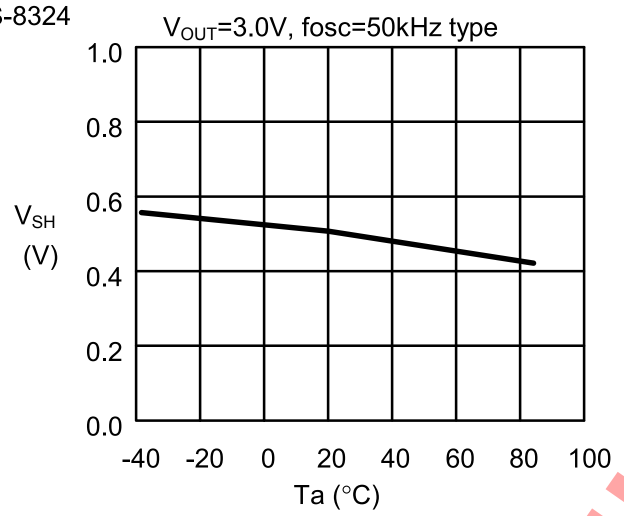
MaxDuty - Ta



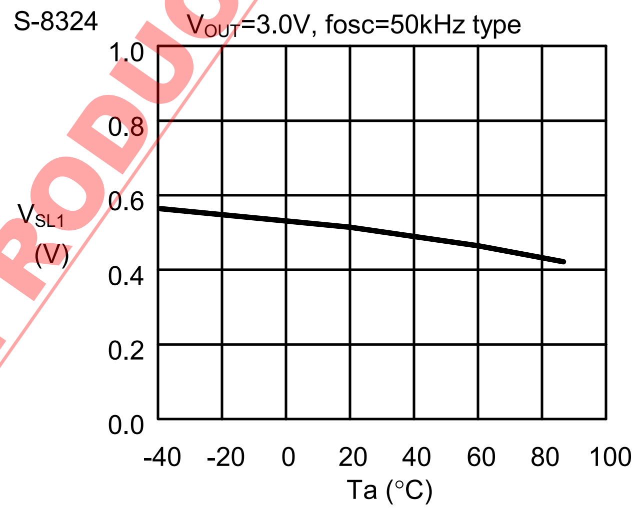
PFMDuty - Ta



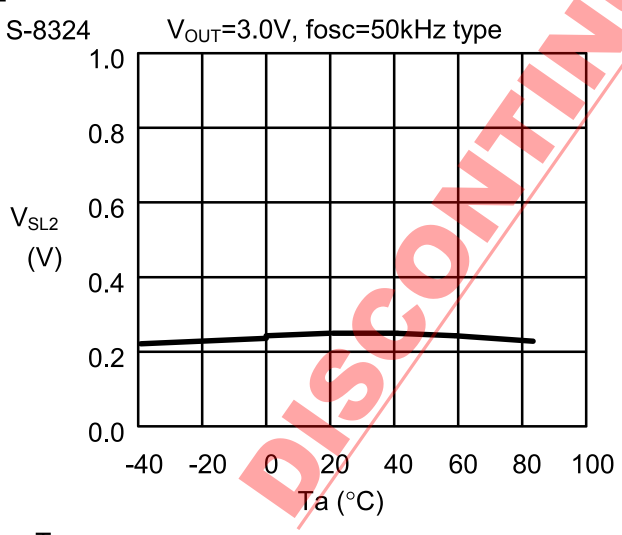
V_{SH} - Ta



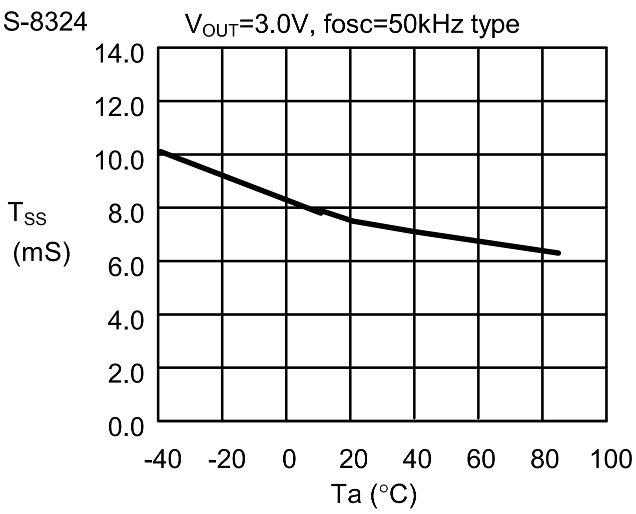
V_{SL1} - Ta



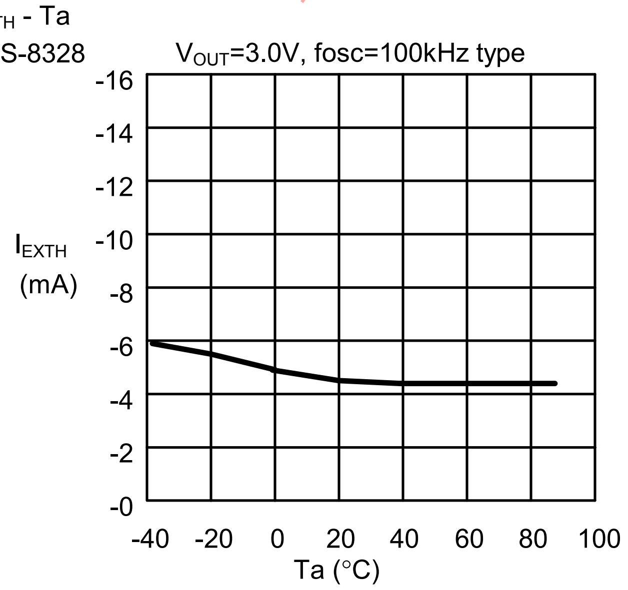
V_{SL2} - Ta



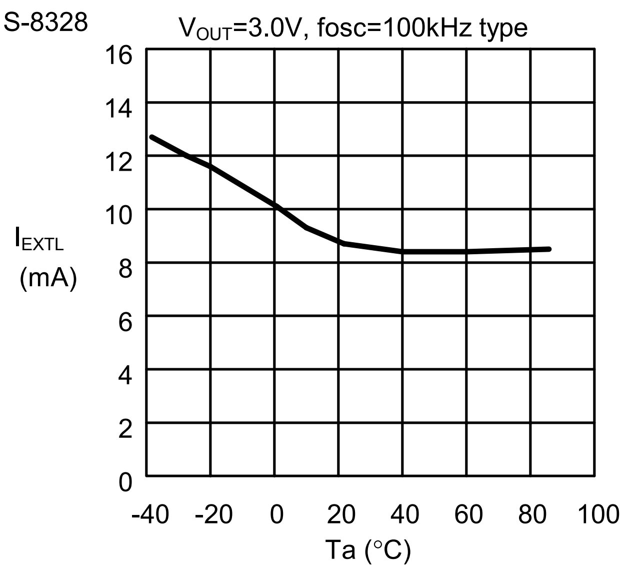
T_{SS} - Ta



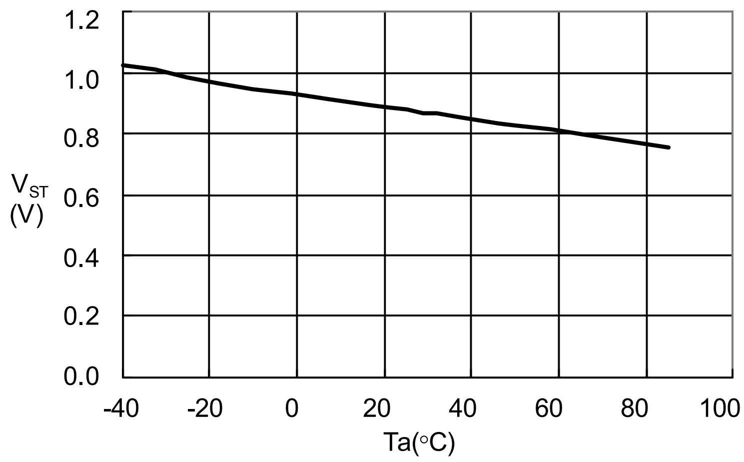
I_{EXTH} - Ta



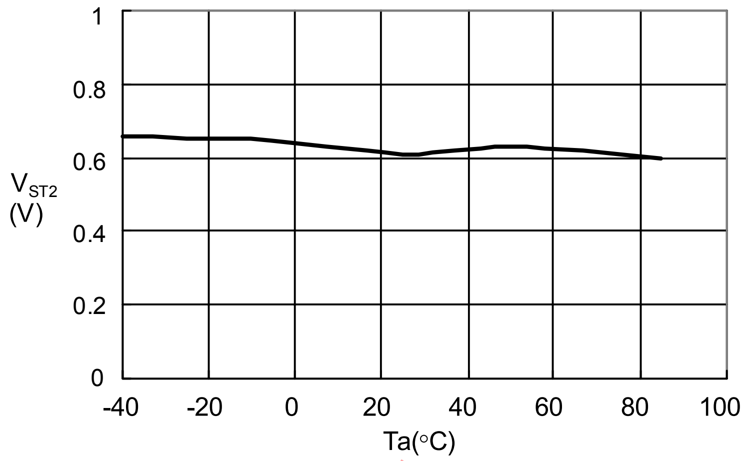
I_{EXTL} - Ta



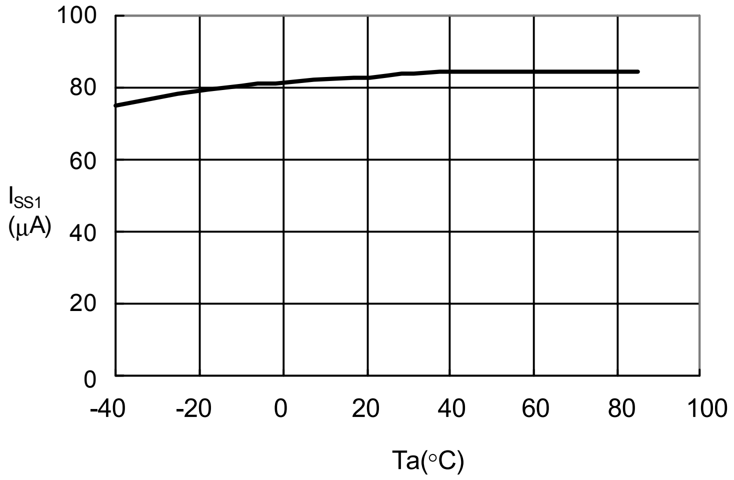
V_{ST1} - Ta
S-8324 V_{OUT}=3.3V, fosc=250kHz type



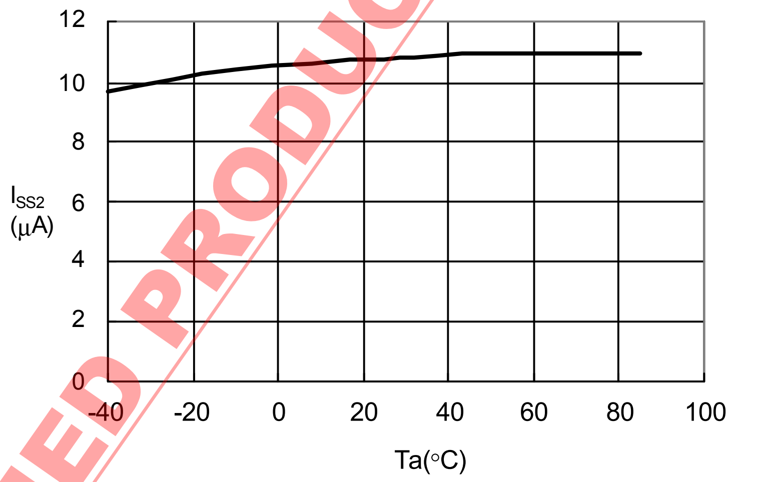
V_{ST2} - Ta
S-8324 V_{OUT}=3.3V, fosc=250kHz type



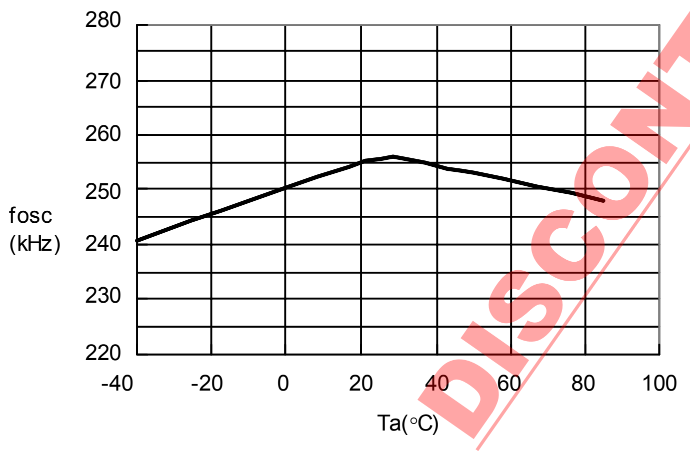
I_{SS1} - Ta
S-8324 V_{OUT}=3.3V, fosc=250kHz type



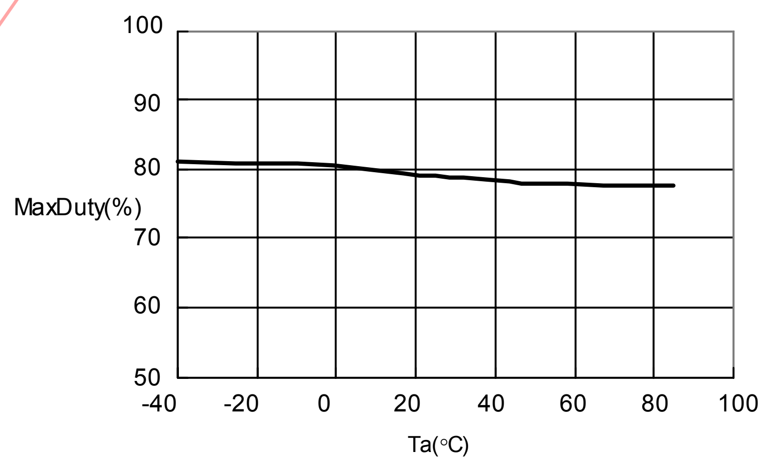
I_{SS2} - Ta
S-8324 V_{OUT}=3.3V, fosc=250kHz type



f_{OSC} - Ta
S-8324 V_{OUT}=3.3V, fosc=250kHz type

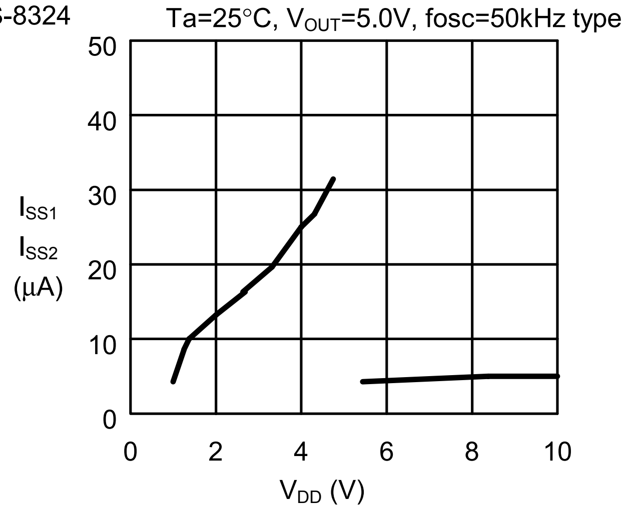


MaxDuty - Ta
S-8324 V_{OUT}=3.3V, fosc=250kHz type

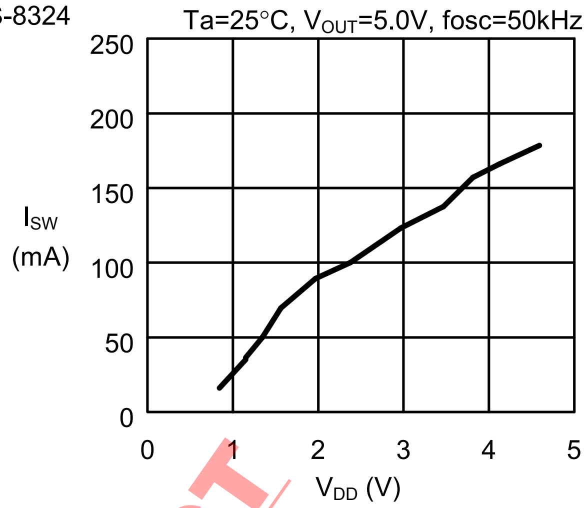


■ Characteristics for the Power Voltage

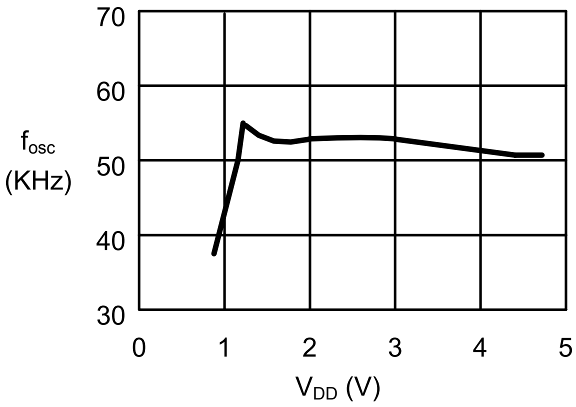
$I_{SS1, 2}$ - V_{DD}
S-8324 Ta=25°C, V_{OUT}=5.0V, fosc=50kHz type



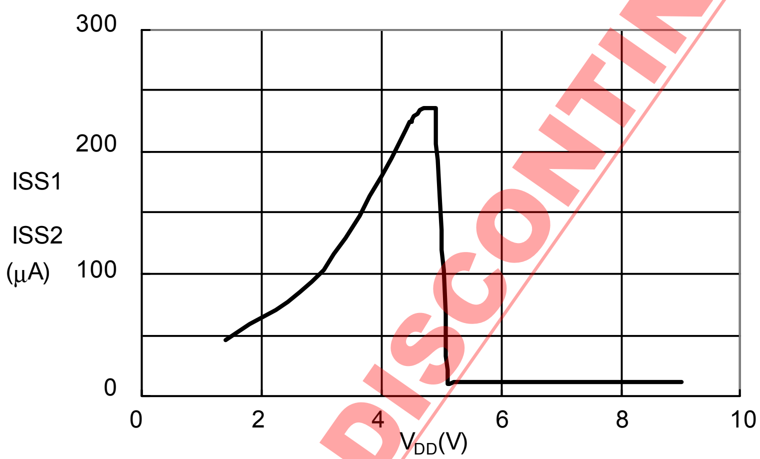
I_{SW} - V_{OUT}
S-8324 Ta=25°C, V_{OUT}=5.0V, fosc=50kHz type



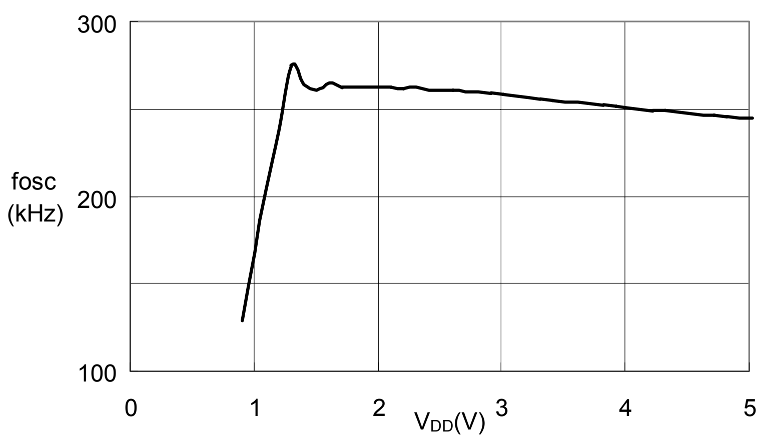
f_{osc} - V_{DD}
S-8324 Ta=25°C, V_{OUT}=5.0V, fosc=50kHz type



$I_{SS1, 2}$-V_{DD}
S-8324J50 Ta=25°C, V_{OUT}=5.0V, fosc=250kHz type



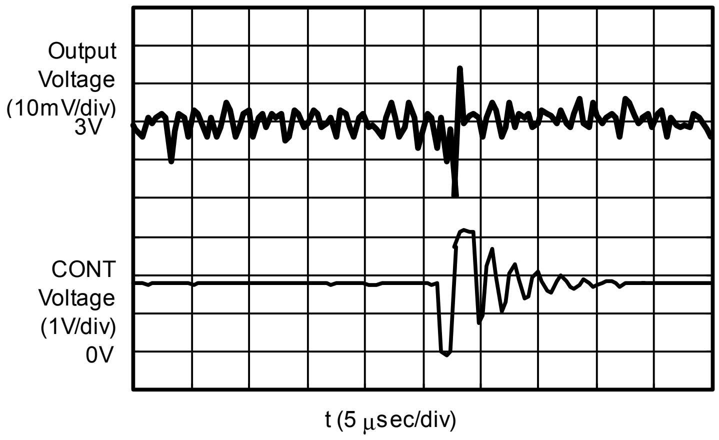
f_{osc} - V_{DD}
S-834J50 Ta=25°C, V_{OUT}=5.0V, fosc=250kHz type



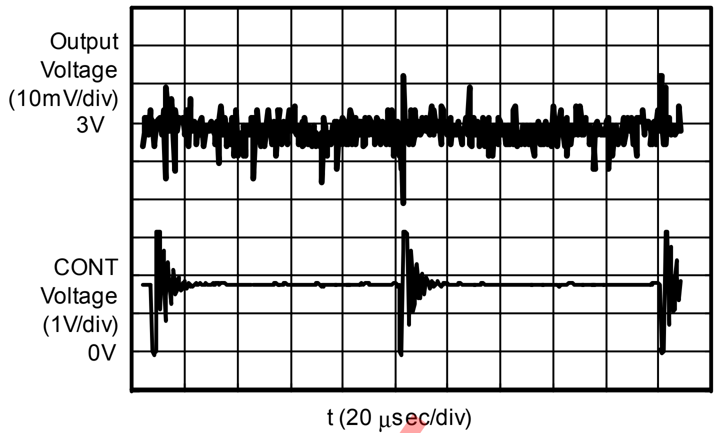
■ Ripple characteristics

S-8324A30

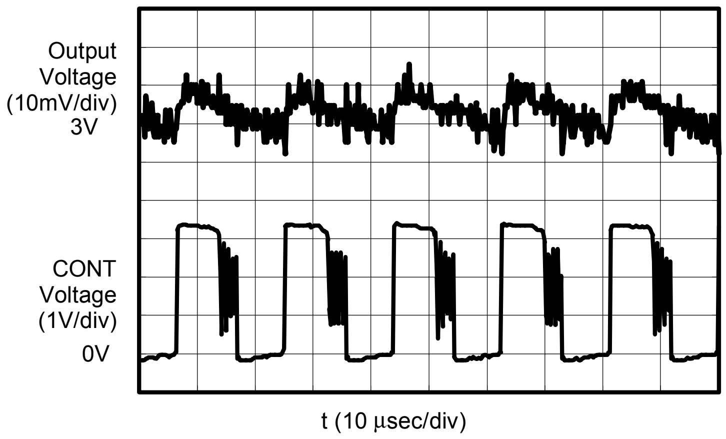
1. Light Load (I_{OUT}=200μA) V_{IN}=1.8V



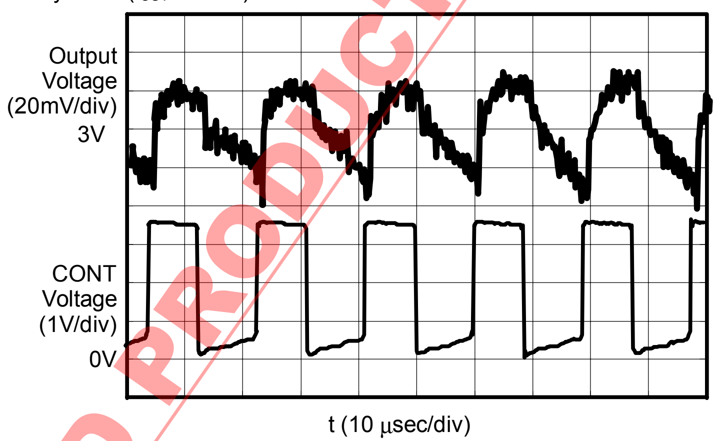
V_{IN}=1.8V



2. Medium Load (I_{OUT}=10mA) V_{IN}=1.8V

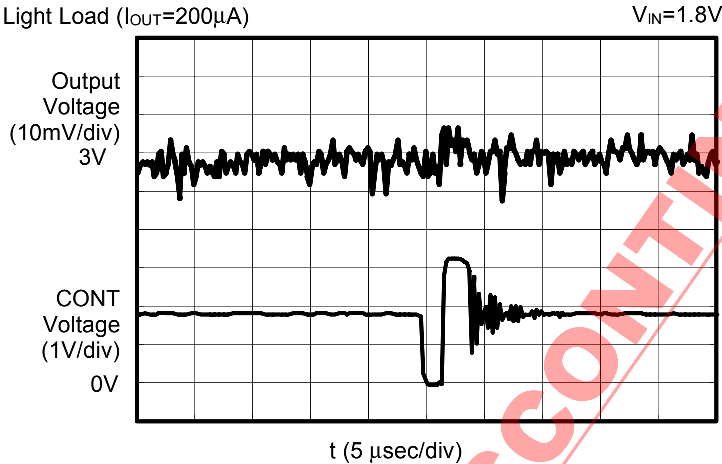


3. Heavy Load (I_{OUT}=60mA) V_{IN}=1.8V

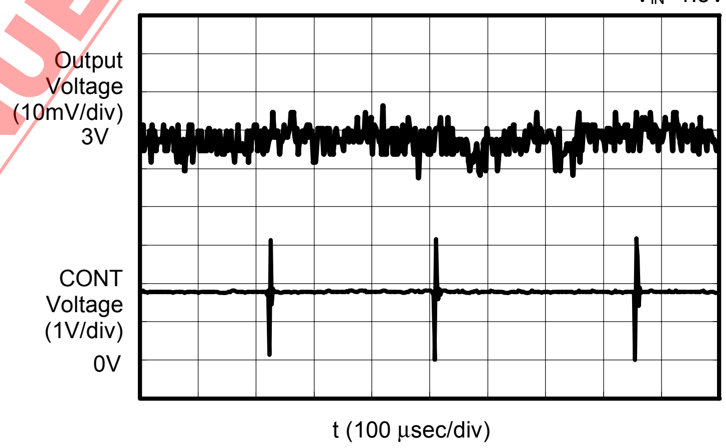


S-8328B30

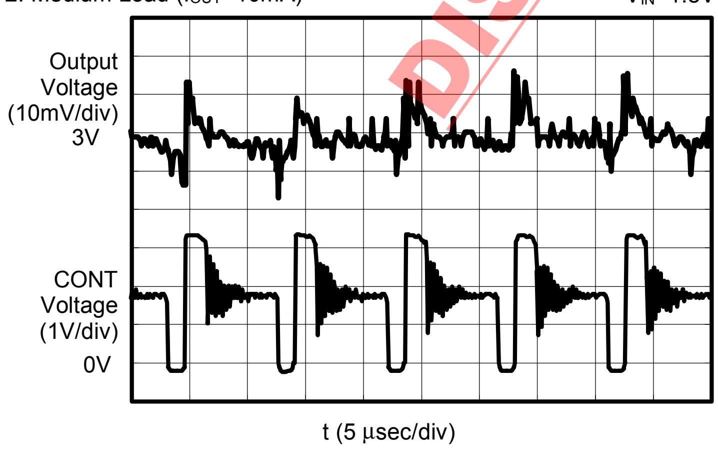
1. Light Load (I_{OUT}=200μA) V_{IN}=1.8V



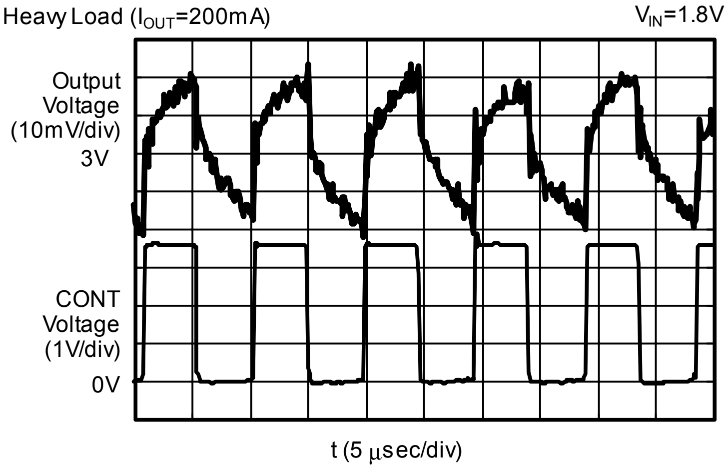
V_{IN}=1.8V



2. Medium Load (I_{OUT}=10mA) V_{IN}=1.8V



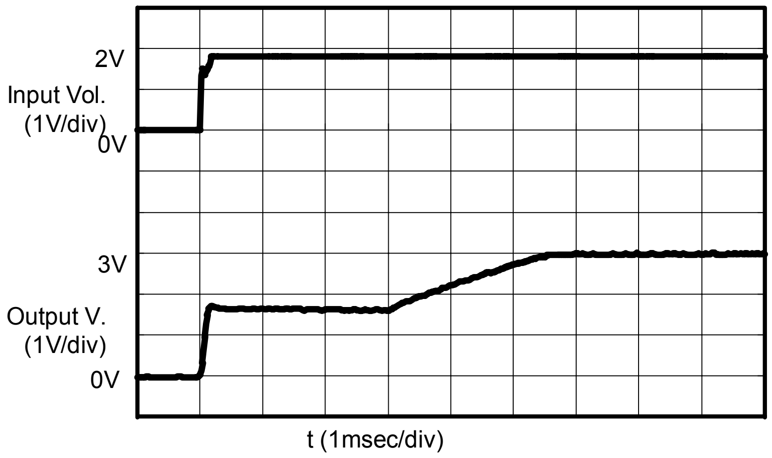
3. Heavy Load (I_{OUT}=200mA) V_{IN}=1.8V



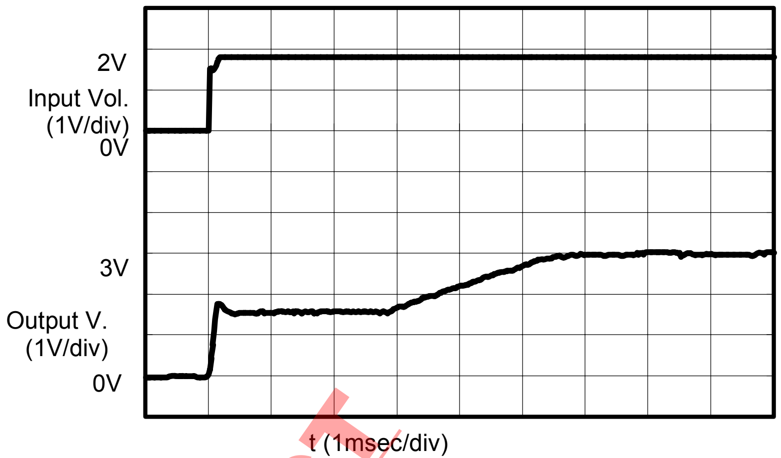
■ Transient Responses

1. Powering ON due to V_{IN} (V_{IN}: 0V → 1.8 V)

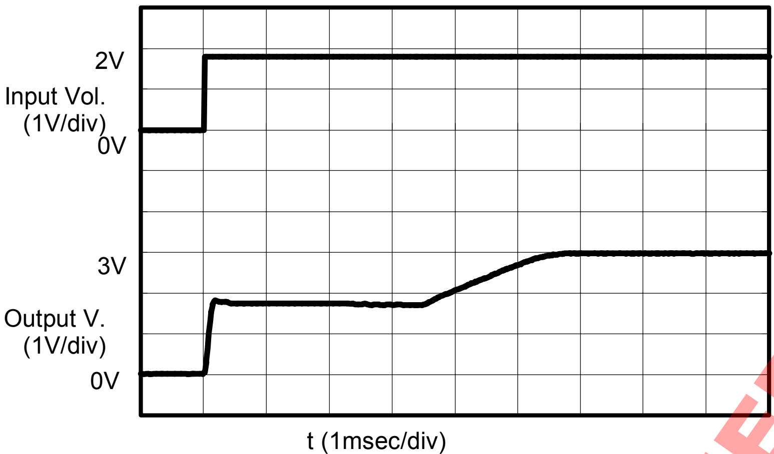
S-8324A30 (Light Load:I_{OUT}=1mA)



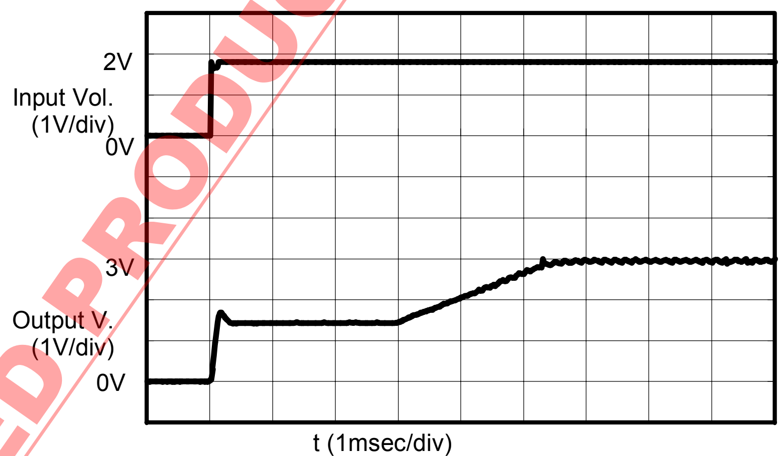
S-8324A30 (Heavy Load:I_{OUT}=60mA)



S-8328B30 (Light Load:I_{OUT}=1mA)

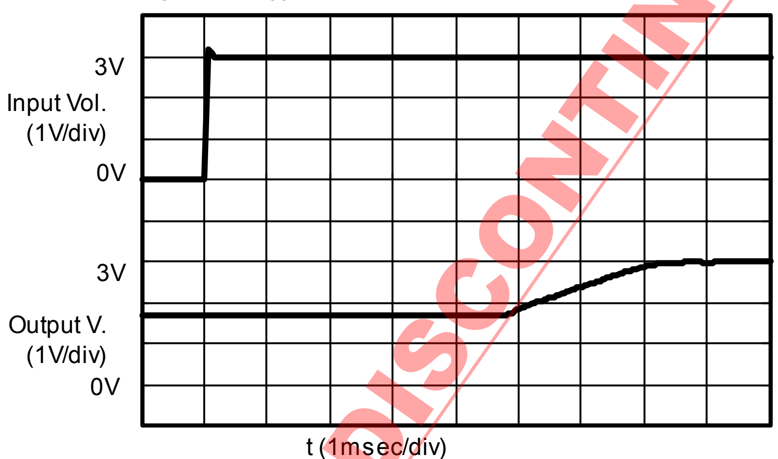


S-8328B30 (Heavy Load:I_{OUT}=200mA)

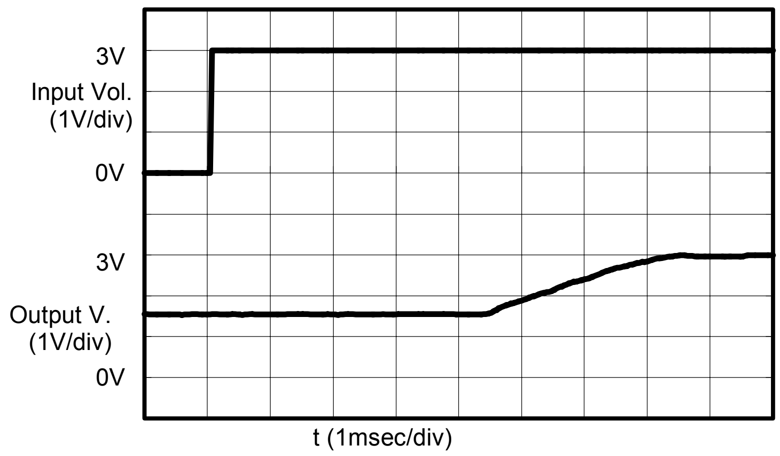


2. Powering ON due to Shutdown pin (Von/off: 0V → 3.0 V)

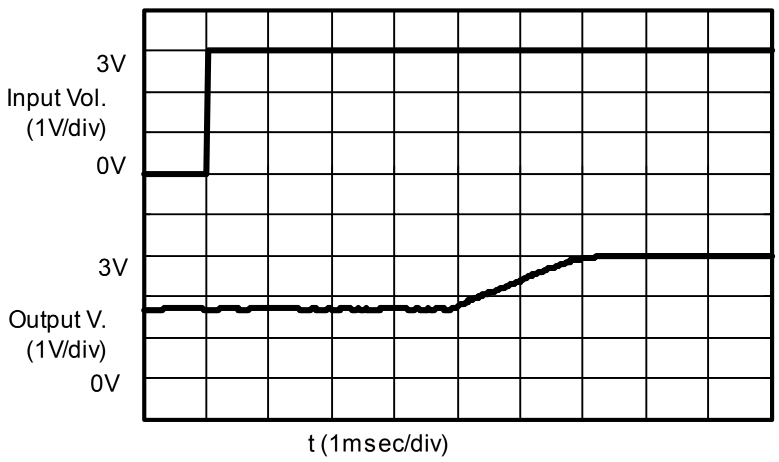
S-8324A30 (Light Load:I_{OUT}=1mA) V_{IN}=1.8V



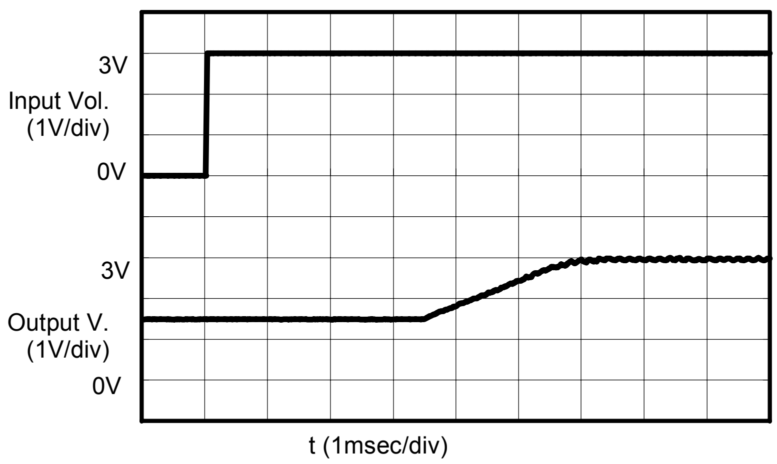
S-8324A30 (Heavy Load:I_{OUT}=60mA) V_{IN}=1.8V



S-8328B30 (Light Load:I_{OUT}=1mA) V_{IN}=1.8V

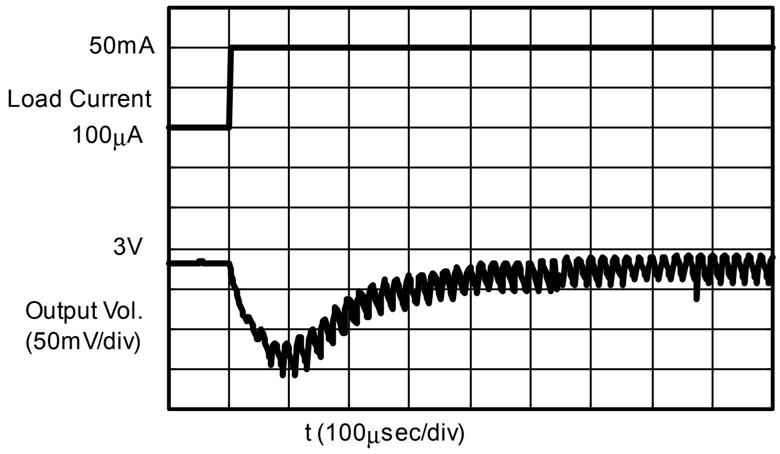


S-8328B30 (Heavy Load:I_{OUT}=200mA) V_{IN}=1.8V

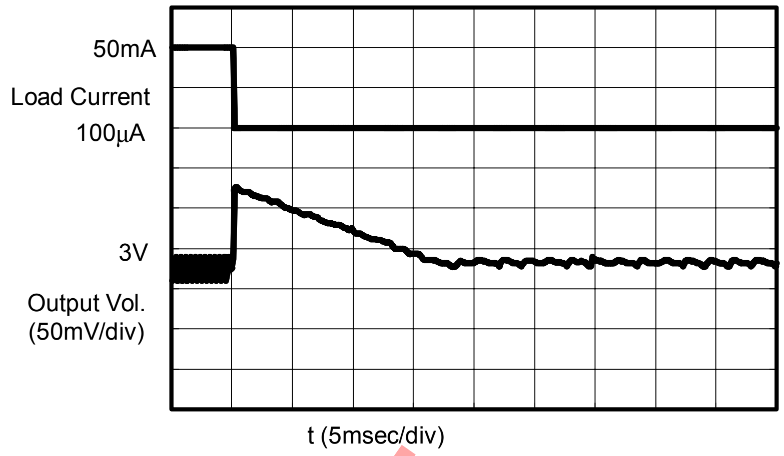


3. Load Fluctuations

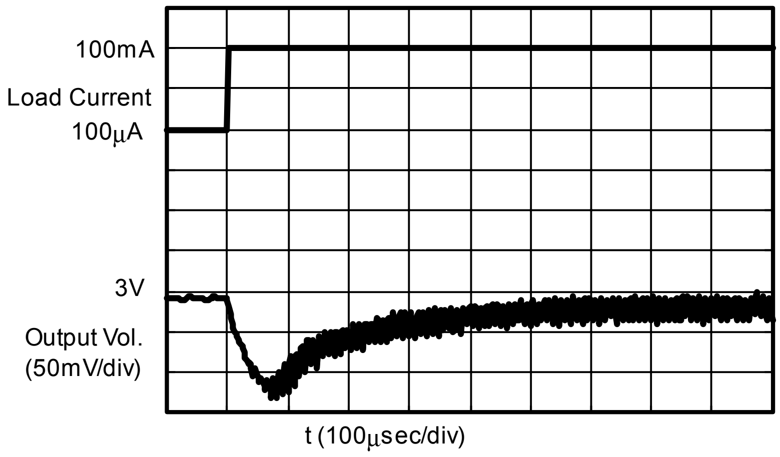
S-8324A30 (I_{OUT}:100µA→50mA) V_{IN}=1.8V



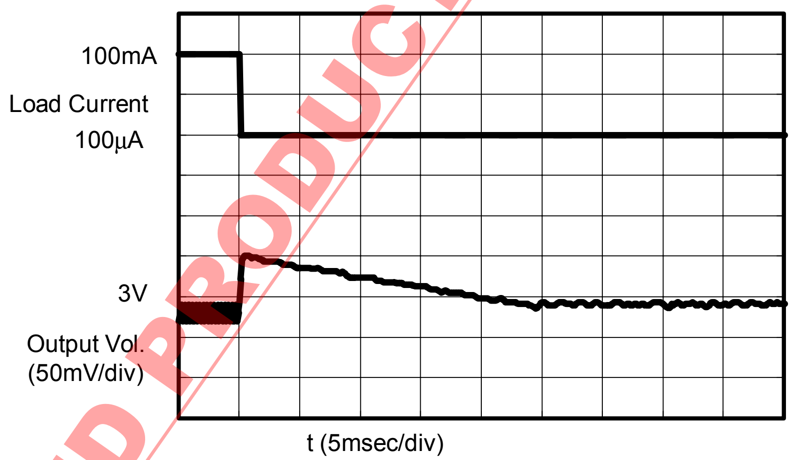
S-8324A30 (I_{OUT}:50mA→100µA) V_{IN}=1.8V



S-8328B30 (I_{OUT}:100µA→100mA) V_{IN}=1.8V



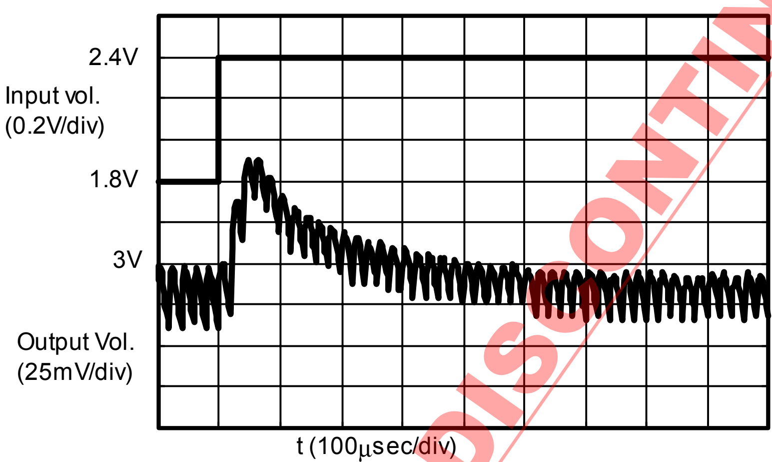
S-8328B30 (I_{OUT}:100mA→100µA) V_{IN}=1.8V



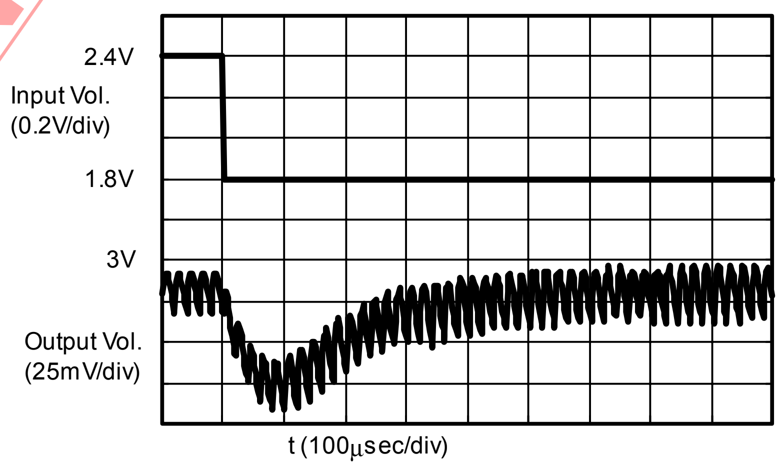
There is no significant difference in load/power-voltage fluctuations between A, B, and H types.

4. Power Voltage Fluctuations

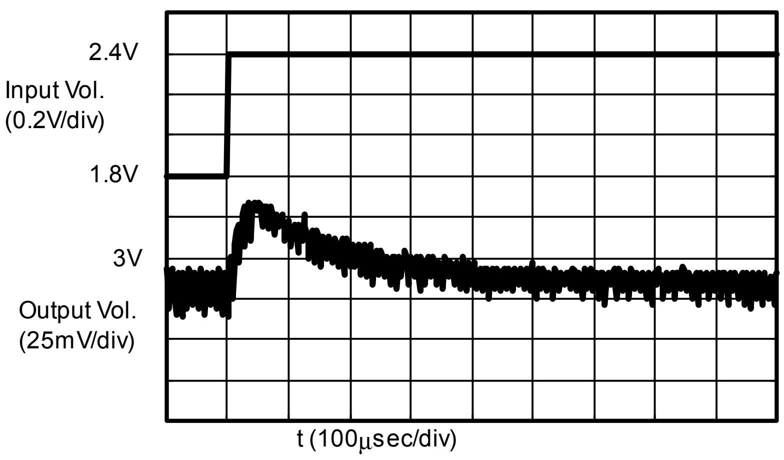
S8324A30 (V_{IN}:1.8V→2.4V) I_{OUT}=50mA



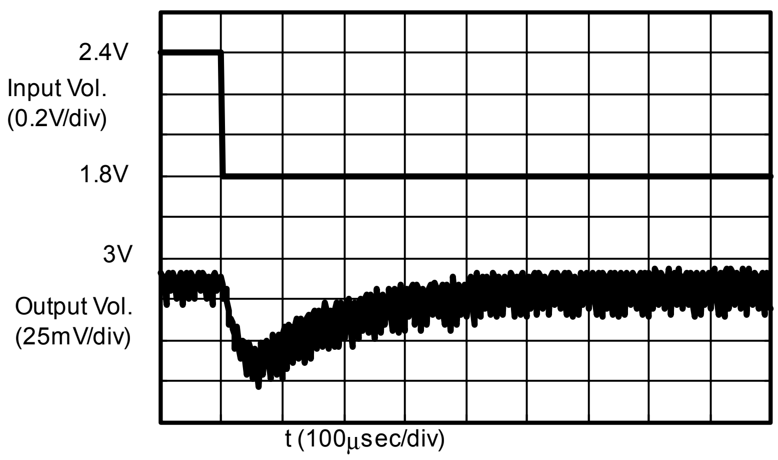
S8324A30 (V_{IN}:2.4V→1.8V) I_{OUT}=50mA



S8328B30 (V_{IN}:1.8V→2.4V) I_{OUT}=100mA



S8328B30 (V_{IN}:2.4V→1.8V) I_{OUT}=100mA

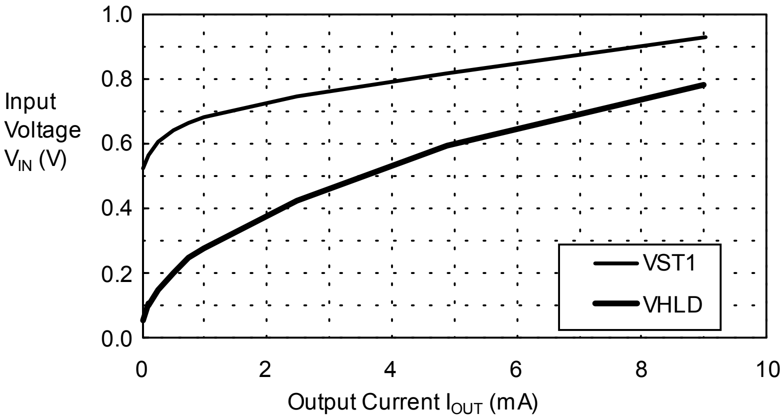


There is no significant difference in load/power-voltage fluctuations between A, B, and H types.

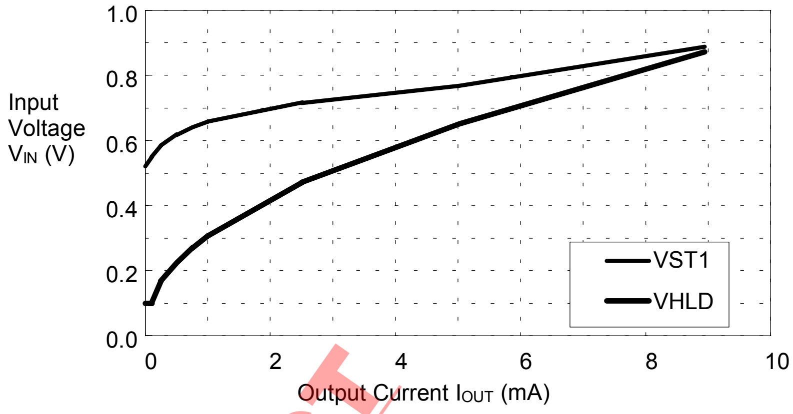
■ Operation Start Voltage and Operation Holding Voltage Characteristics for Output Current

(The characteristics measurement circuits are Standard Circuit(1) for S-8324A/H, Standard Circuit(2) for S-8328B, Standard Circuit(8) for S-8328H. The external parts are subject to the electrical properties of each A/B/H type.)

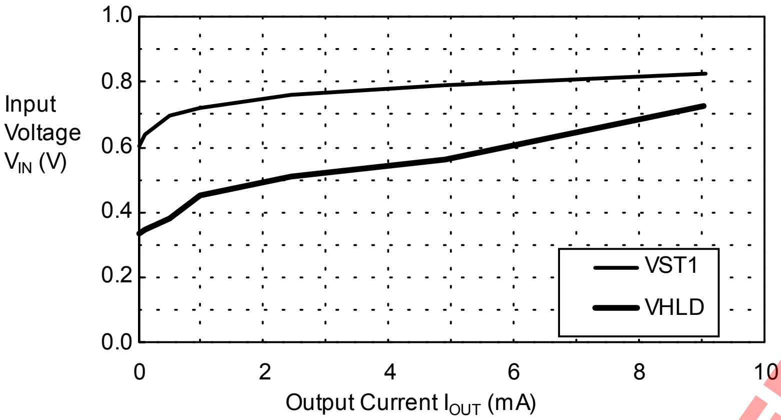
S-8324A30



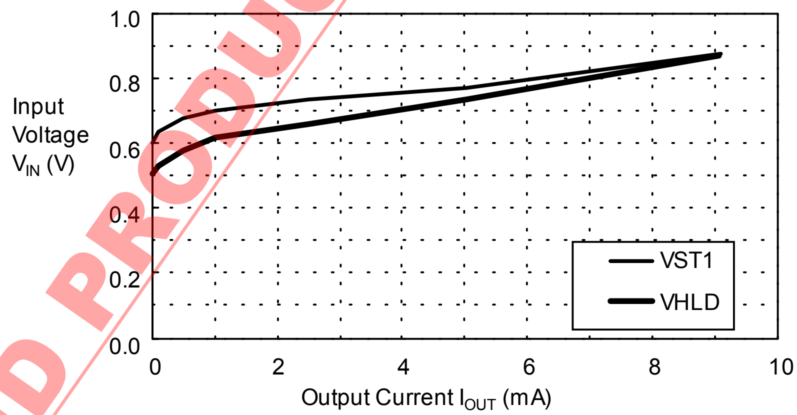
S-8324A50



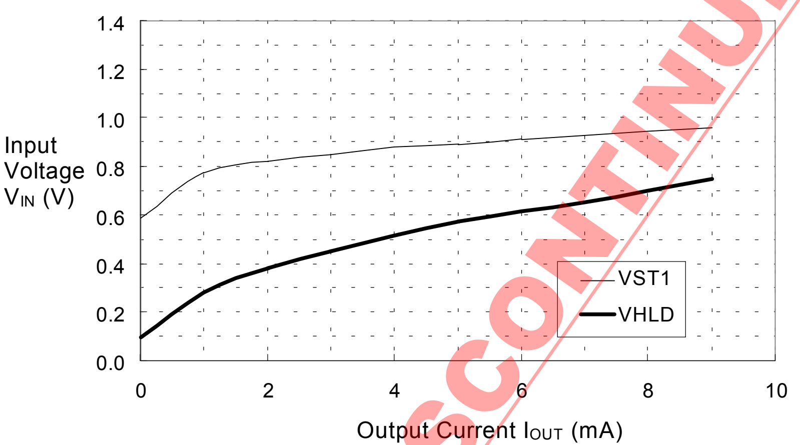
S-8328B30



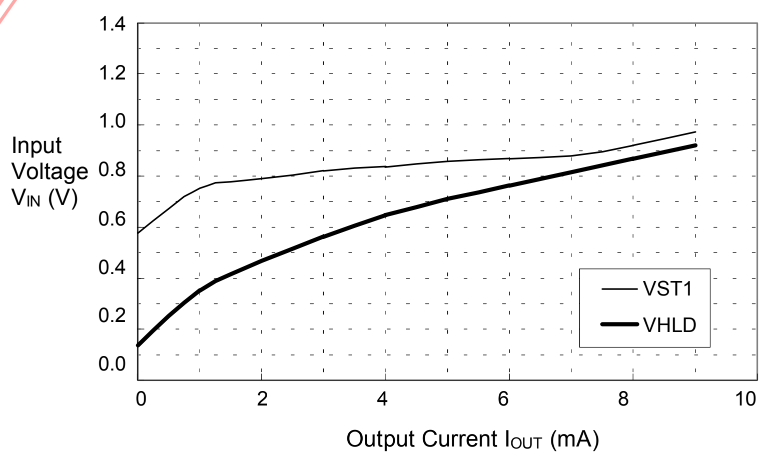
S-8328B50



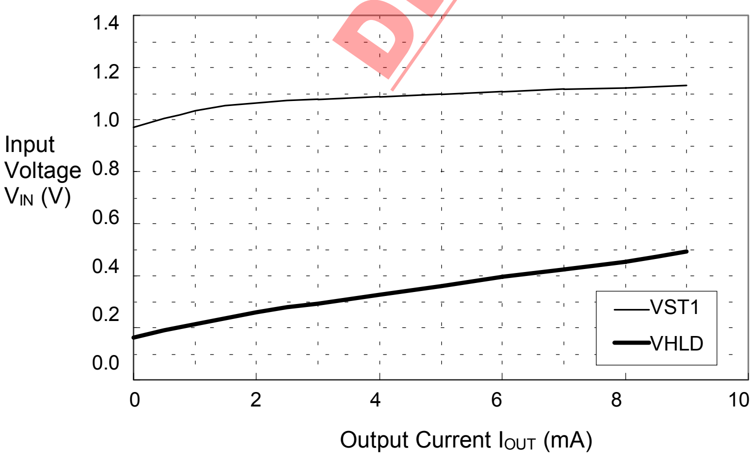
S-8324H33



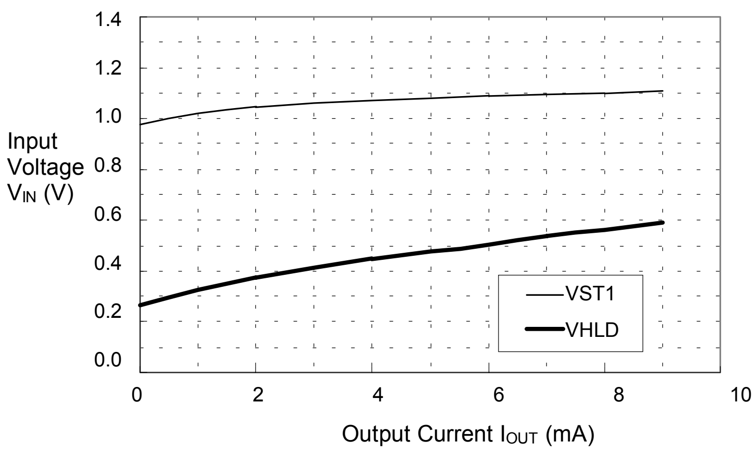
S-8324H50



S-8328H33



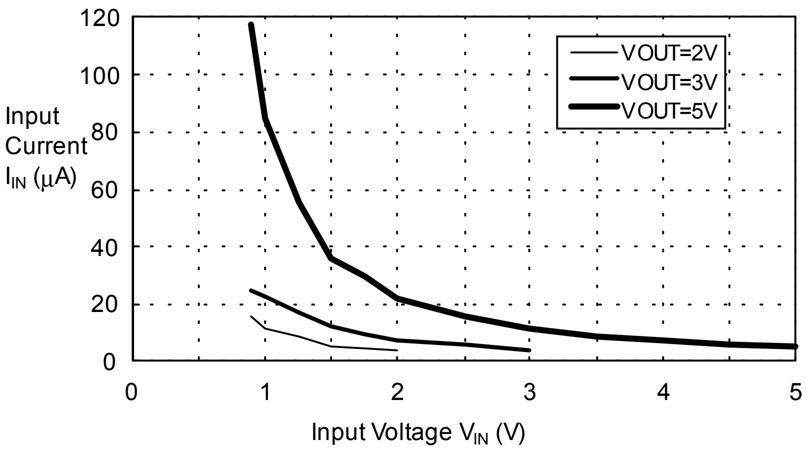
S-8328H50



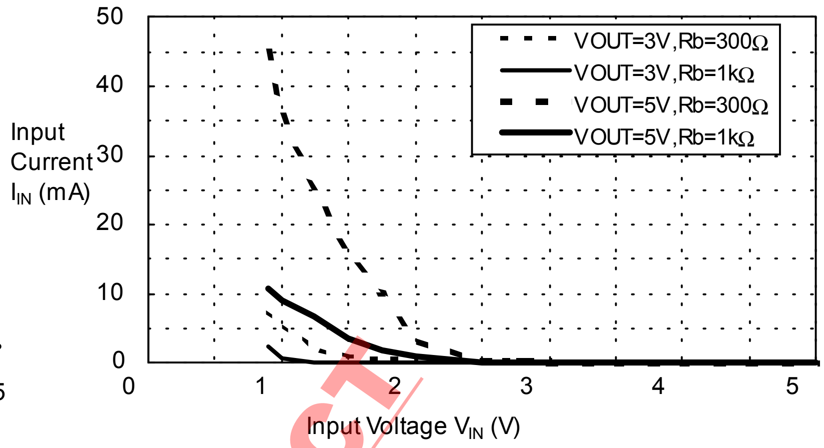
■ Input Voltage Characteristics for Input Current

(The characteristics measurement circuits are Standard Circuit(1) for S-8324A/H, Standard Circuit(2) for S-8328B, Standard Circuit(8) for S-8328H. The external parts are compatible with the specified conditions of electrical characteristics of Types A, B and H, respectively. The input current adopted for the measuring condition is the consumption current from V_{IN} under no load.)

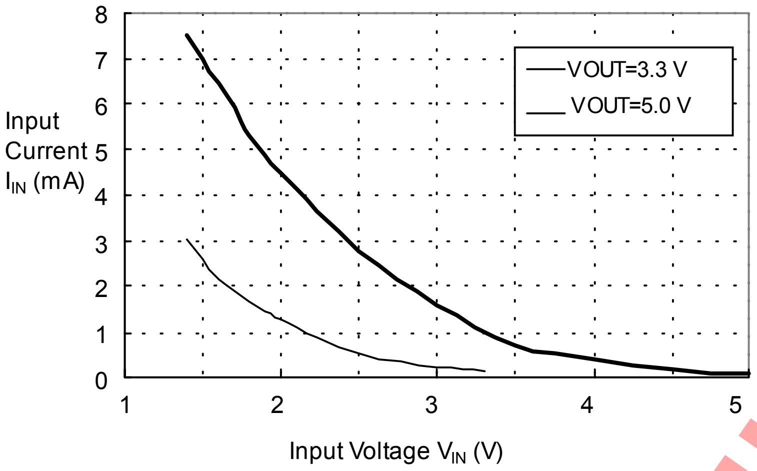
S-8324A



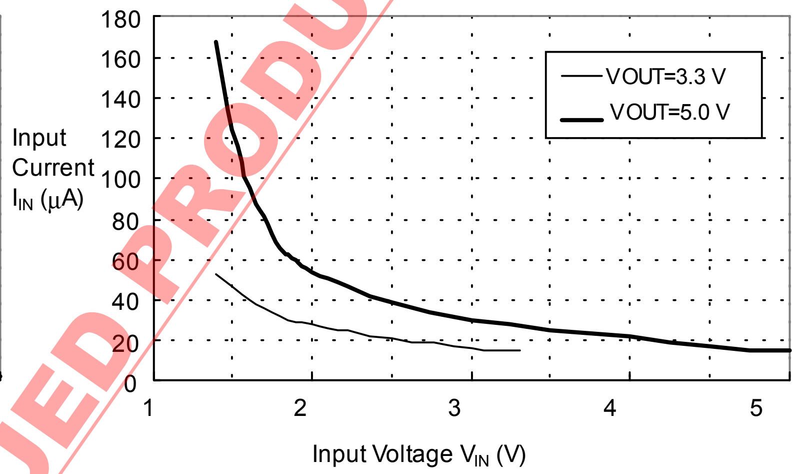
S-8328B



S-8324H



S-8328H



■ Reference Data

Use reference data to choose the external parts.

Reference data give yor the procedure to choose the recommended external parts for various applications and its characteristics data.

1. Classification of Products and Inductors by Usage

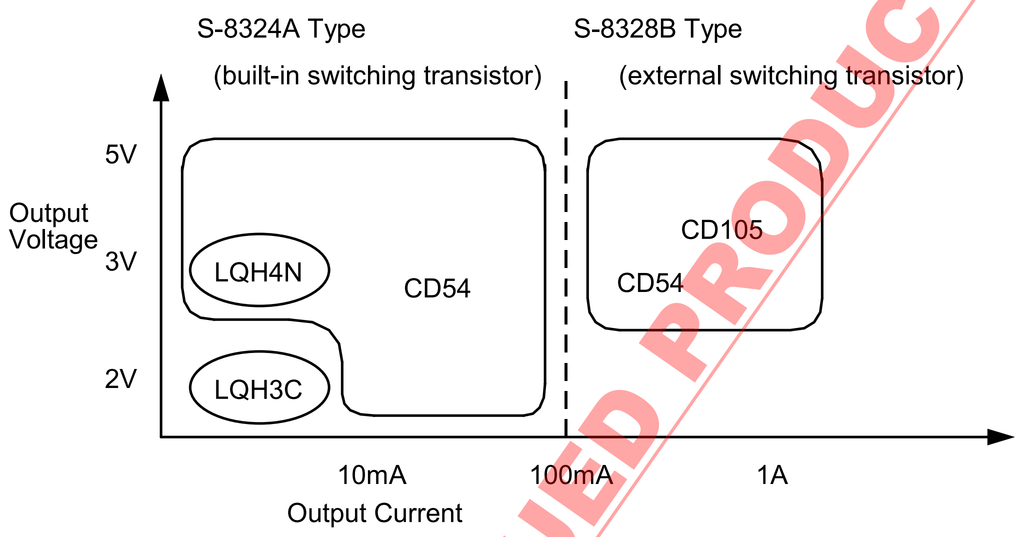
The products are classified in general into built-in/external switching transistor(S-8324/8) types and low/high switching frequency(A,B/H) types.

Compared with built-in switching transistors, external switching transistors can yield larger output current but their efficiency decreases in a small output current range(especially less than 1mA).

Compared with low frequency models, the high frequency models can yield smaller external parts, in particular inductors, and smaller output ripple voltage. However, they need more than two alkaline-manganese battery cells(operation voltage increases from 0.9V to 1.4V).

And the efficiency decreases in a small output current range(especially less than 1mA).

The figures below summarize above features. Please refer to those figures when choosing your models.



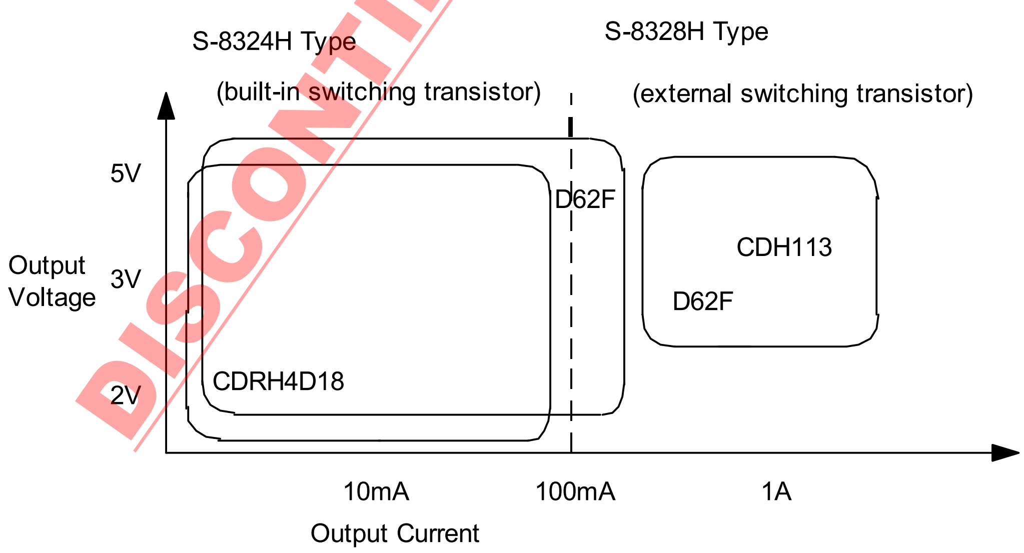
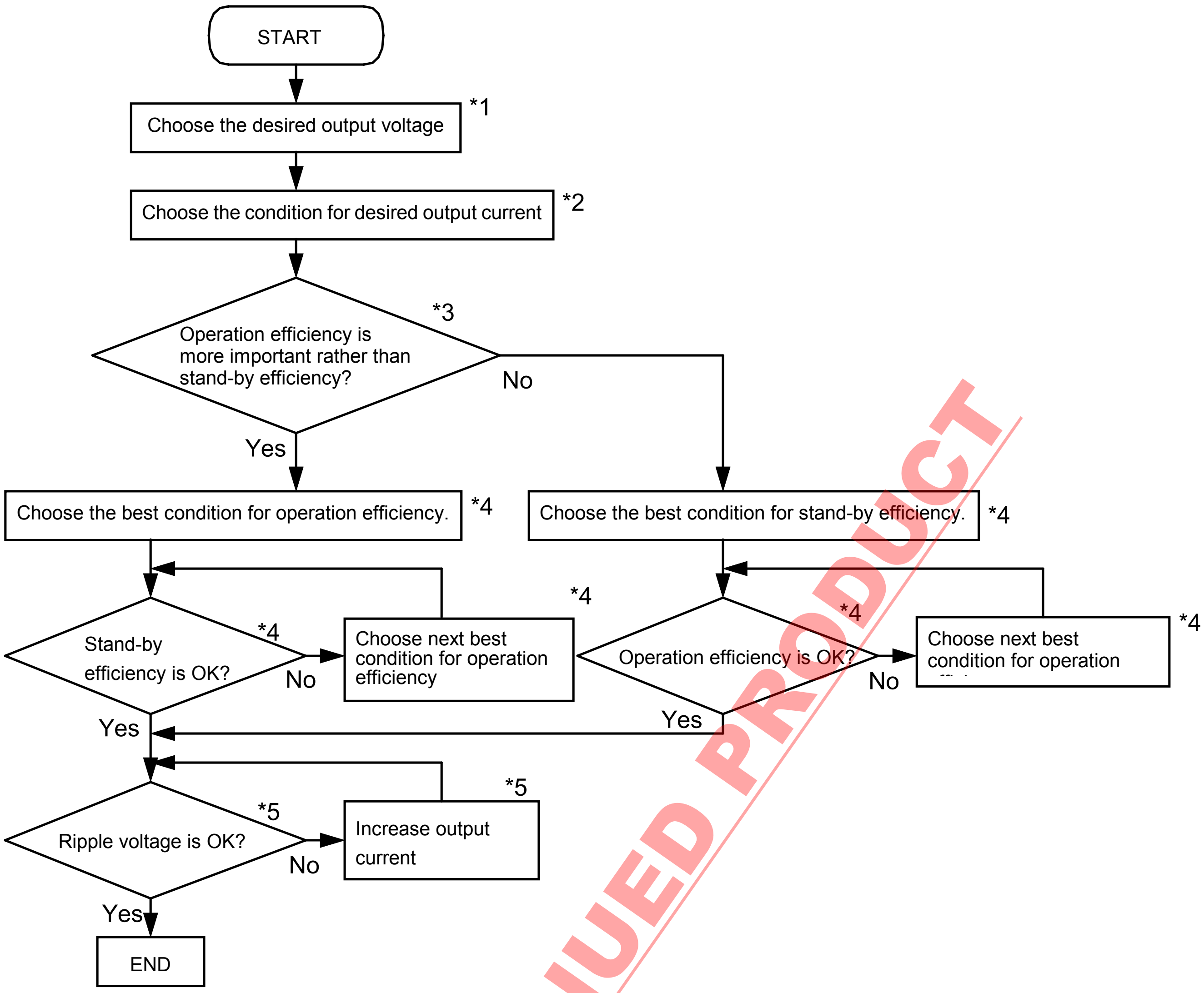


Figure 36 Classification of Inductors by Output Current

2. Procedure to choose the most suitable condition from reference data.

   Please refer to the procedures shown below when choosing external parts based on the reference data.



*1) Choose desired output voltage from conditions (1) to (17) shown in Table 1 and 2.
When desired output voltage does not exist in Tables, choose the next higher voltage.
For instance, when V_{OUT}=3V for S-8324A, choose from conditions (3) to (6).

*2) Choose all conditions from conditions choosed avobe for output current needed for input voltage (min) of the operational condition from “Reference data 1 (a) output voltage characteristics for output current”.
For instance, when 10mA output current is needed at V_{IN}=0.9V, choose from conditions (4) to (6).

*3) Stand-by efficiency means the efficiency when the output current is small (approx. 100μA), operation efficiency means the efficiency when the output current is large (several mA).
For instance, go to “YES” when operation efficiency is more important rather than stand-by efficiency.

*4) Read the efficiency for input voltage and output current in operational condition from “Reference data 1 (b) efficiency characteristics for output current”.
For instance, when V_{IN} =0.9V at I_{OUT}=10mA, the efficiency is max. (75%) in condition (6) in conditions (4) to (6).
There is no difference between conditions (4) to (6) when the output current is 100μA at stand-by condition.
Therefore, choose condition (6).

*5) Read the ripple voltage under the operational condition selected above from “Reference data 2 ripple voltage characteristics for output current”.
For instance, when condition (6) is selected above, the ripple voltage is 14mV at V_{IN}=0.9V and I_{OUT}=10mA.

3. Reference Data for External Components

Table 1 S-8324 Series

Condition	Product type	V_{OUT}	Model name of L	L value	D	C_{OUT}
(1)	A	2V	LQH3C	220µH	MA720	22µF
(2)	A	2V	LQH4N	220µH	↑	↑
(3)	A	3V	LQH4N	220µH	↑	↑
(4)	A	3V	CD54	47µH	↑	↑
(5)	A	3V	CD54	100µH	↑	↑
(6)	A	3V	CD54	220µH	↑	↑
(7)	A	5V	CD54	47µH	↑	↑
(8)	A	5V	CD54	100µH	↑	↑
(9)	A	5V	CD54	220µH	↑	↑
(10)	H	2.5V	CDRH4D18	22µH	↑	↑
(11)	H	2.5V	D62F	22µH	↑	↑
(12)	H	3.3V	CDRH4D18	22µH	↑	↑
(13)	H	3.3V	D62F	10µH	↑	↑
(14)	H	3.3V	D62F	22µH	↑	↑
(15)	H	5V	CDRH4D18	22µH	↑	↑
(16)	H	5V	D62F	10µH	↑	↑
(17)	H	5V	D62F	22µH	↑	↑

Table 2 S-8328 Series

Condition	Product type	V_{OUT}	Model name of L	L value	Model name of external transistor	Rb	Cb	D	C_{OUT}
(18)	B	3V	CD105	22µH	2SD1628G	300Ω	0.01µF	MA735	47µF×2
(19)	B	3V	CD105	22µH	↑	1KΩ	0.0022µF	MA735	47µF×2
(20)	B	3V	CD54	47µH	↑	1KΩ	0.0022µF	MA720	47µF
(21)	B	3V	D75C	47µH	↑	1KΩ	0.0022µF	MA720	47µF
(22)	B	5V	CD105	22µH	↑	300Ω	0.01µF	MA735	47µF×2
(23)	B	5V	CD105	22µH	↑	1KΩ	0.0022µF	MA735	47µF×2
(24)	B	5V	CD54	47µH	↑	1KΩ	0.0022µF	MA720	47µF
(25)	B	5V	D75C	47µH	↑	1KΩ	0.0022µF	MA720	47µF
(26)	H	3.3V	D62F	6.8µH	TN0200T	—	—	MA720	100µF
(27)	H	3.3V	CDH113	10µH	NDS335H	—	—	MA735	↑
(28)	H	5V	D62F	6.8µH	TN0200T	—	—	MA720	↑
(29)	H	5V	CDH113	10µH	NDS335N	—	—	MA735	↑

The properties of external parts are shown below.

Table 3

Part	Product name	Manufacturer's name	L value	DC resistance	Max allowable current	Diameter	Height
	CD105	Sumida	22µF	0.10Ω	1.95A	10.0mm	5.4mm
	CD54	↑	47µF	0.37Ω	0.72A	5.8mm	4.5mm
	↑	↑	100µF	0.70Ω	0.52A	↑	↑
	↑	↑	220µF	1.57Ω	0.35A	↑	↑
	CDRH4D18	↑	22µH	0.397Ω	0.41A	4.5mm	2.0mm
	CDH113	↑	10µH	0.054Ω	2.00A	11.0mm	3.7mm
Inductor	LQH4N	Murata	220µF	5.40Ω	0.11A	4.5mm	2.6mm
	LQH3C	↑	220µF	8.40Ω	0.07A	3.2mm	2.0mm
	D75C	Toko	47µF	0.20Ω	0.76A	7.6mm	5.1mm
	↑	↑	100µH	0.40Ω	0.50A	↑	↑
	D62F	↑	6.8µH	0.075Ω	1.36A	6.0mm	2.7mm
	↑	↑	10µH	0.110Ω	1.20A	↑	↑
	↑	↑	22µH	0.247Ω	0.70A	↑	↑
Diode	MA720	Matsushita	forward current 500mA(at V_F=0.55V)				
(Schottky)	MA735	↑	forward current 1A(at V_F=0.5V)				
Output capacitor	F93	Nichicon	Surface Mount Tantlum electrolytic capacitor				
External transistor	2SD1628G	Sanyo	bipolar NPN transistor				
	TN0200T	Temic Siliconics	MOS FET Nch transistor				
	NDS335N	National Semiconductor	MOS FET Nch transistor				

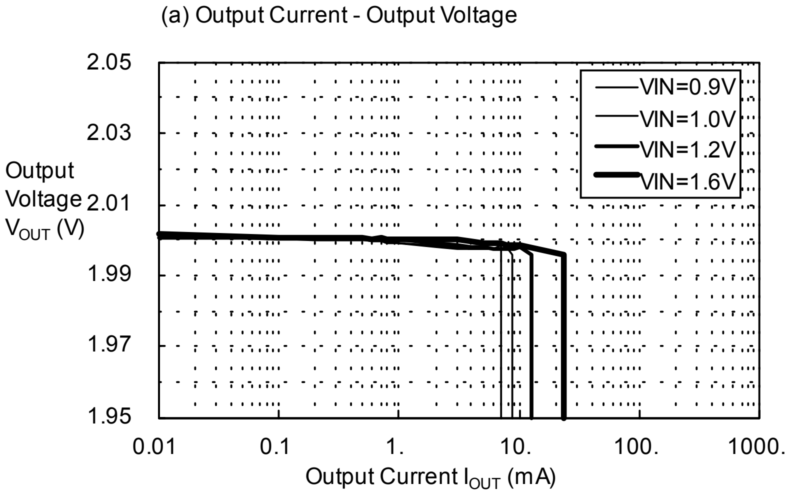
The S-8324/28 Series improves efficiency by switching PWM control to PFM control automatically when the output current is decreased.

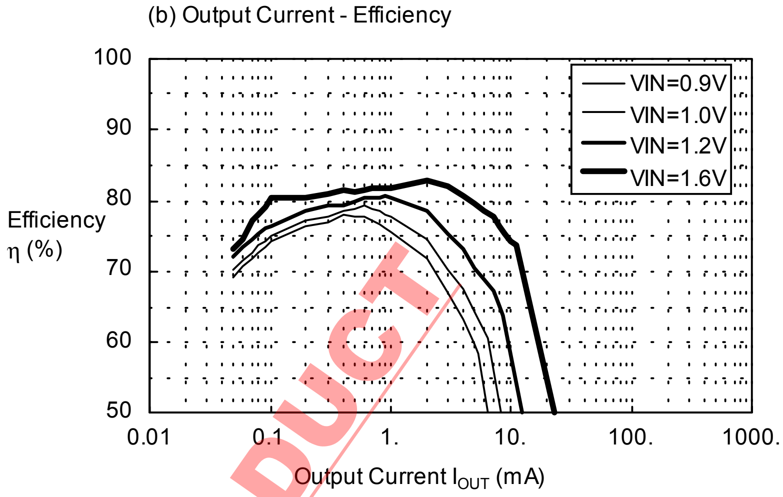
The reference data 1 shows the output current data switching PWM control to PFM control.

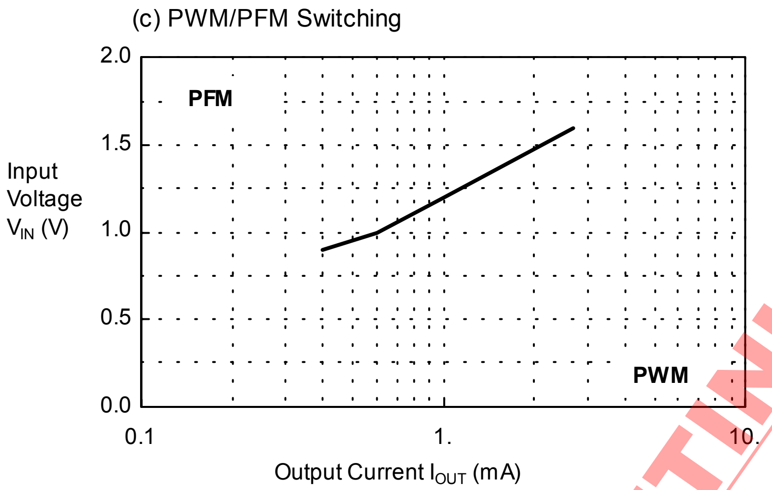
4. Reference Data 1

Output voltage characteristics for output current and (b) efficiency characteristics for output current under conditions (1) to (29) shown in Tables 1 and 2 are shown below.

(1)S-8324A20(LQH3C:220µH)

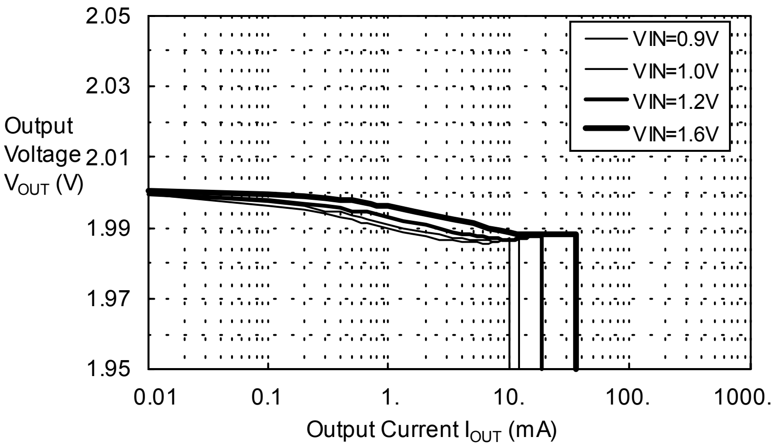




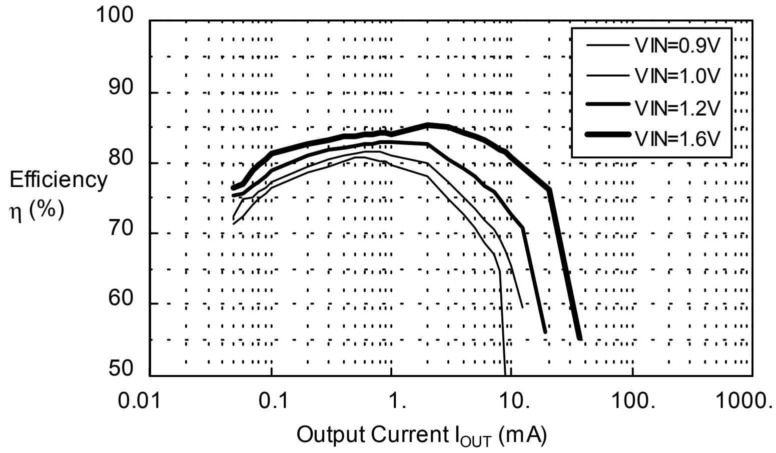


(2)S-8324A20(LQH4N:220μH)

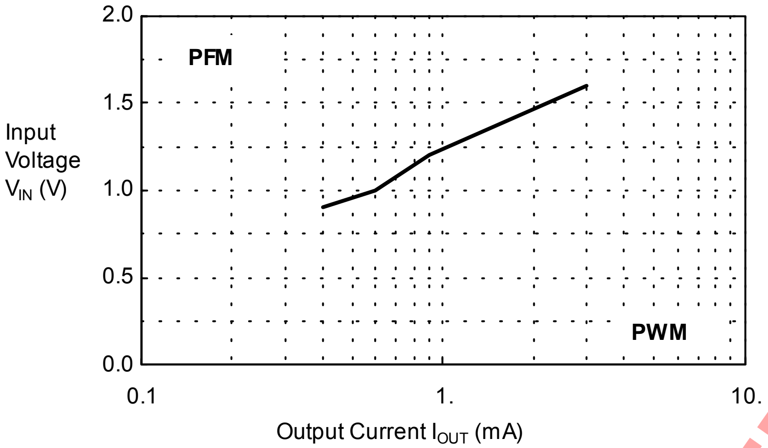
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

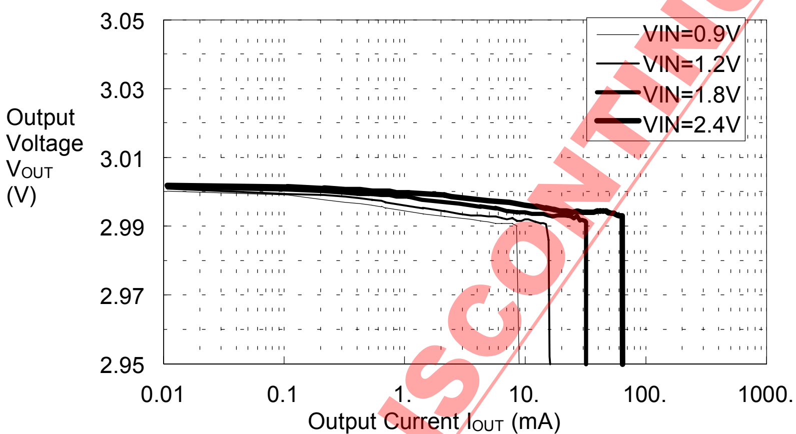


(c) PWM/PFM Switching

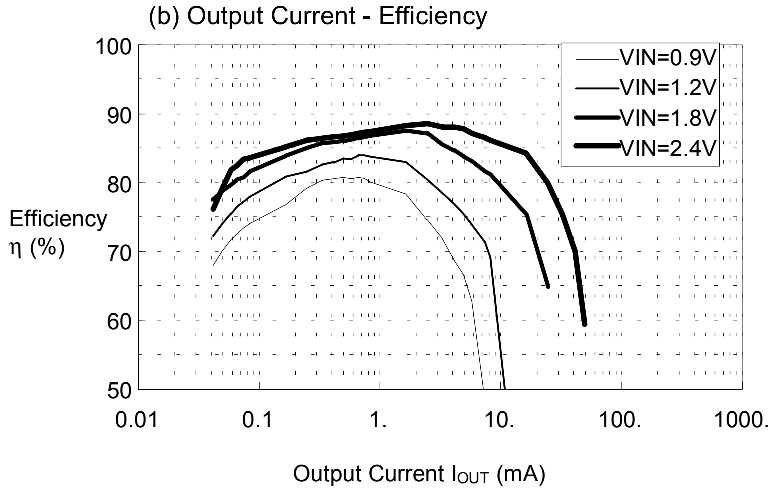


(3)S-8324A30(LQH4N:220μH)

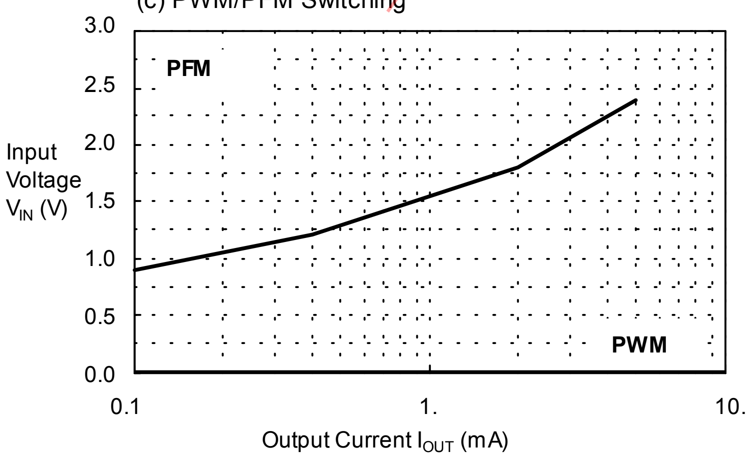
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

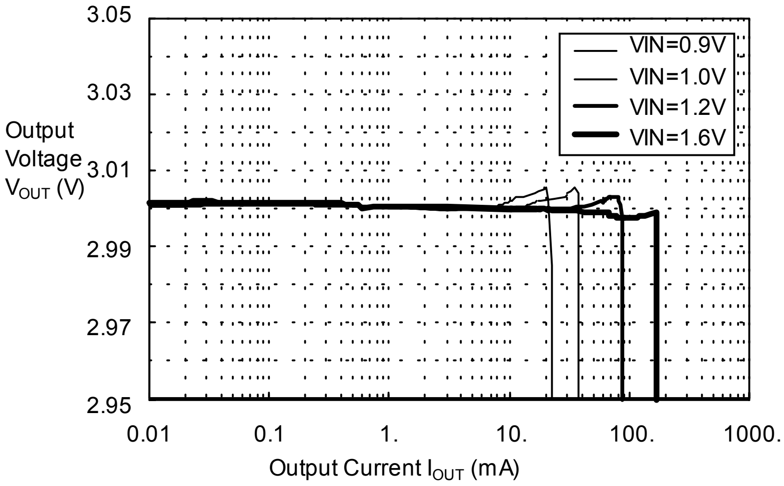


(c) PWM/PFM Switching

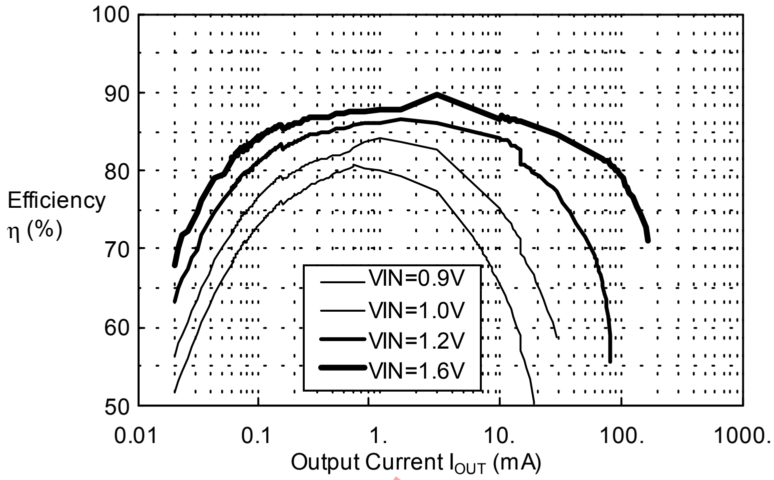


(4)S-8324A30(CD54:47μH)

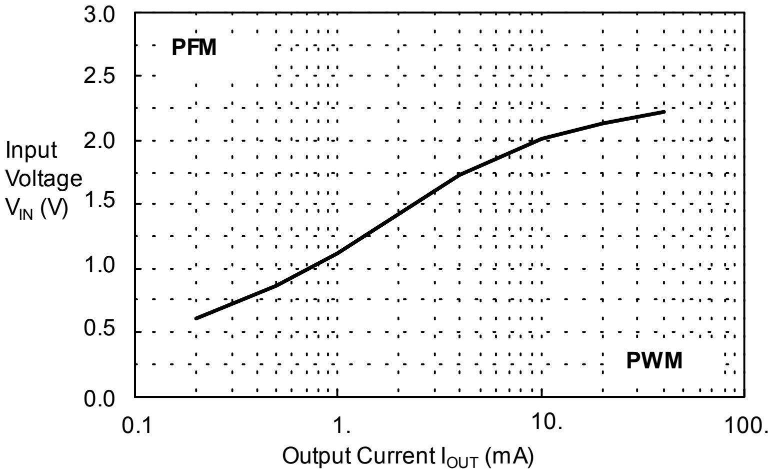
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

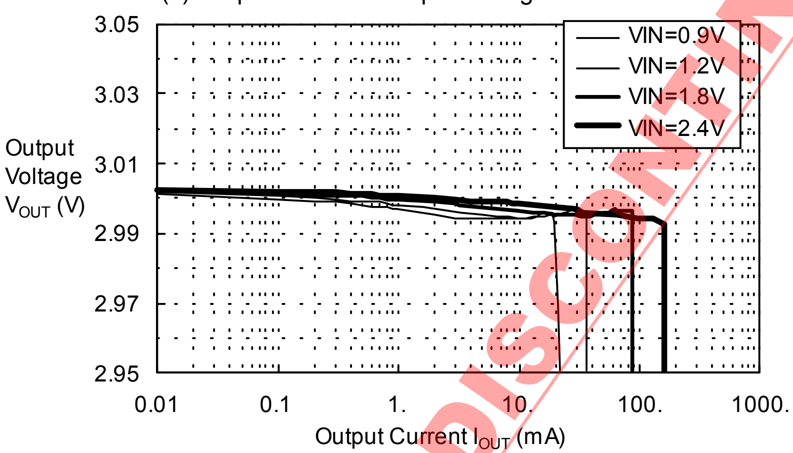


(c) PWM/PFM Switching

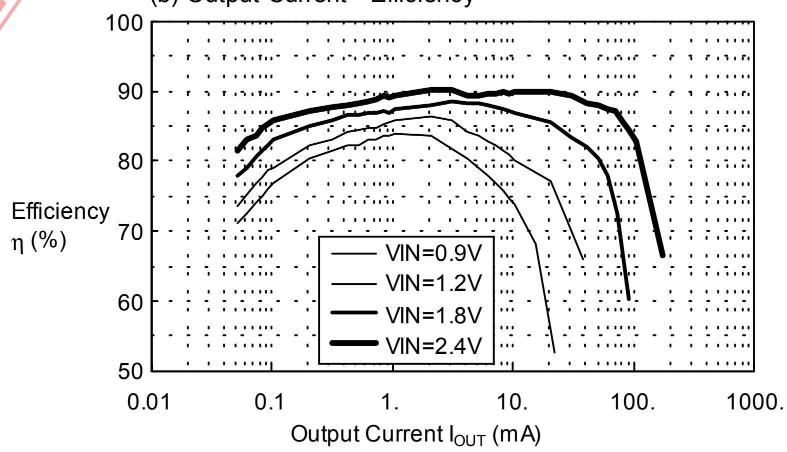


(5)S-8324A30(CD54:100μH)

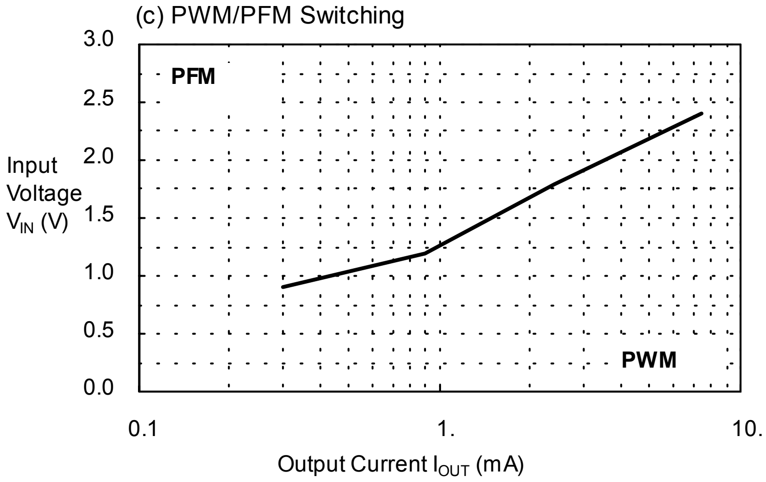
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

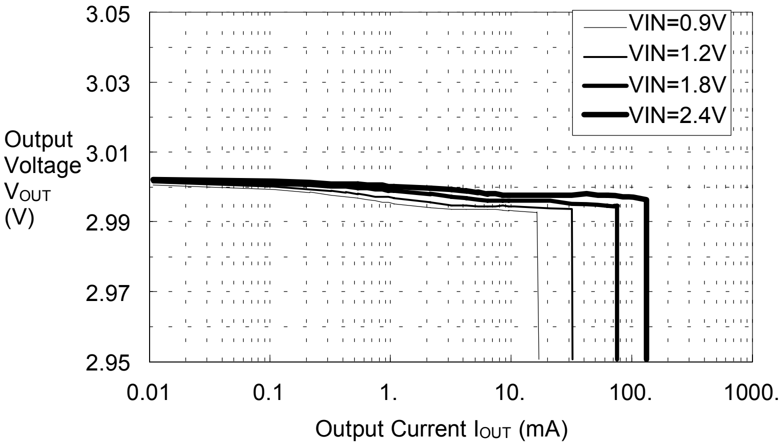


(c) PWM/PFM Switching

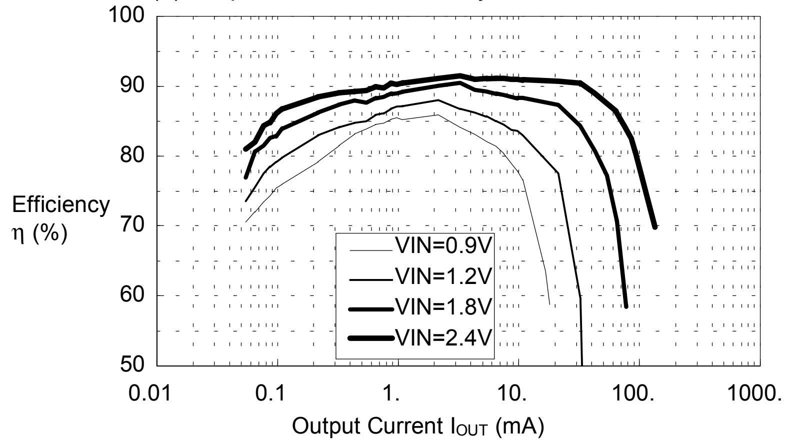


(6)S-8324A30(CD54:220μH)

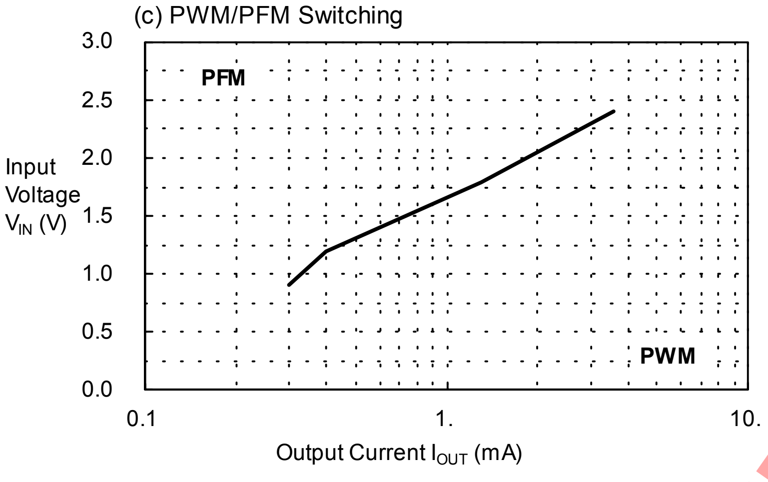
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

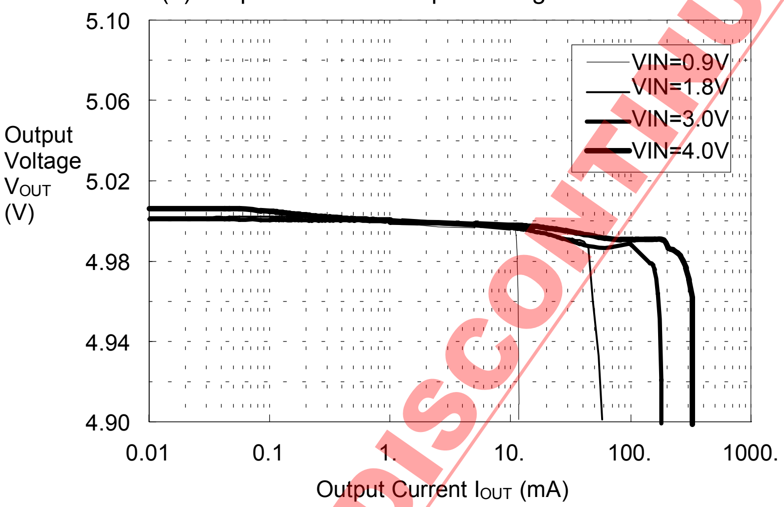


(c) PWM/PFM Switching

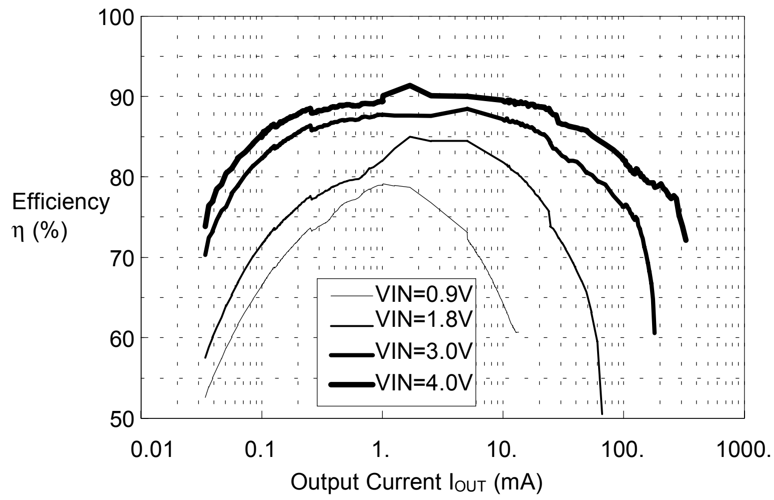


(7)S-8324A50(CD54:47μH)

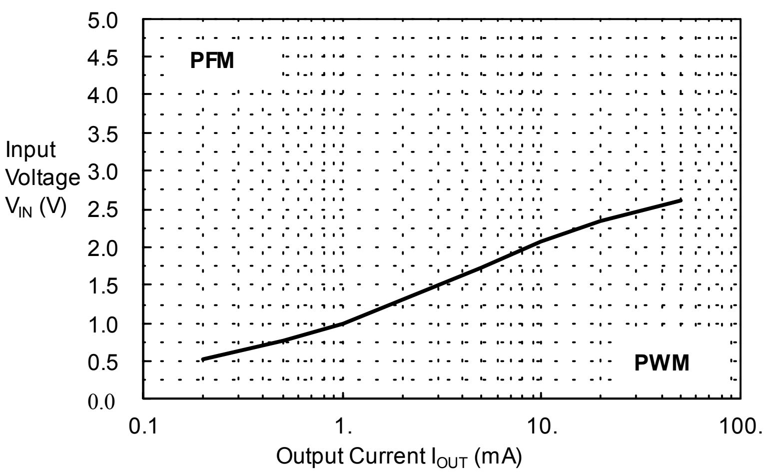
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

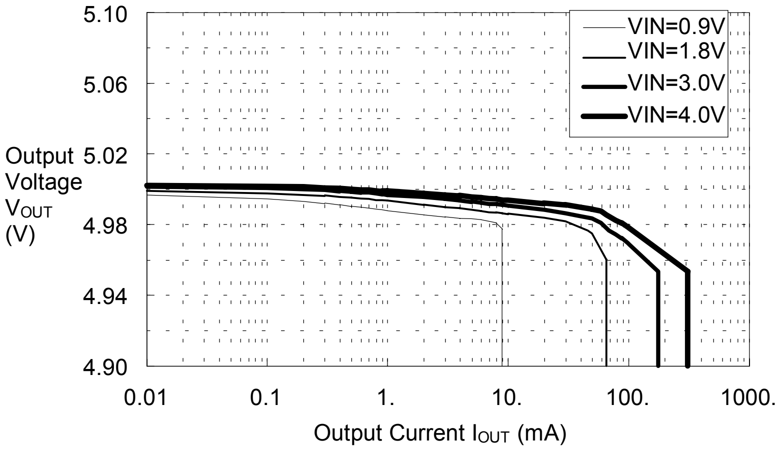


(c) PWM/PFM Switching

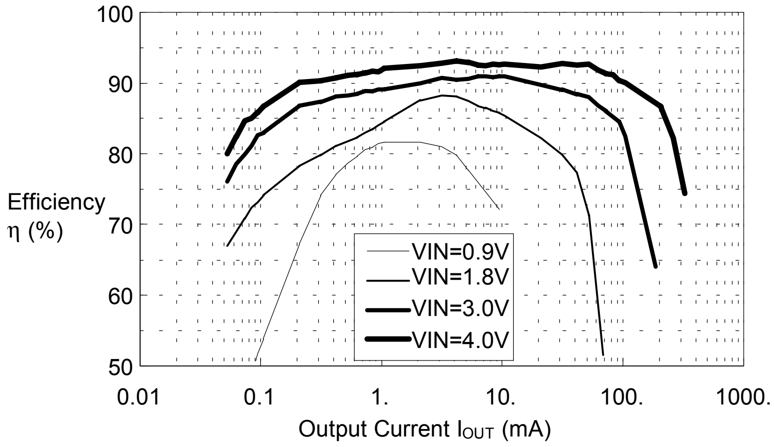


(8)S-8324A50(CD54:100μH)

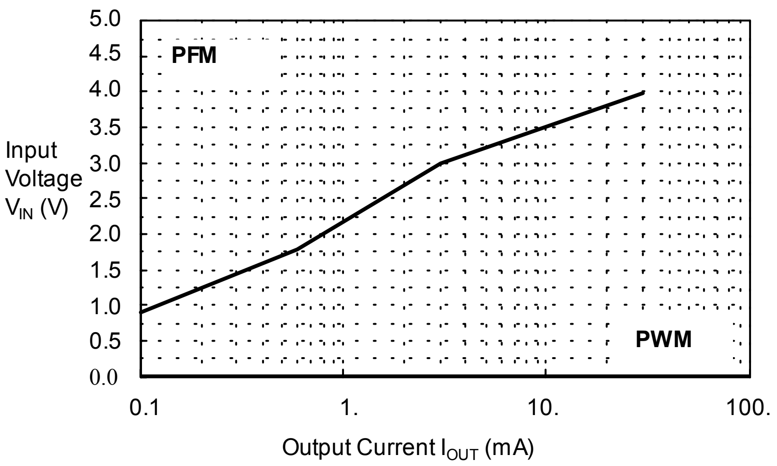
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

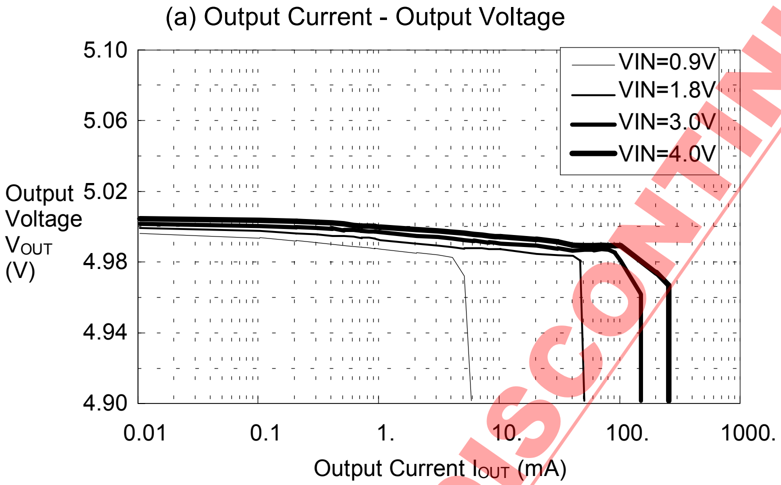


(c) PWM/PFM Switching

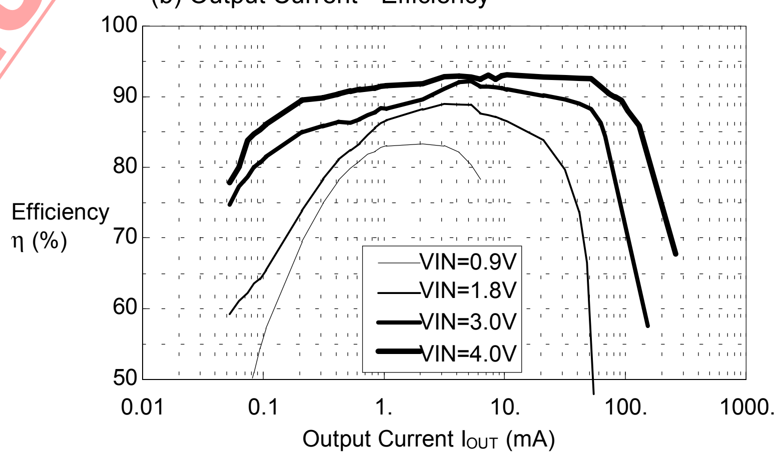


(9)S-8324A50(CD54:220μH)

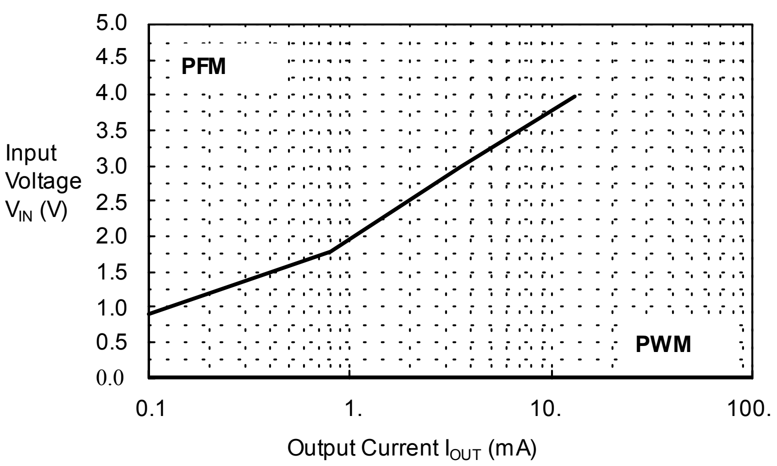
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

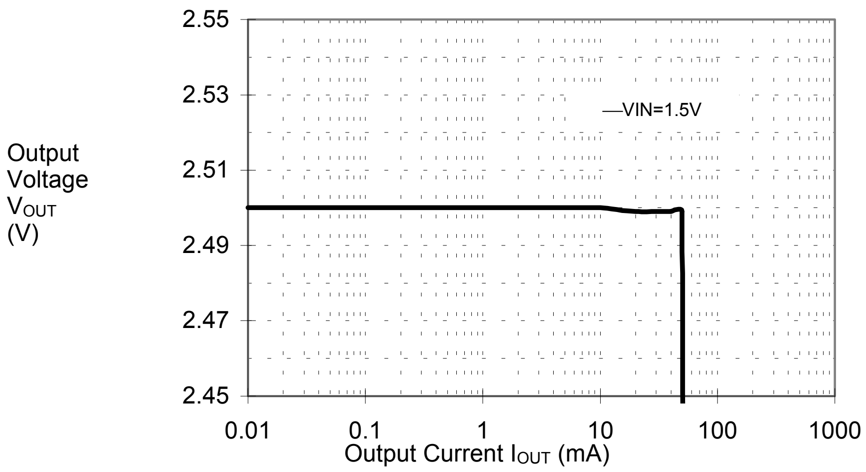


(c) PWM/PFM Switching

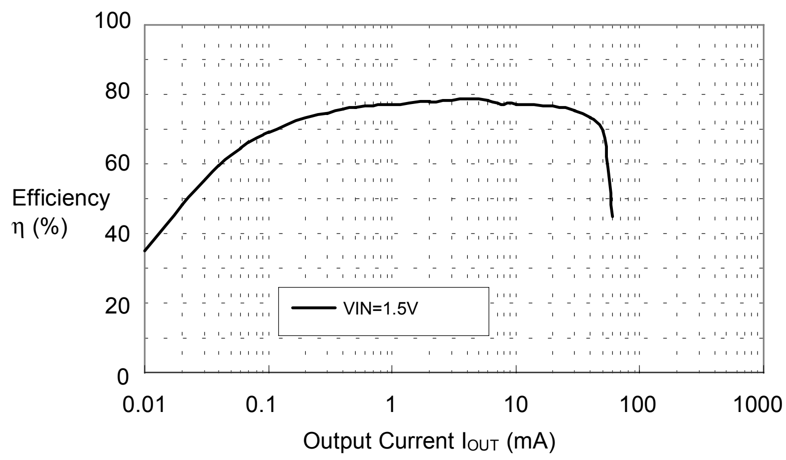


(10)S-8324H25(CDRH4D18:22µH)

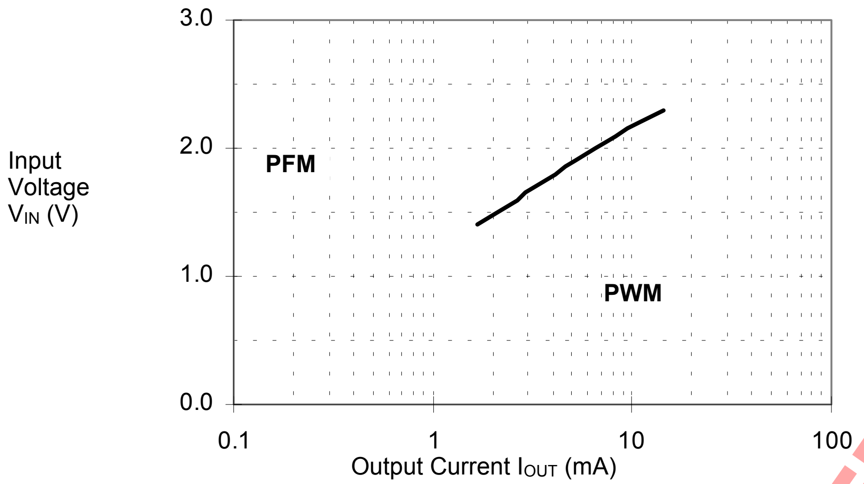
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

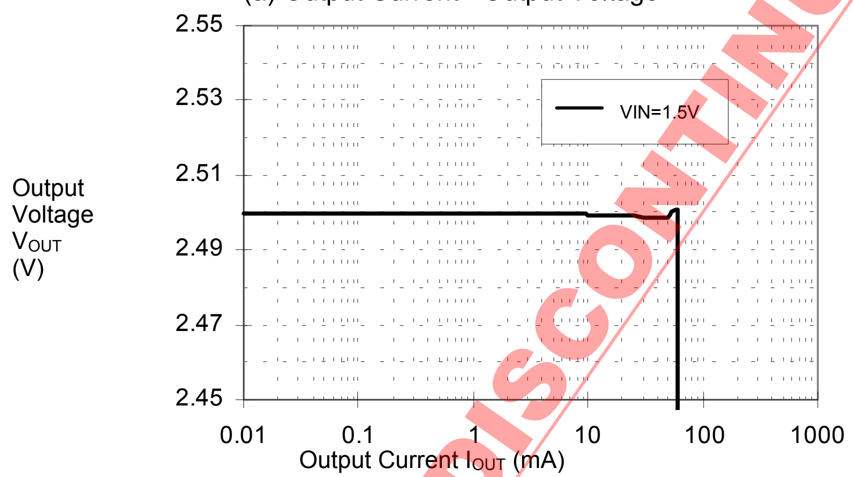


(c) PWM/PFM Switching

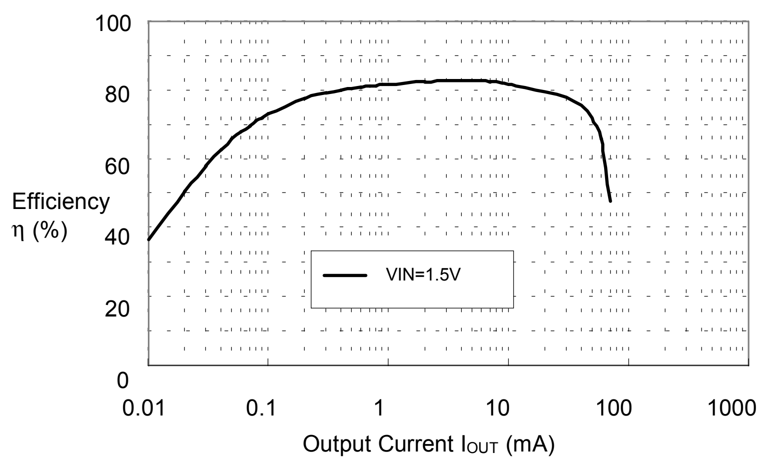


(11)S-8324H25(D62F:22µH)

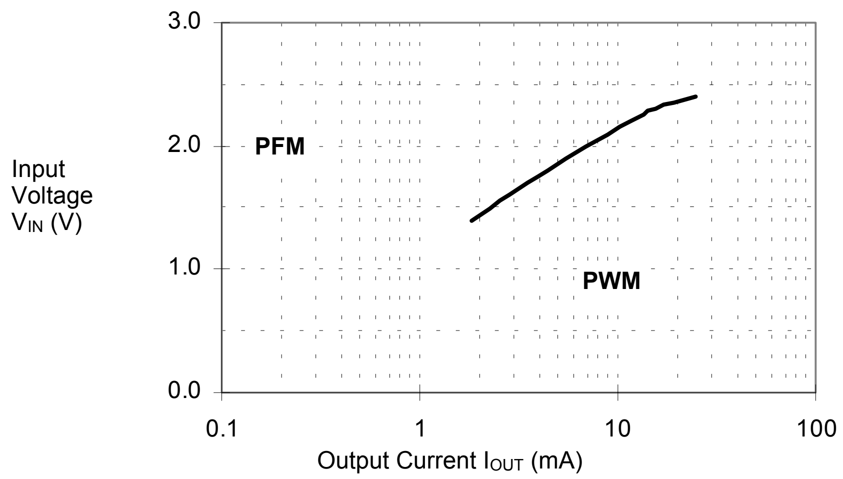
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

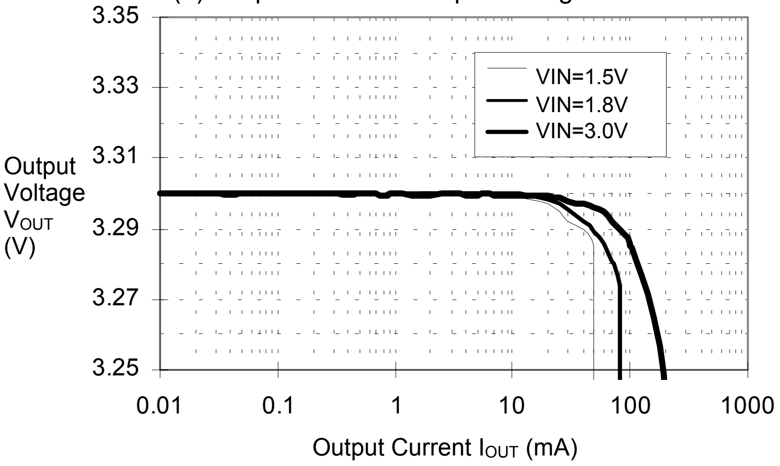


(c) PWM/PFM Switching

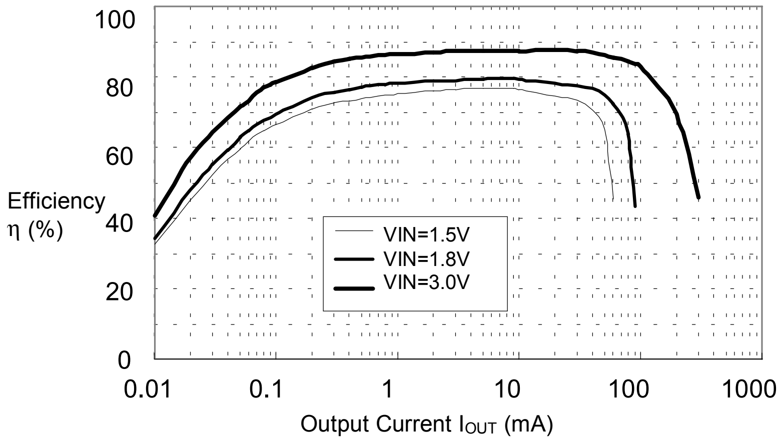


(12)S-8324H33(CDRH4D18:22µH)

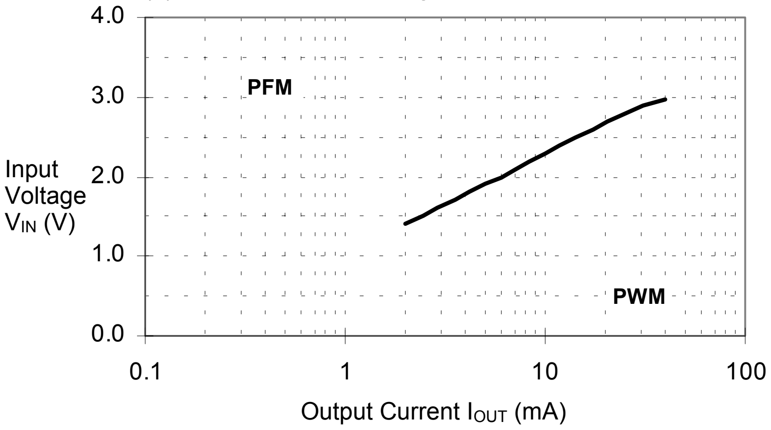
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

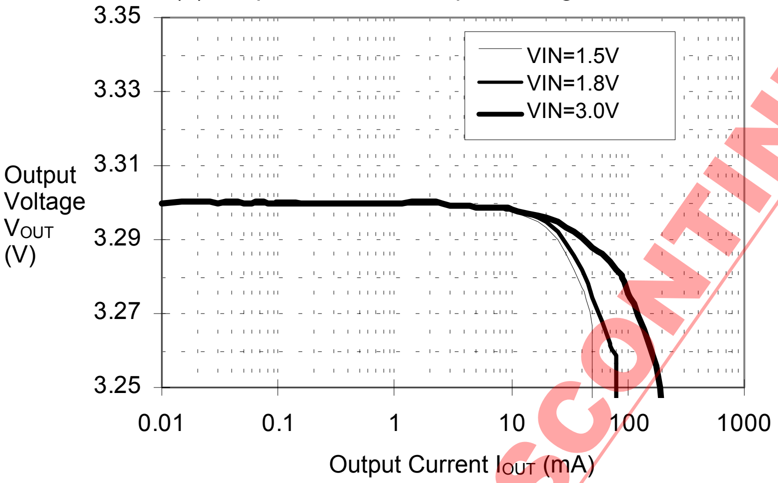


(c) PWM/PFM Switching

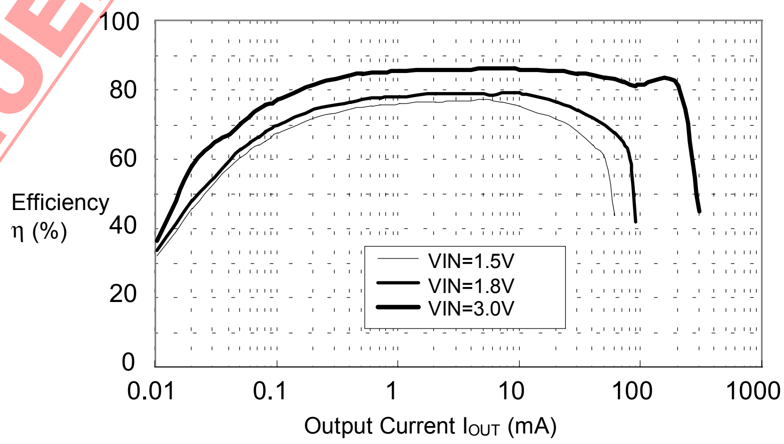


(13)S-8323H33(D62F:10µH)

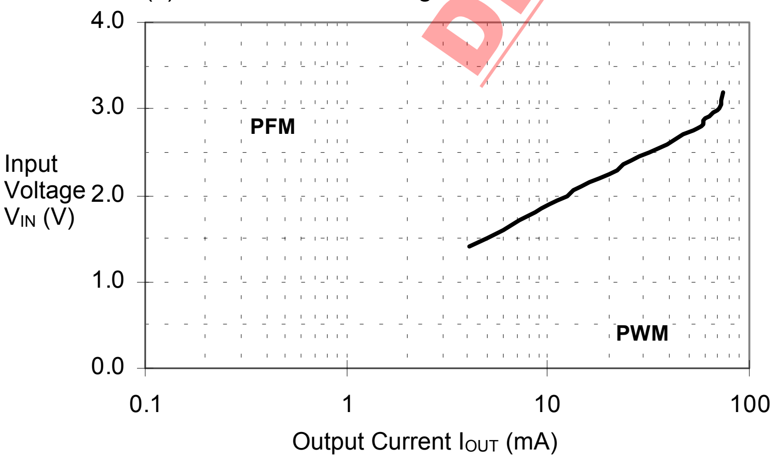
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

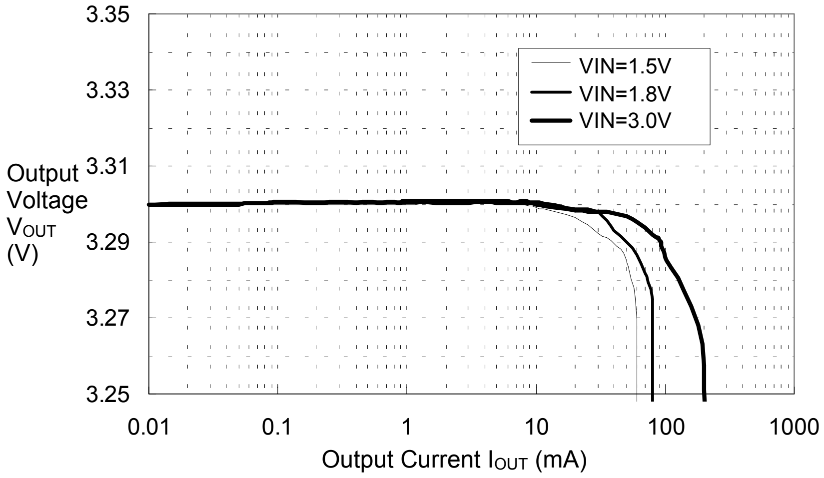


(c) PWM/PFM Switching

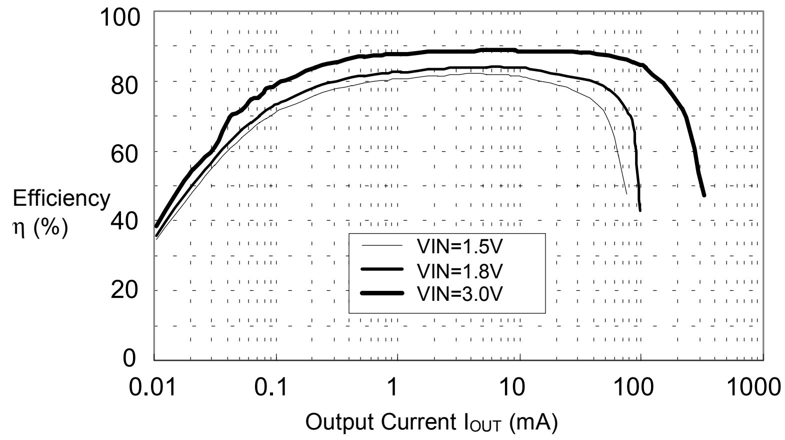


(14)S-8324H33(D62F:22µH)

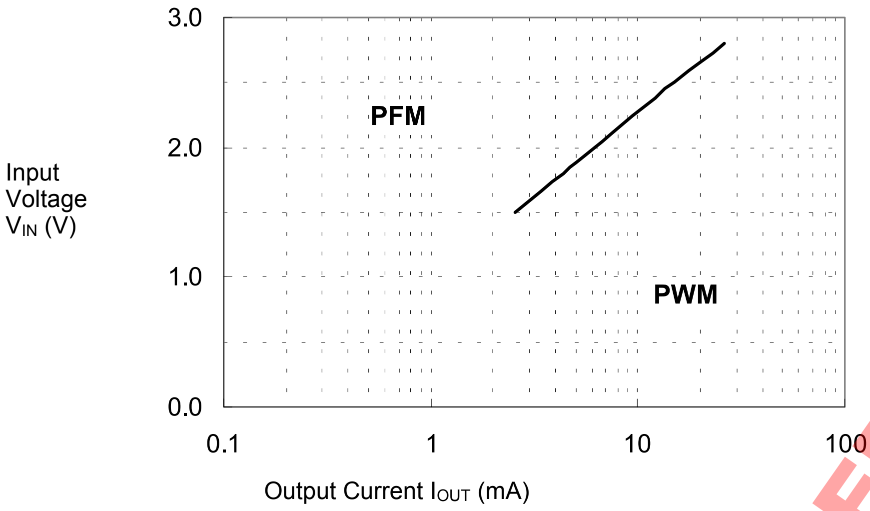
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

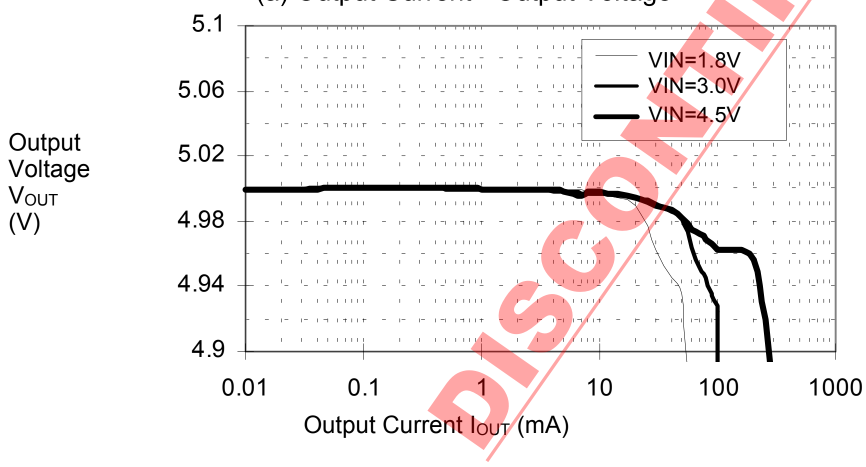


(c) PWM/PFM Switching

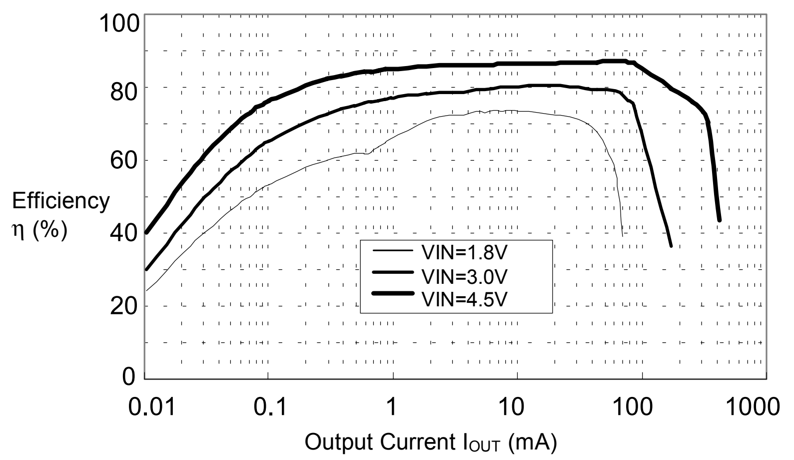


(15)S-8324H50(CDRH 4D18:22µH)

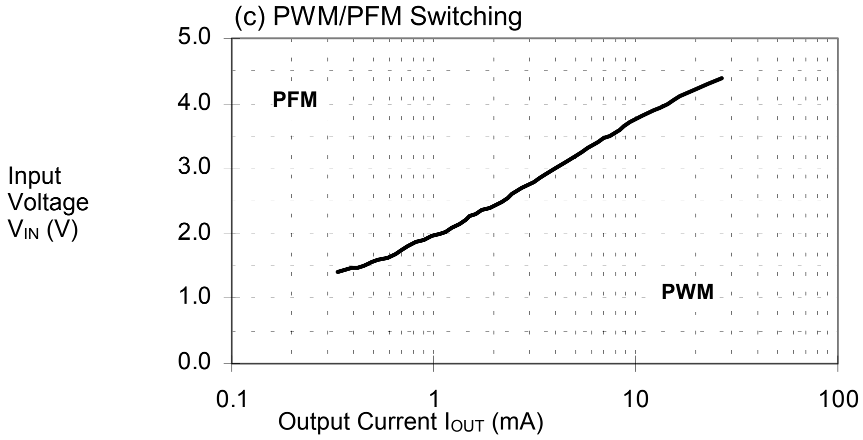
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

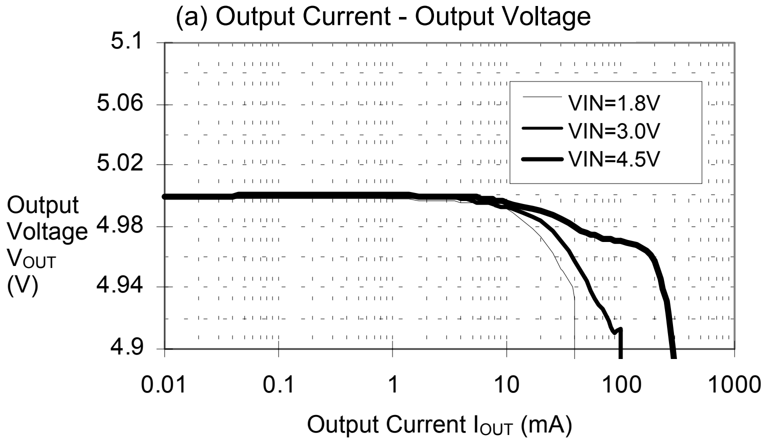


(c) PWM/PFM Switching

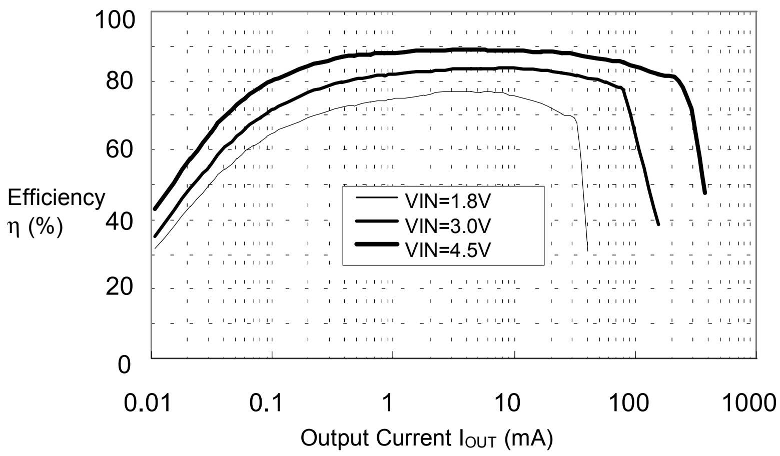


(16)S-8324H50(D62F:10μH)

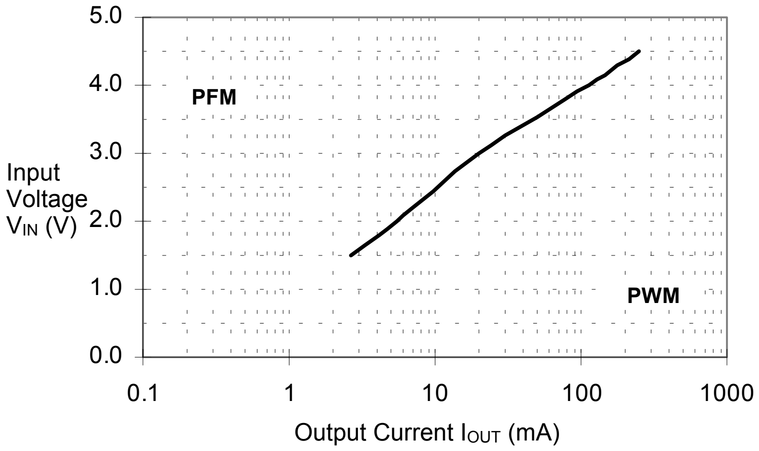
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

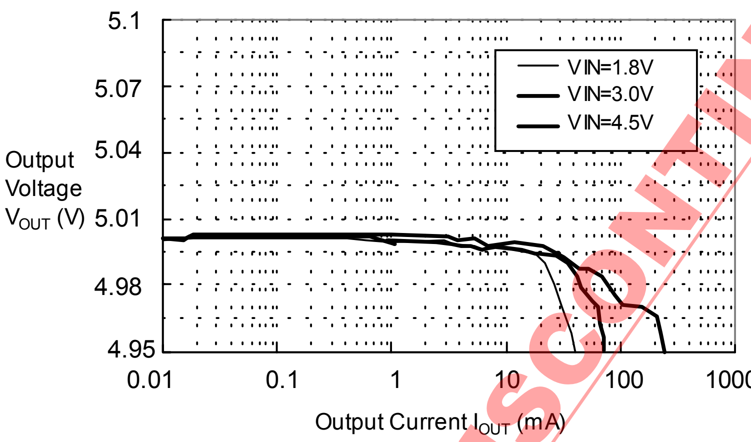


(c) PWM/PFM Switching

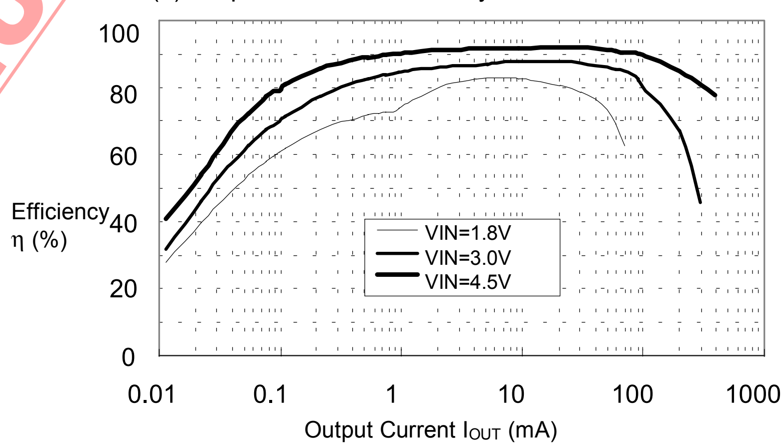


(17)S-8324H50(D62F:22μH)

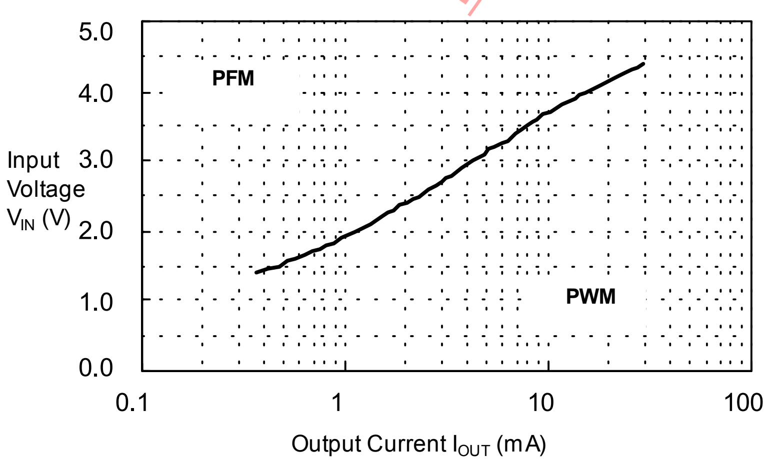
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

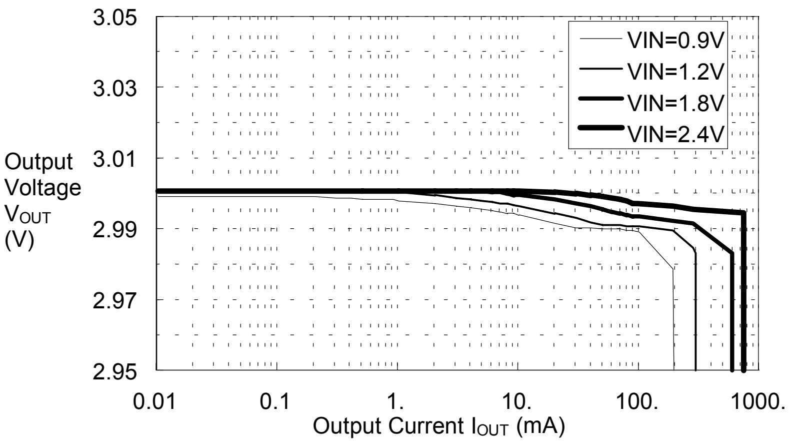


(c) PWM/PFM Switching

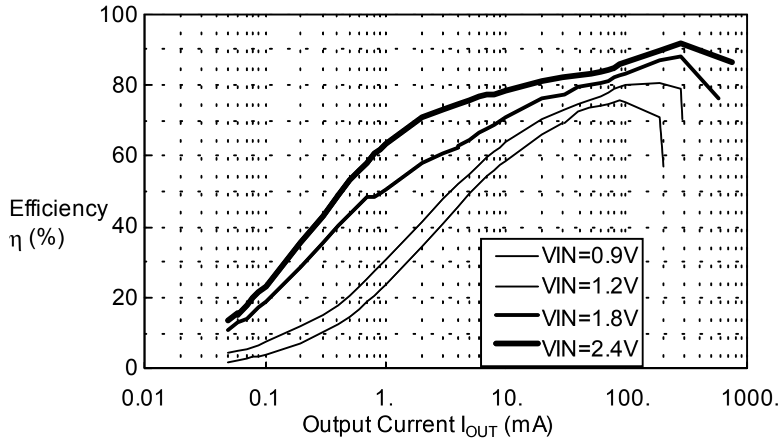


(18)S-8328B30(CD105:22μH,Rb=300Ω,Cb=0.01μF)

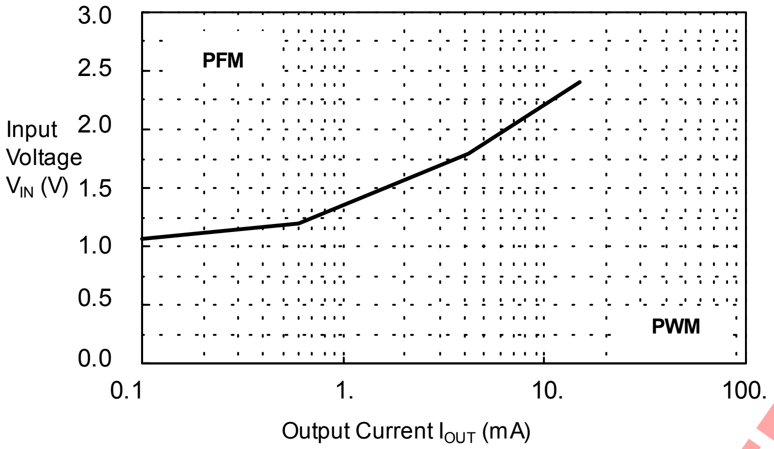
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

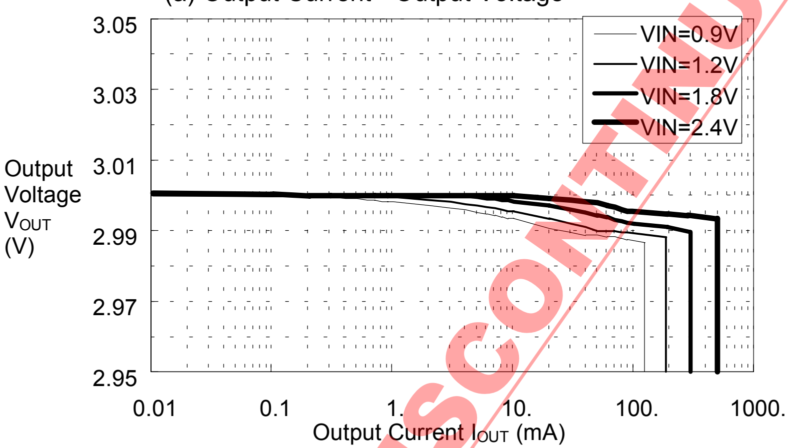


(c) PWM/PFM Switching

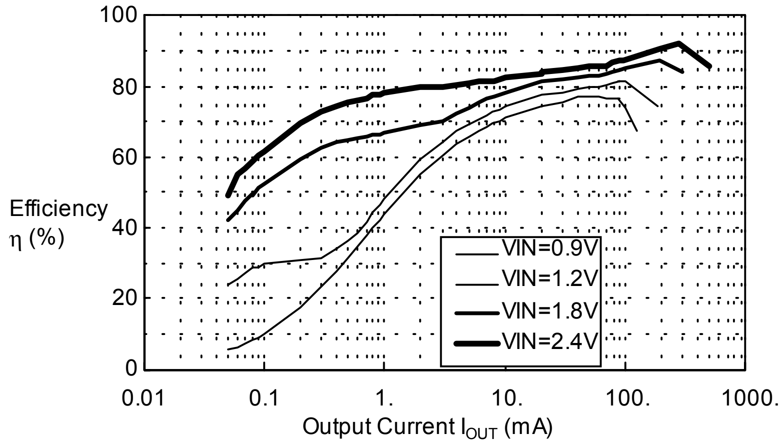


(19)S-8328B30(CD105:22μH,Rb=1kΩ,Cb=0.0022μF)

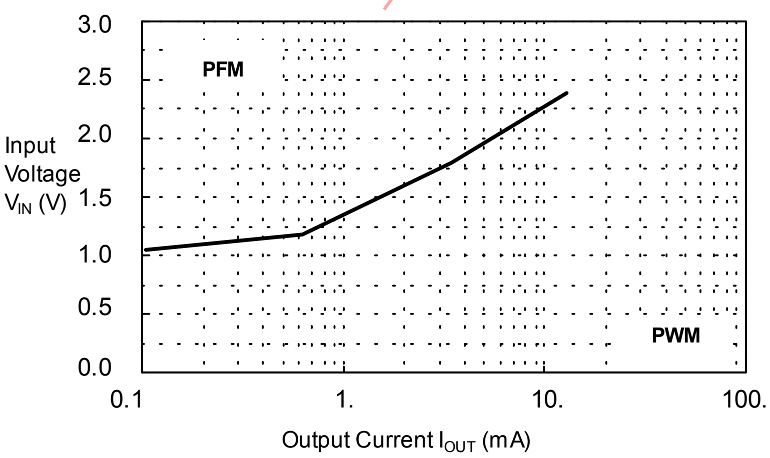
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

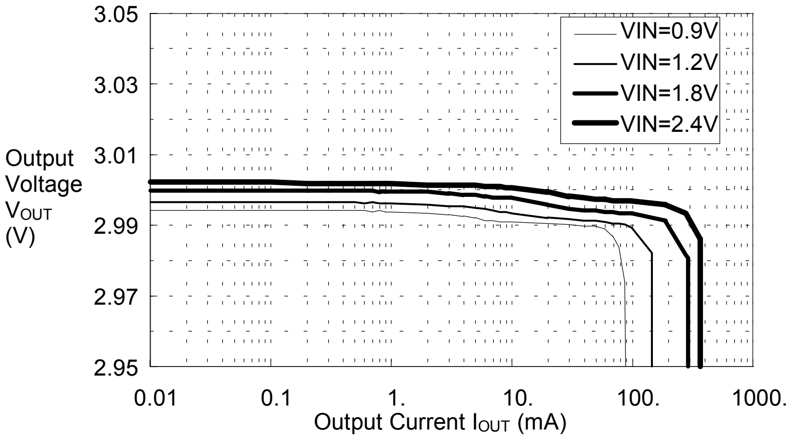


(c) PWM/PFM Switching

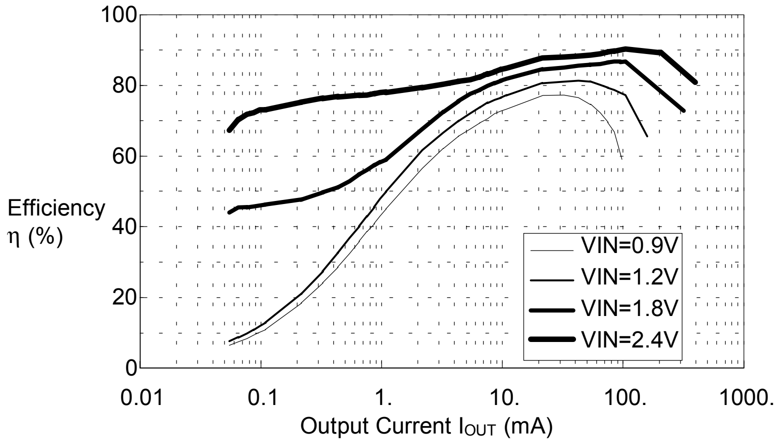


(20)S-8328B30(CD54:47µH,Rb=1kΩ,Cb=0.0022µF)

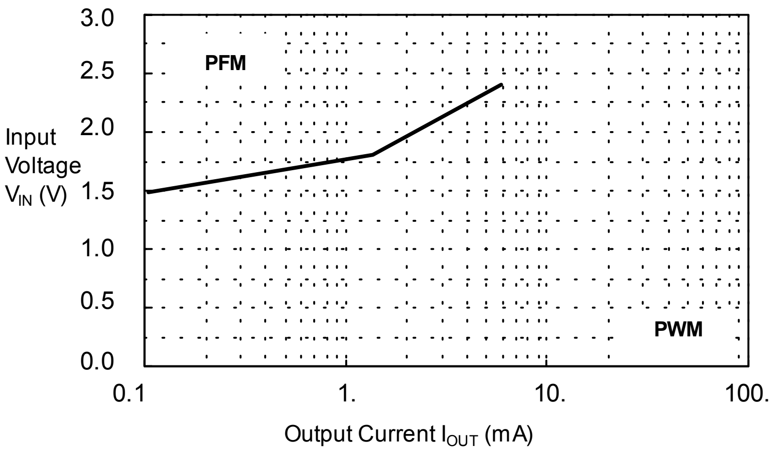
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

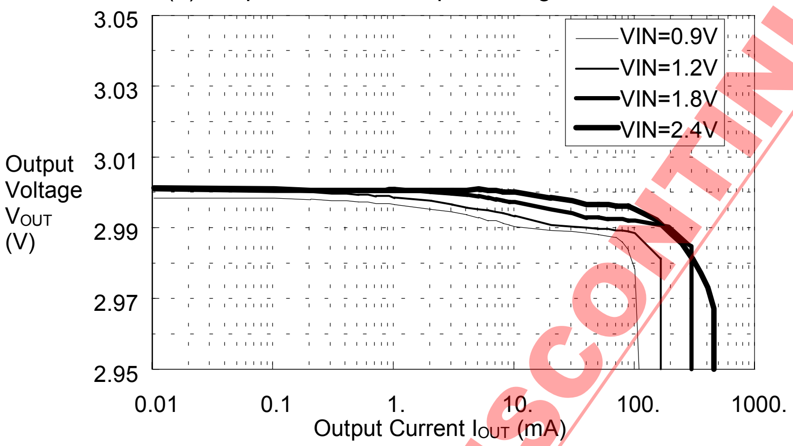


(c) PWM/PFM Switching

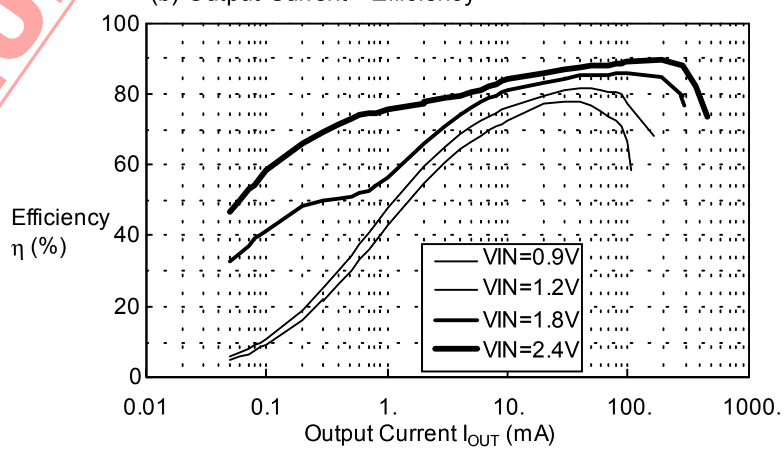


(21)S-8328B30(D75C:47µH,Rb=1kΩ,Cb=0.0022µF)

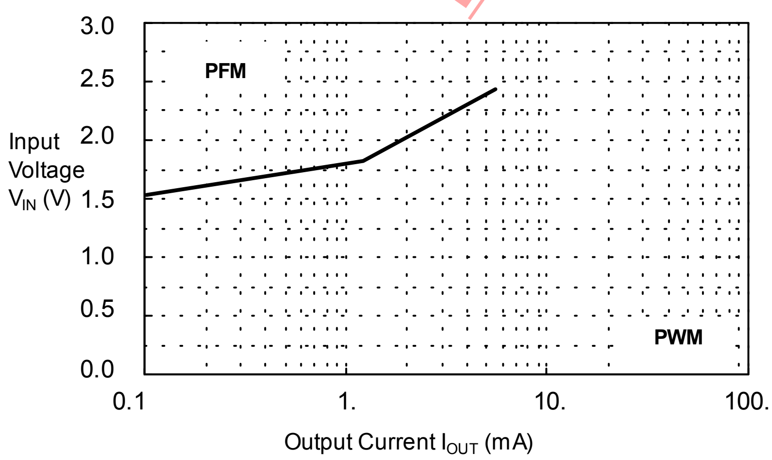
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

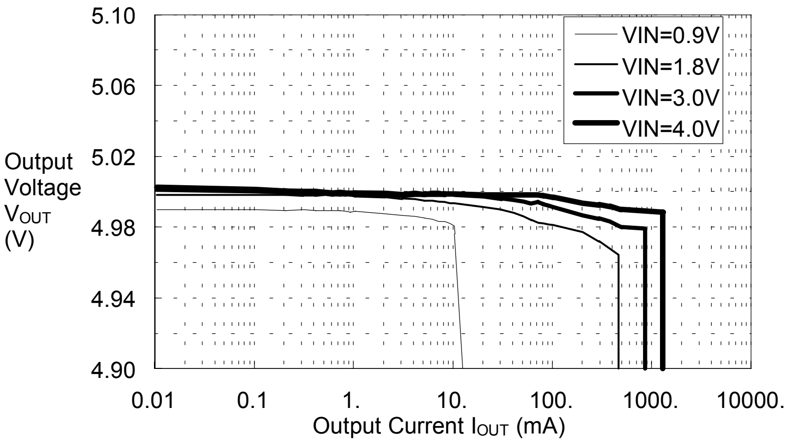


(c) PWM/PFM Switching

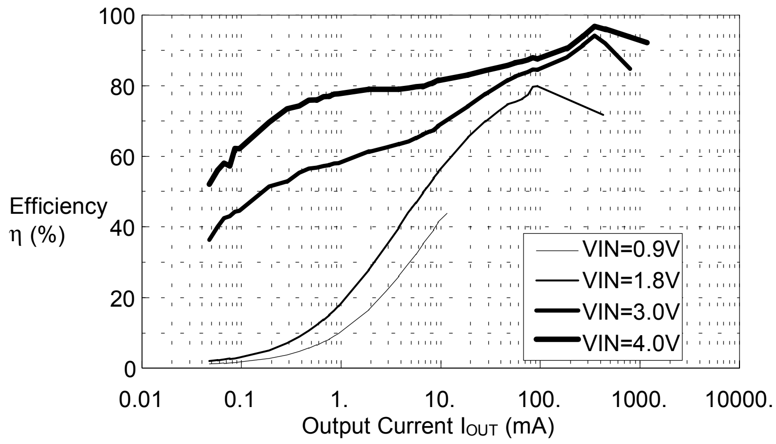


(22)S-8328B50(CD105:22μH,Rb=300Ω,Cb=0.01μF)

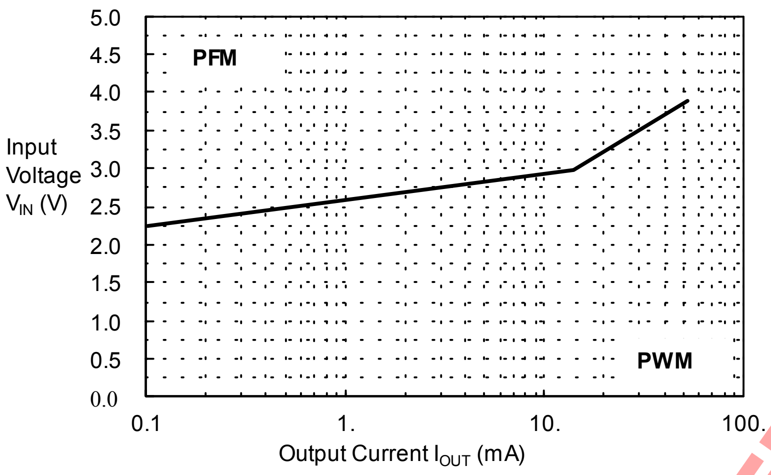
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

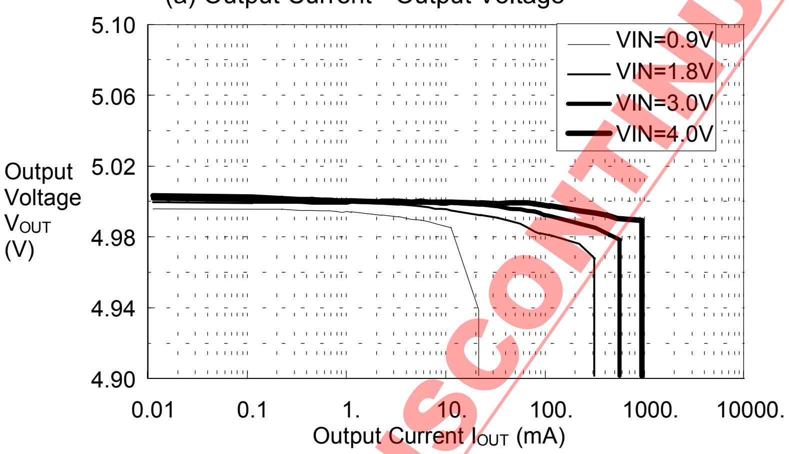


(c) PWM/PFM Switching

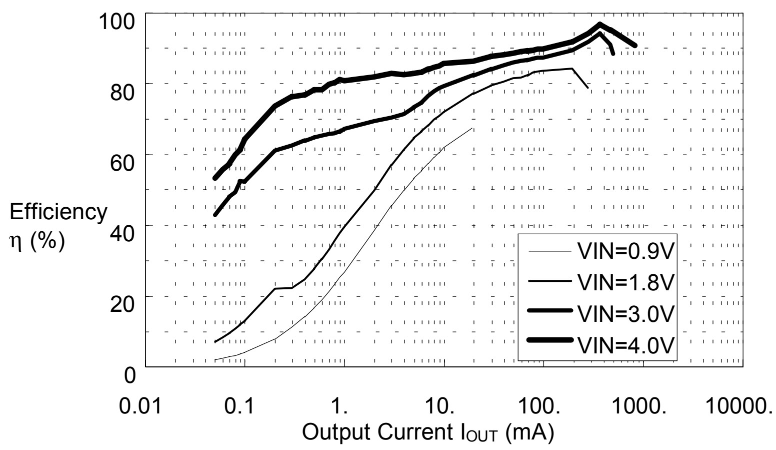


(23)S-8328B50(CD105:22μH,Rb=1kΩ,Cb=0.0022μF)

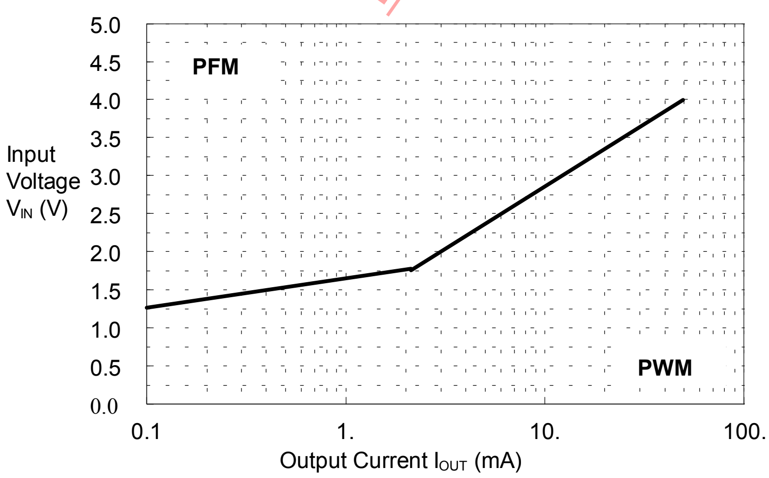
(a) Output Current - Output Voltage



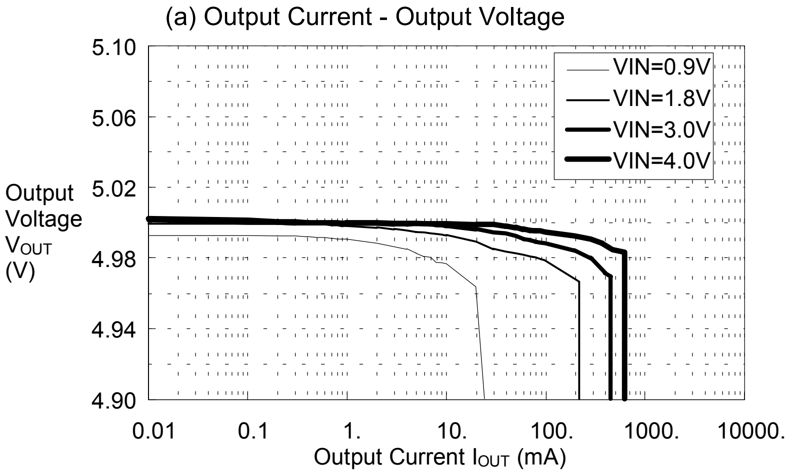
(b) Output Current - Efficiency

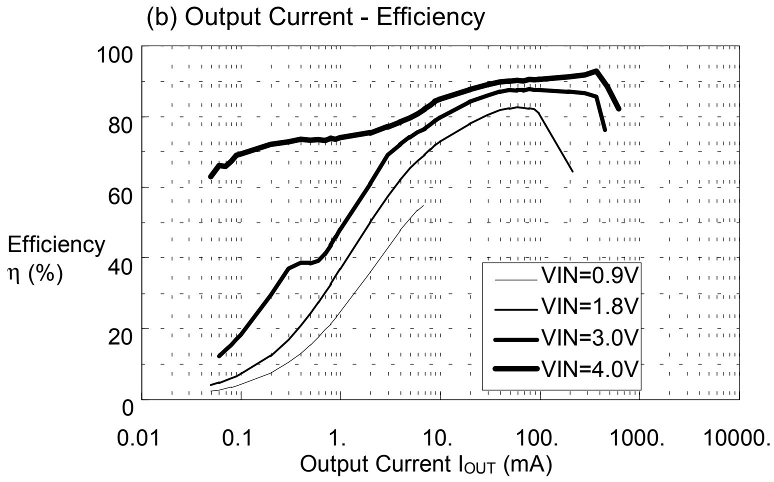


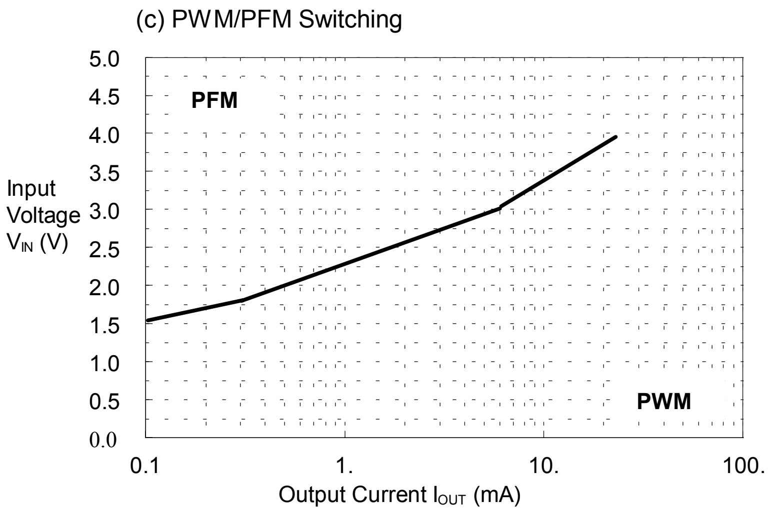
(c) PWM/PFM Switching



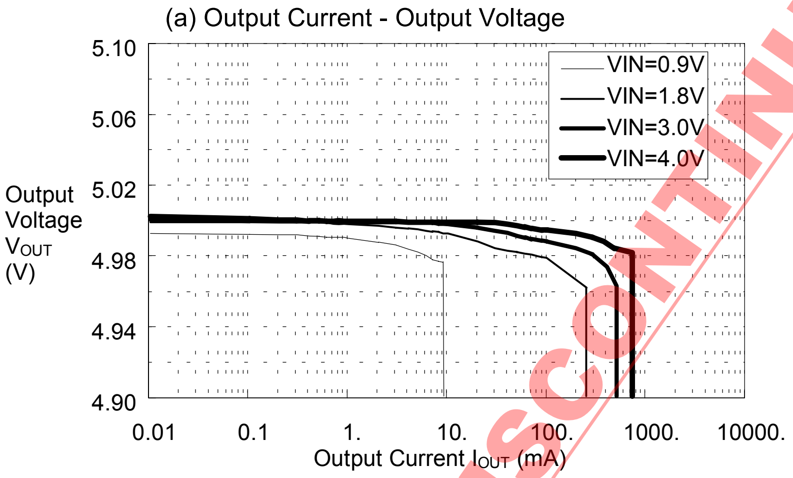
(24)S-8328B50(CD54:47μH,Rb=1kΩ,Cb=0.0022μF)

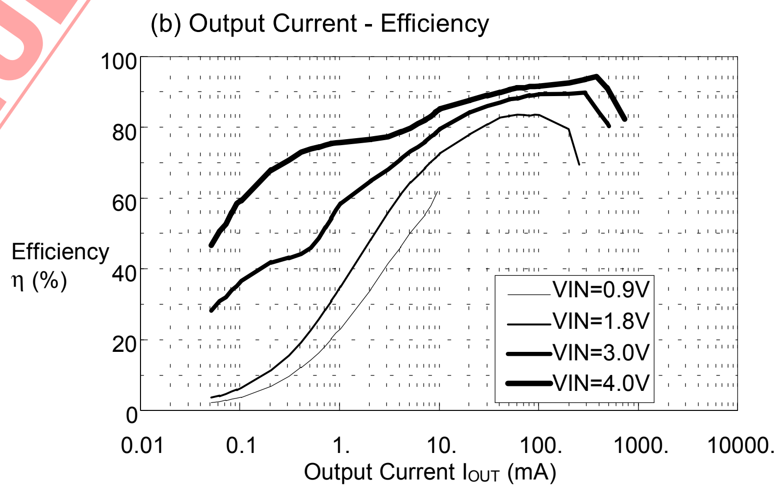


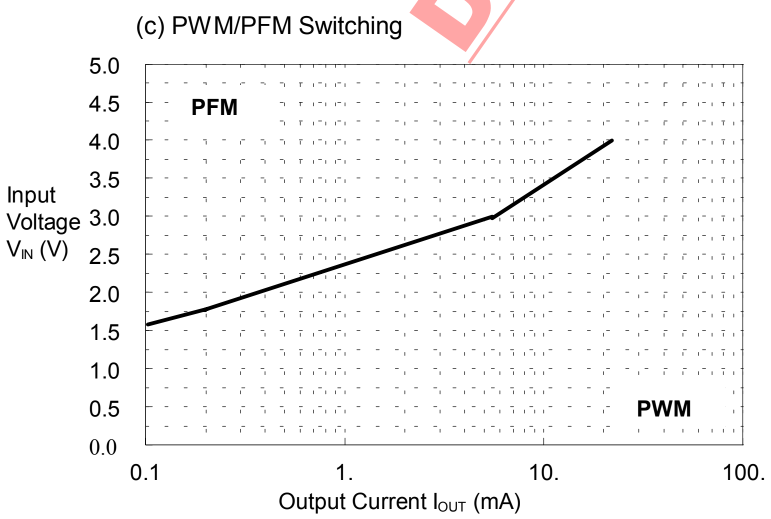




(25)S-8328B50(D75C:47μH,Rb=1kΩ,Cb=0.0022μF)

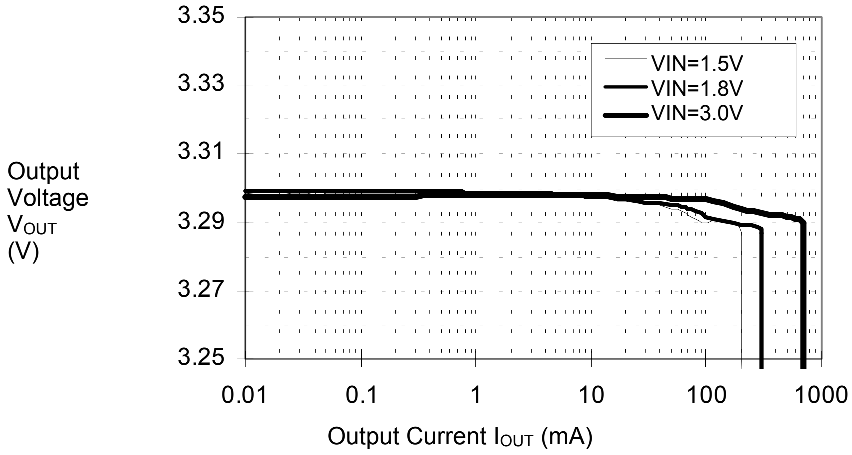




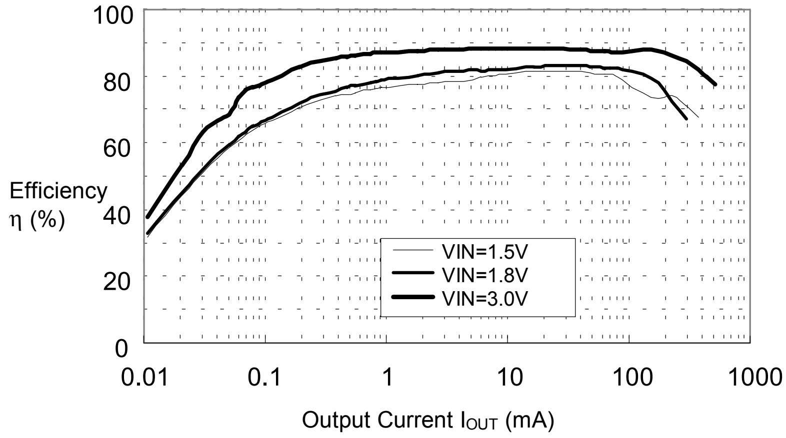


(26)S-8328H33(D62F:6.8µH)

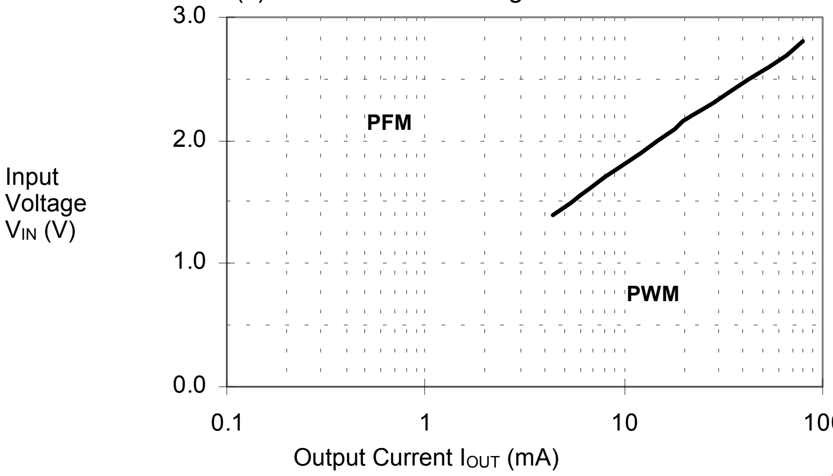
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

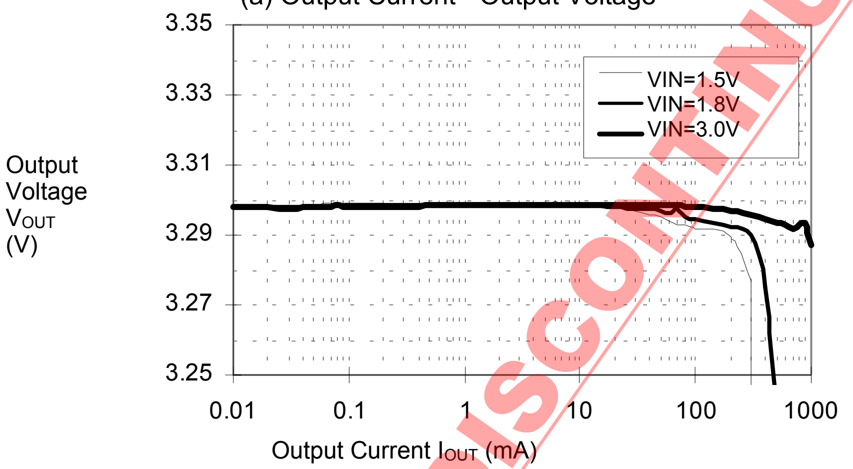


(c) PWM/PFM Switching

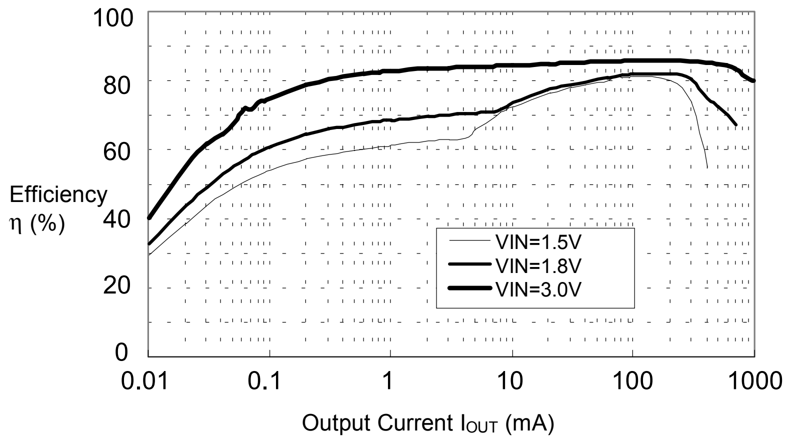


(27)S-8328H33(CDH113:10µH)

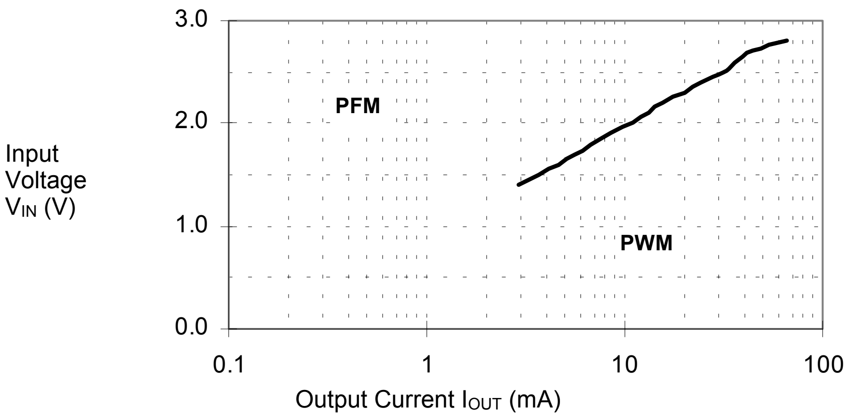
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

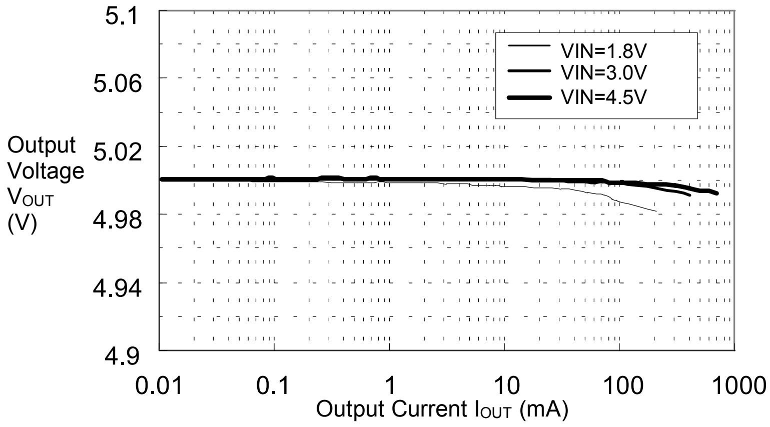


(c) PWM/PFM Switching

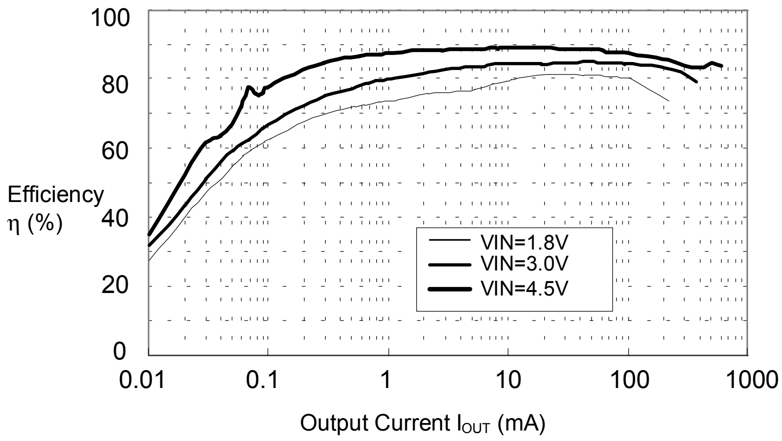


(28)S-8328H50(D62F:6.8μH)

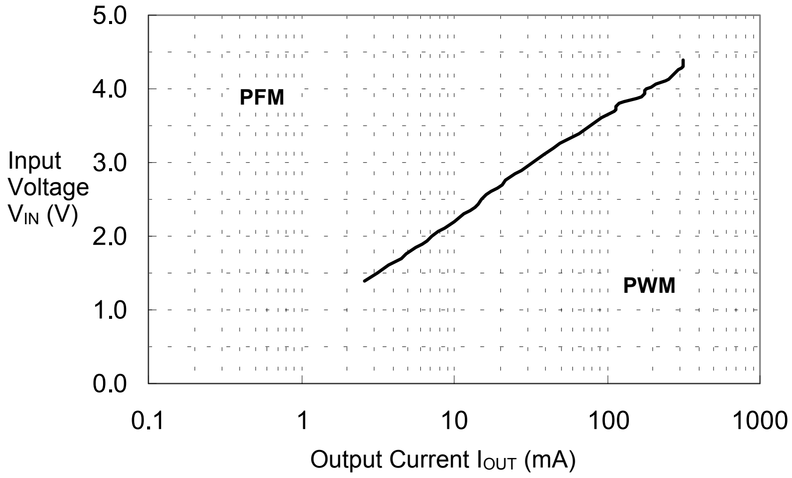
(a) Output Current - Output Voltage



(b) Output Current - Efficiency

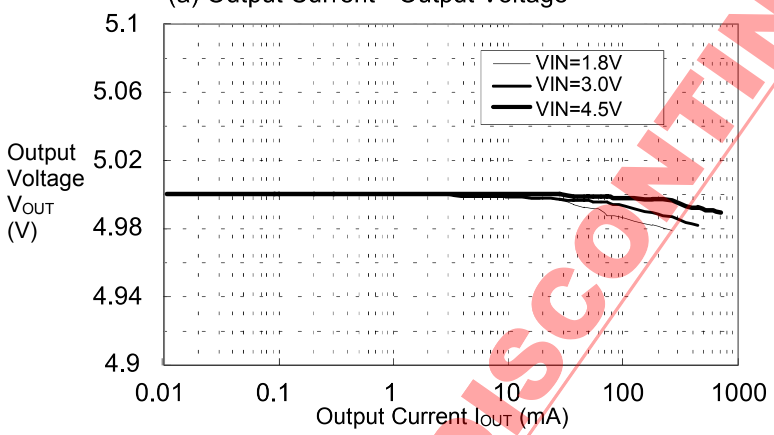


(c) PWM/PFM Switching

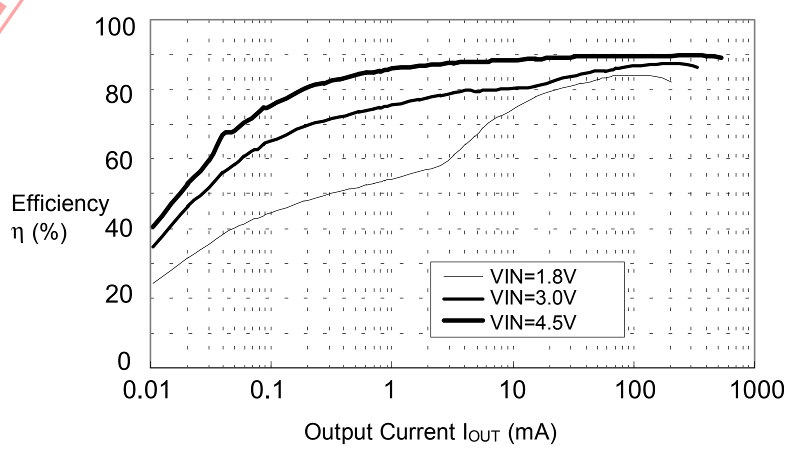


(29)S-8328H50(CDH113:10μH)

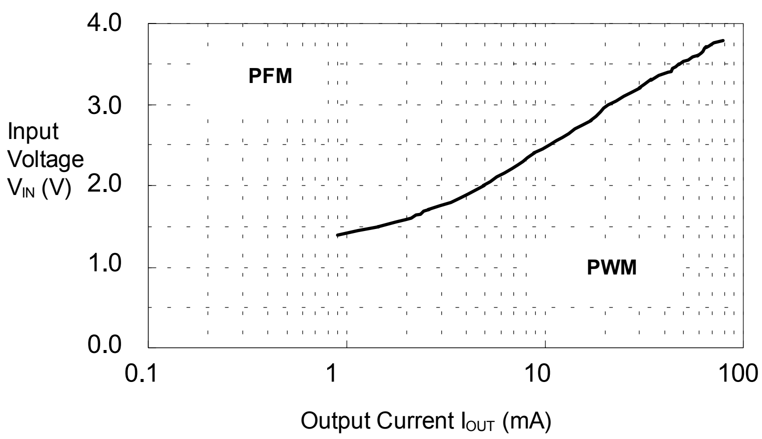
(a) Output Current - Output Voltage



(b) Output Current - Efficiency



(c) PWM/PFM Switching

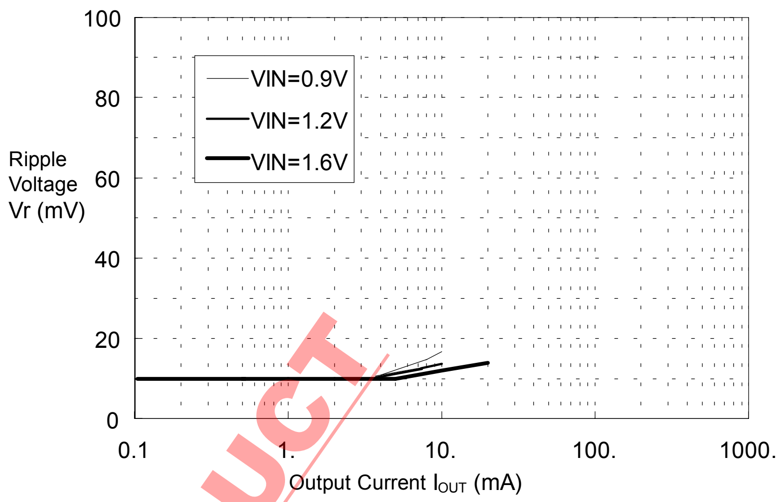


5. Reference Data 2

The ripple voltage characteristics data is shown below:

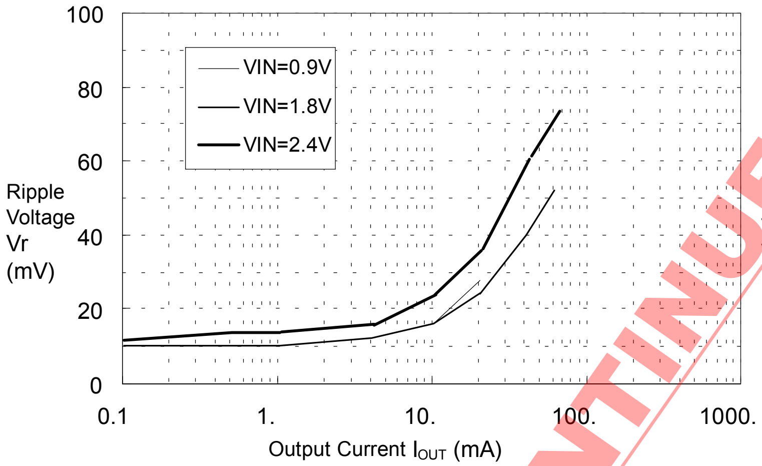
(1)S-8324A20
(LQH3C:220µH,C_{OUT}:22µF)
Similar to (2)

(2)S-8324A20
(LQH4N:220µH,C_{OUT}:22µF)

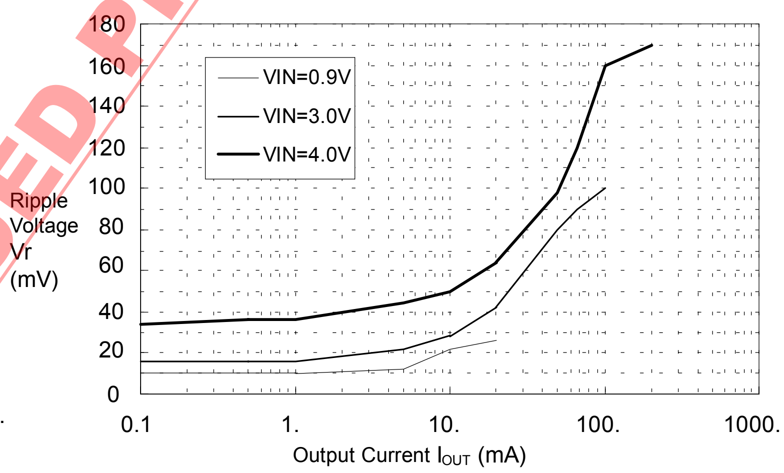


(3)S-8324A30
(LQH4N:220µH,C_{OUT}:22µF)
Similar to (6)

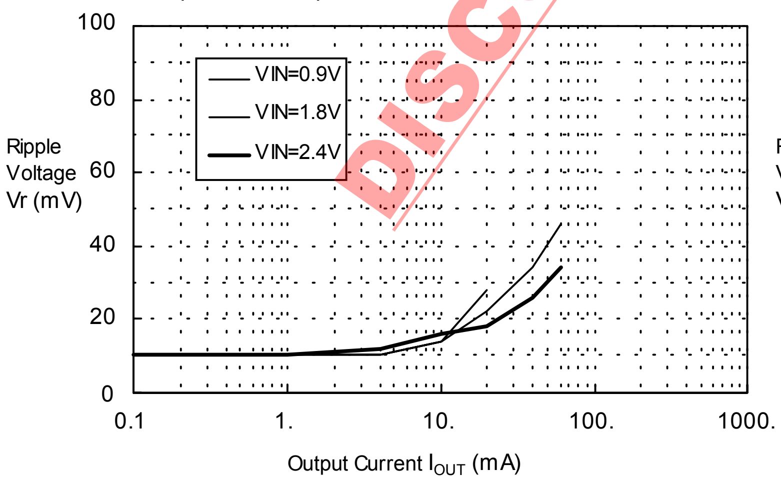
(4)S-8324A30
(CD54:47µH,C_{OUT}:22µF)



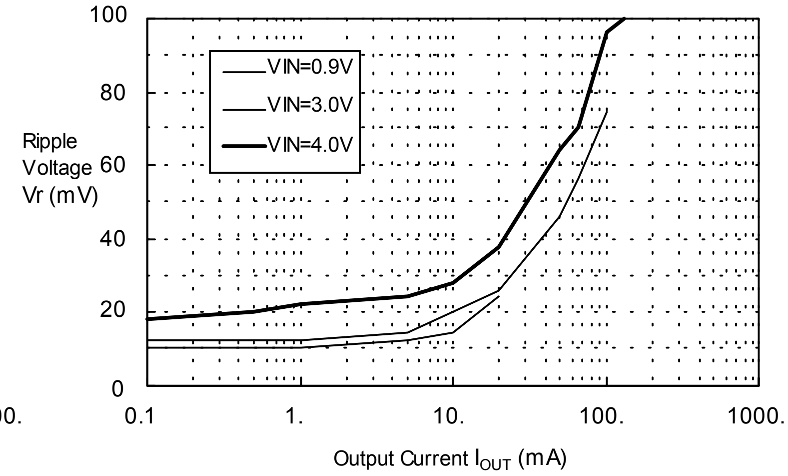
(7)S-8324A50
(CD54:47µH,C_{OUT}:22µF)



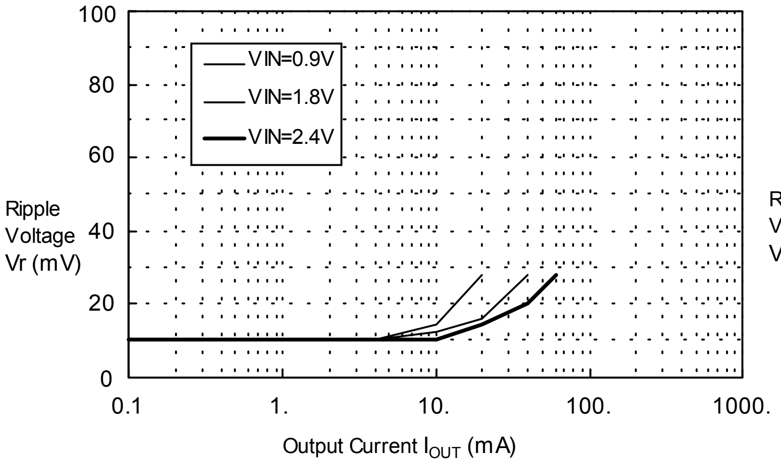
(5)S-8324A30
(CD54:100µH,C_{OUT}:22µF)



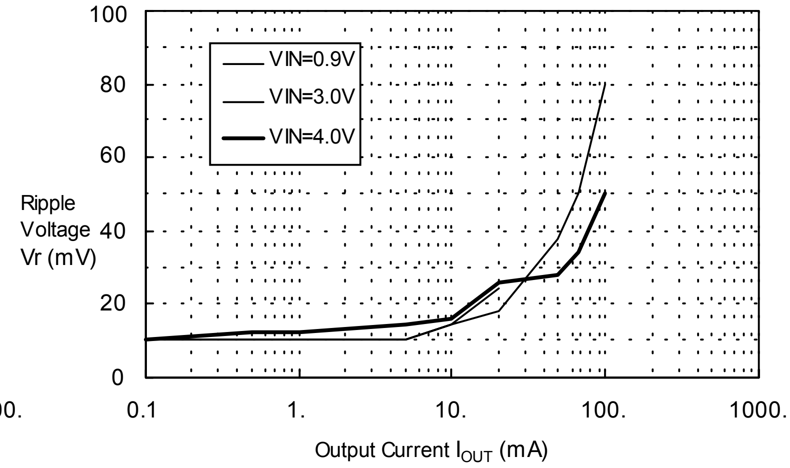
(8)S-8324A50
(CD54:100µH,C_{OUT}:22µF)



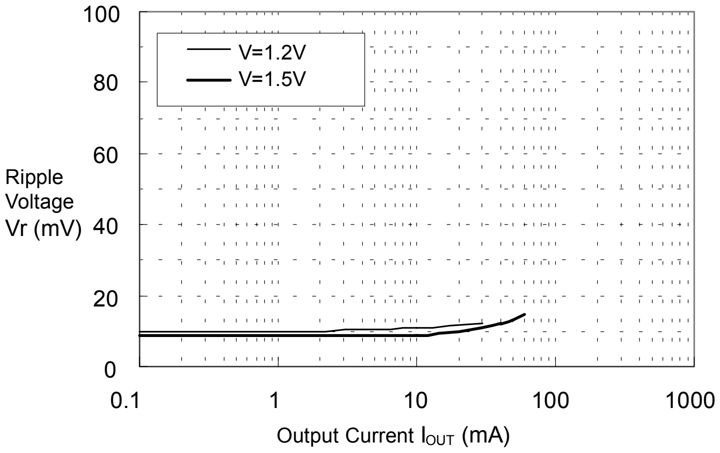
(6)S-8324A30
(CD54:220µH,C_{OUT}:22µF)



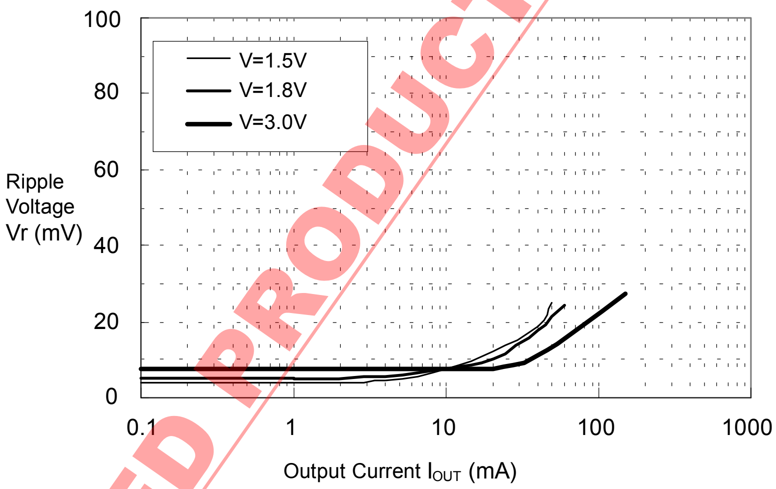
(9)S-8324A50
(CD54:220µH,C_{OUT}:22µF)



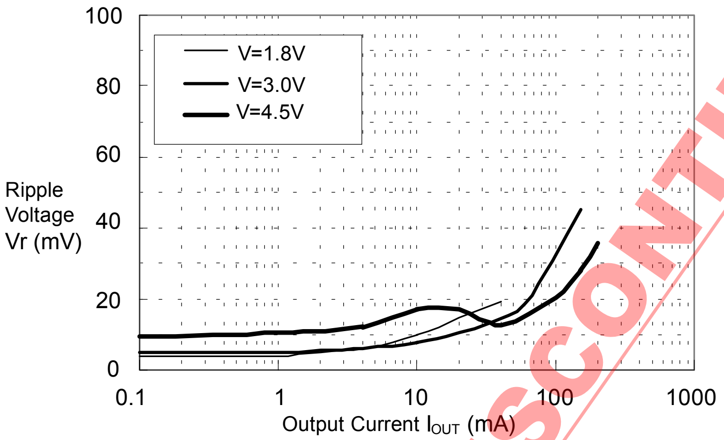
(11)S-8324H25
(D62F:22µH,C_{OUT}:22µF)



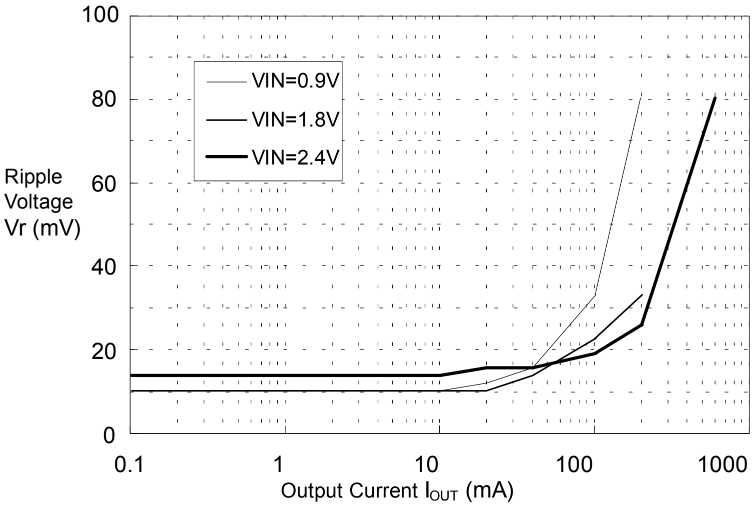
(14)S-8324H33
(D62F:22µH,C_{OUT}:22µF)



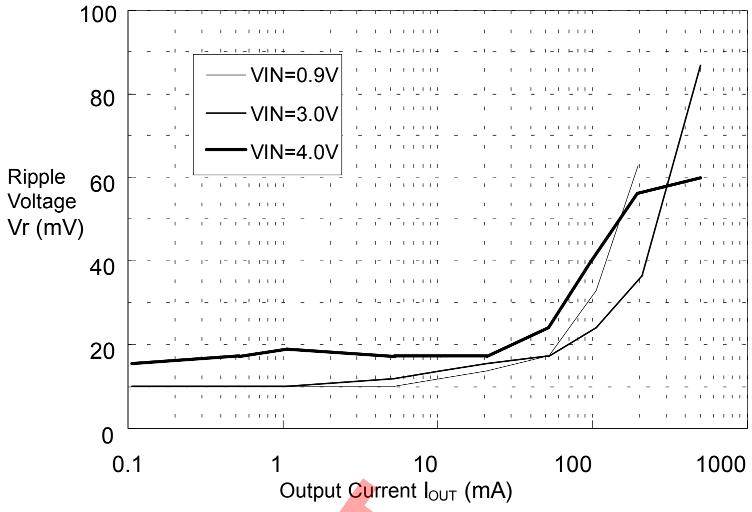
(17)S-8324H50
(D62F:22µH,C_{OUT}:22µF)



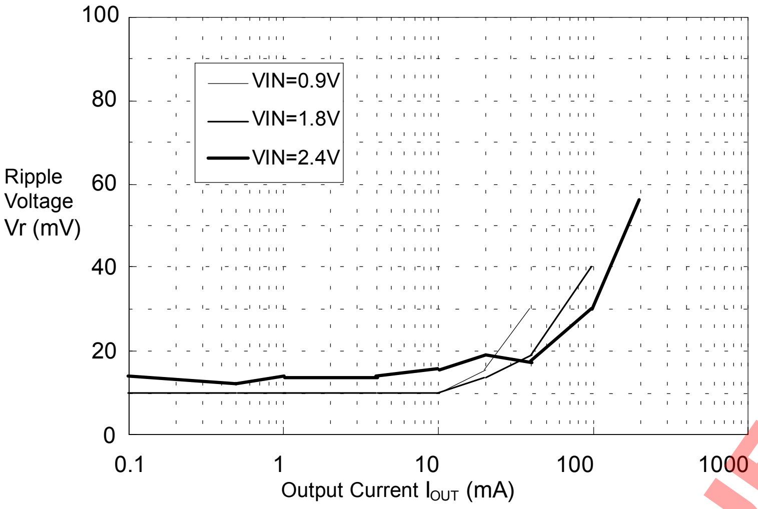
(18)(11)S-8328B30
(CD105:22µH,C_{OUT}:47µF×2)



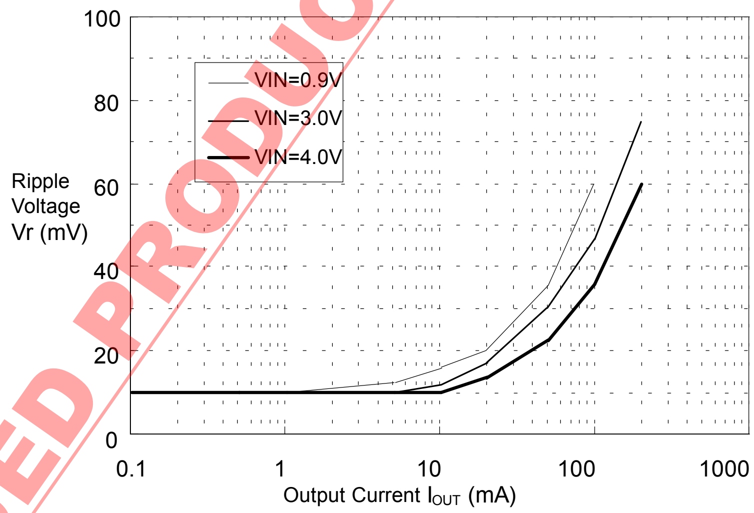
(22)(23)S-8328B50
(CD105:22µH,C_{OUT}:47µF×2)



(20)S-8328B30
(CD54:47µH,C_{OUT}:47µF)



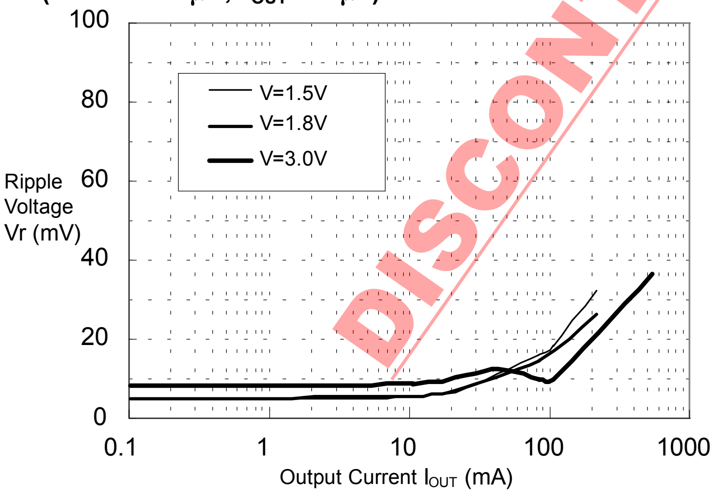
(24)S-8328B50
(CD54:47µH,C_{OUT}:47µF)



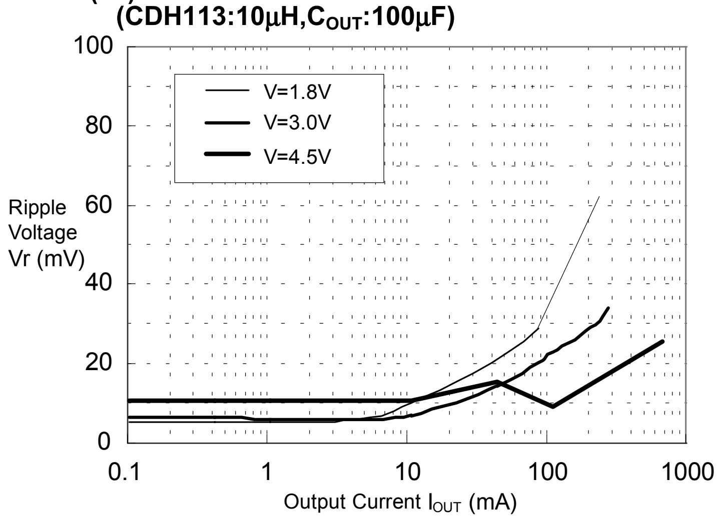
(21)S-8328B30
(D75C:47µH,C_{OUT}:47µF)
Similar to (12)

(25)S-8328B50
(D75C:47µH,C_{OUT}:47µF)
Similar to (16)

(27)S-8328H33
(CDH113:10µH,C_{OUT}:100µF)



(29)S-8328H50
(CDH113:10µH,C_{OUT}:100µF)

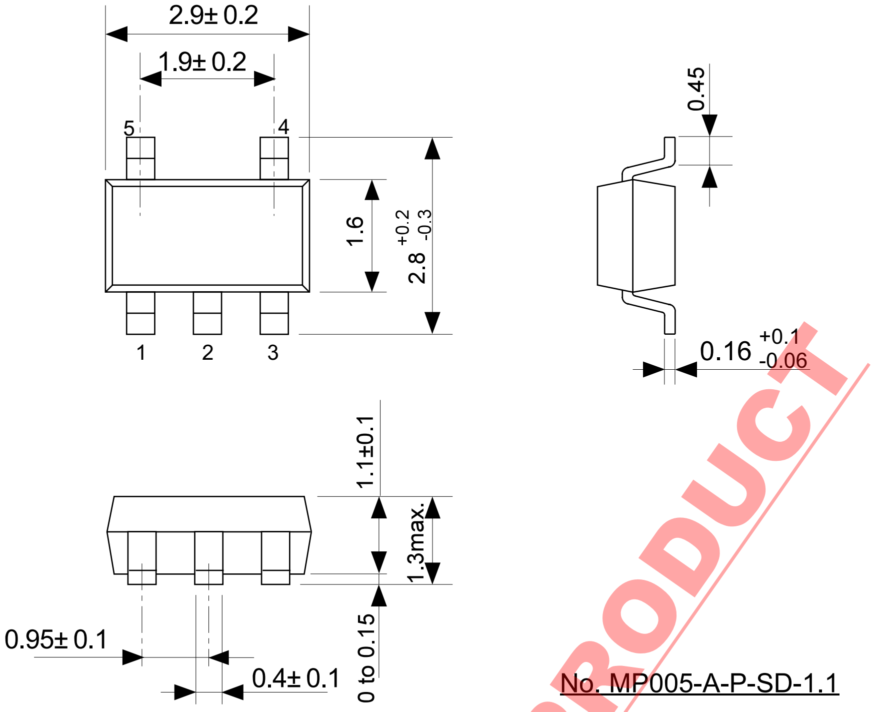


■ SOT-23-5

MP005-A 010907

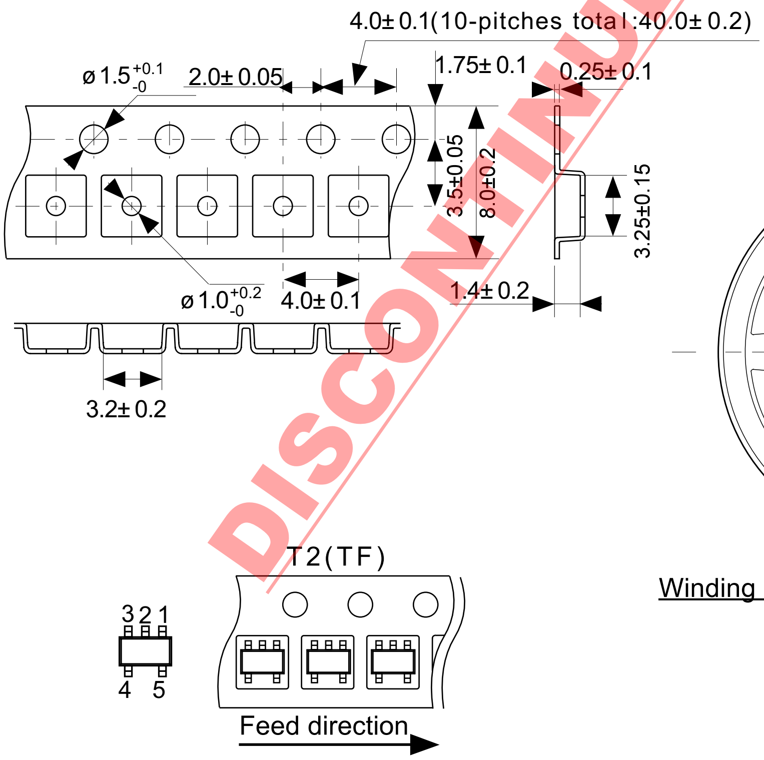
● Dimensions

Unit : mm



No. MP005-A-P-SD-1.1

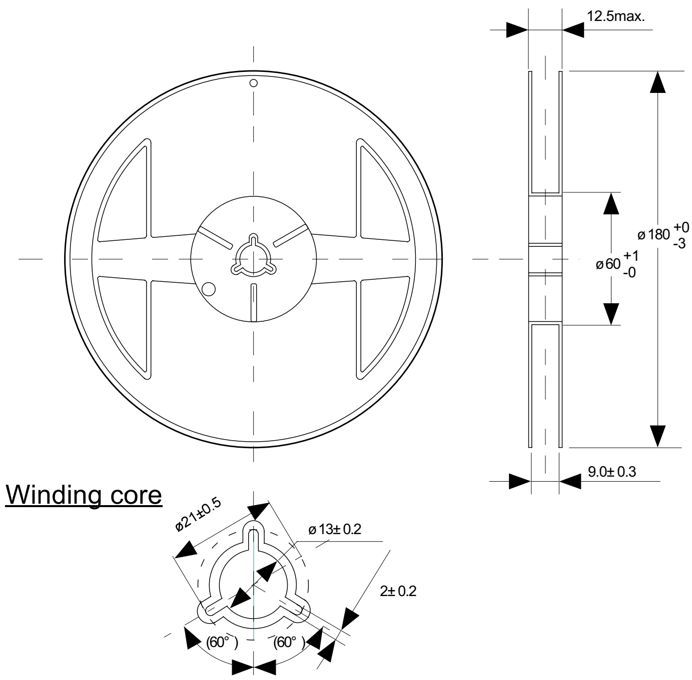
● Tape Specifications



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

● Reel Specifications

3000 pcs./reel



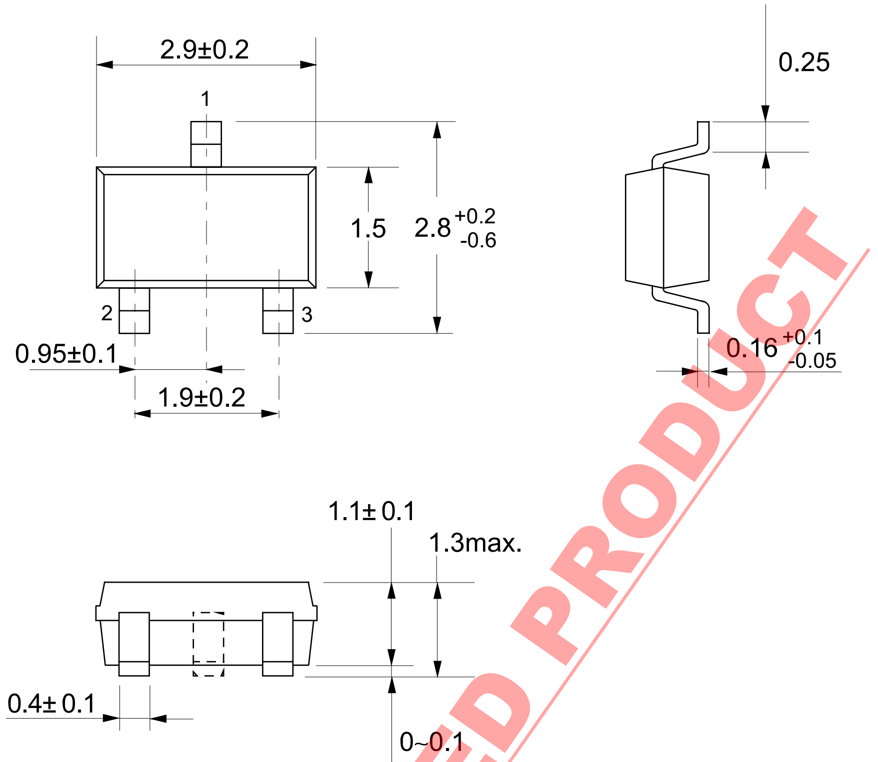
No. MP005-A-R-SD-1. 0

■ SOT-23-3

MP003-A 990531

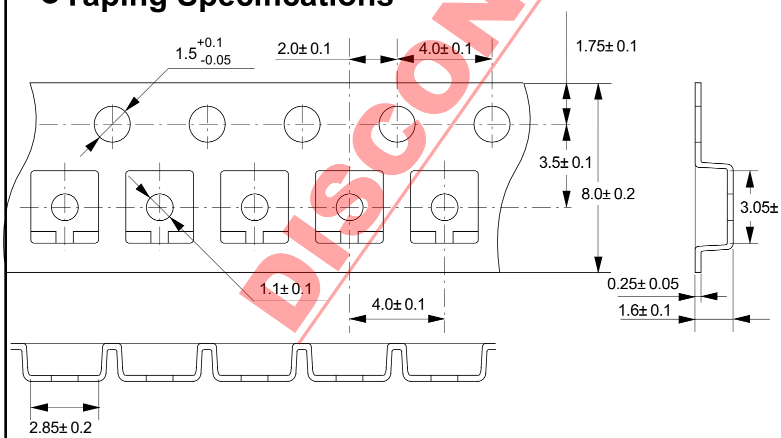
●Dimensions

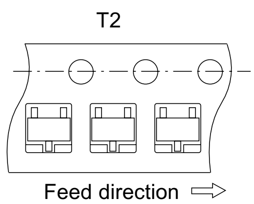
Unit:mm



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

●Taping Specifications

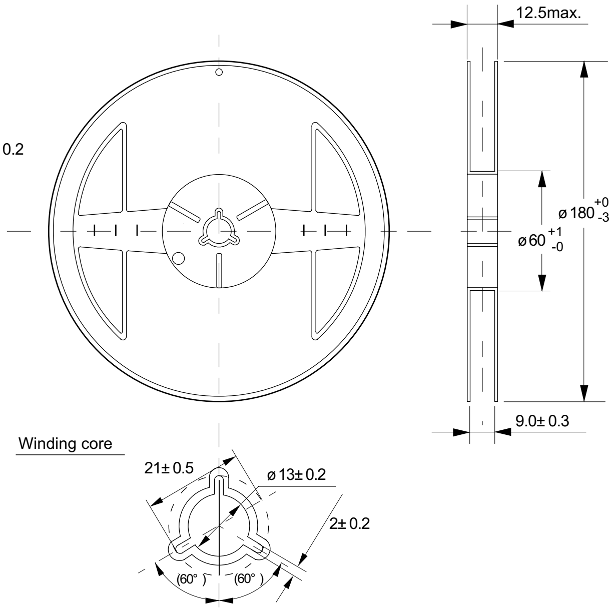




No.:MP003-A-C-SD-1.0

●Reel Specifications

1 reel holds 3000 ICs.



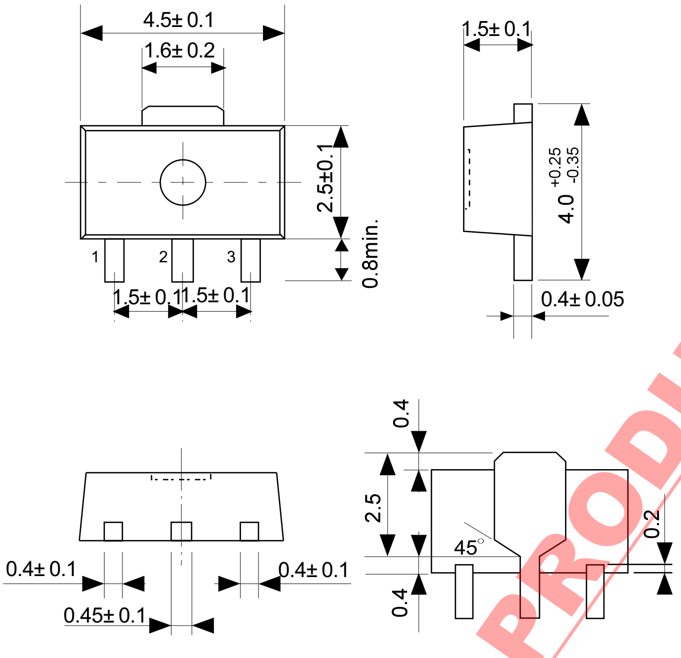
No.:MP003-A-R-SD-1.0

■ SOT-89-3

UP003-A Rev.1.0 020109

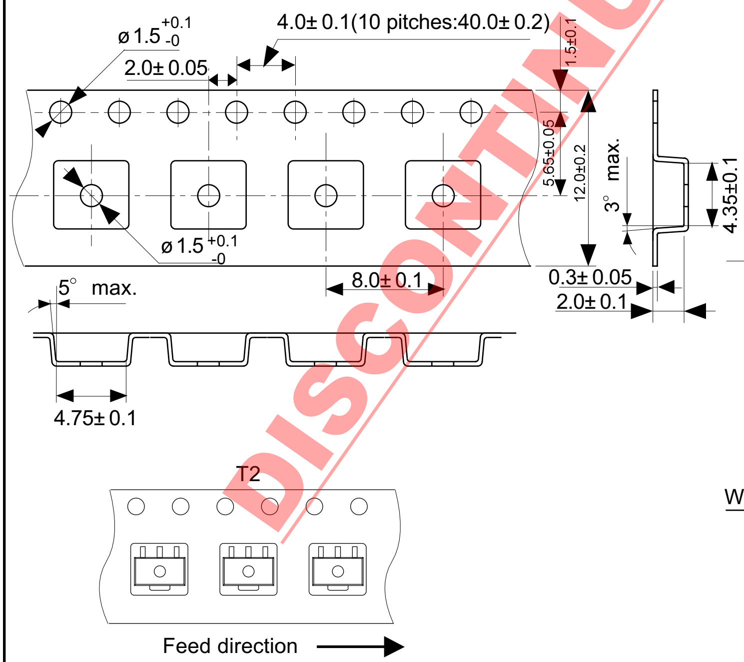
●Dimensions

Unit:mm



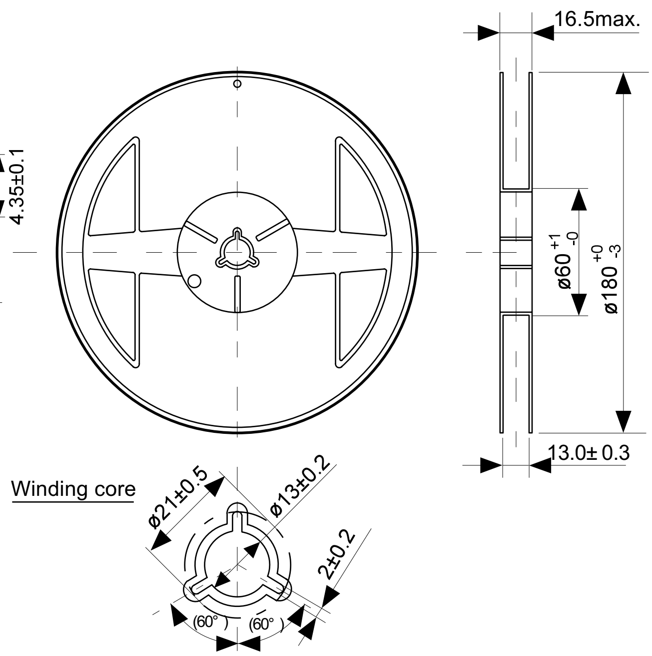
No. UP003-A-P-SD-1.0

●Taping Specifications



●Reel Specifications

1 reel holds 1000 ICs.



No. UP003-A-C-SD-1.0

No. UP003-A-R-SD-1.0