Contents

regulator which mainly consists of a reference voltage source, oscillation circuit, a power MOS FET, and a comparator. The method PFM control circuit automatically switches the duty according to load, offering products of low ripple over a wide range. efficiency, high output current. A step-up switching regulat constructed by externally connecting only a coil, a capacitor and a to the S-8321/8322 Series. This feature, along with its small pac and low current consumption, makes the S-8321/8322 Series ide the power supply of portable equipment. A built-in protection c prevents damage to the IC by turning off the MOS FET wher voltage at CONT pin exceeds the limit during ON of the built-in FET. For applications requiring a high output current, products with an external transistor are also available in S-8322 Series.

■ Features

- Low voltage operation: 0.9 V min. (I_{OUT} = 1 mA)
- Low input current:
  - During operation: 6.8 µA (V_{OUT} = 3 V, no load, typ.)
  - During shutdown: 0.5 µA (max.)
- Duty ratio: auto-switching PFM control circuit type
- External parts: coil, diode, and capacitor only
- Output voltage: accuracy of ±2.4%
- Shutdown function
- External transistor type is available (S-8322 Series)
- A Series : SOT-23-5 package
  B Series : SOT-23-3 package

■ Applications

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

■ Block Diagram

(1) S-8321 Series (2) S-8322 Series

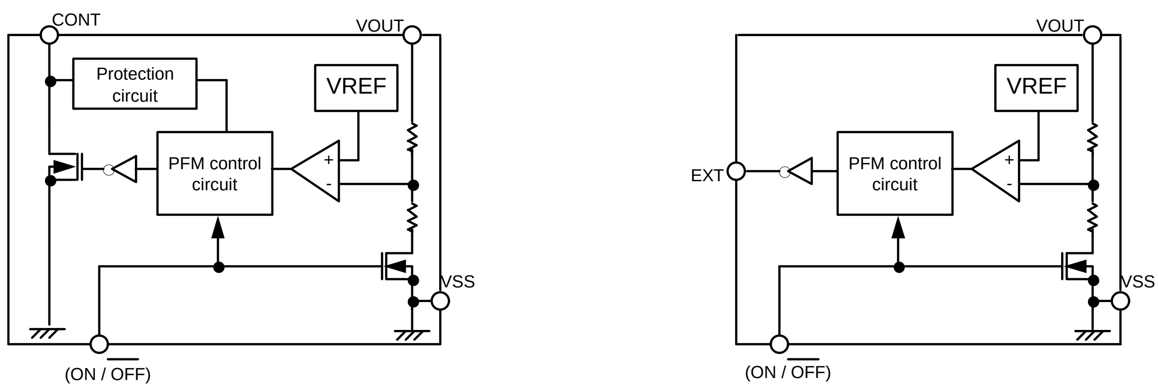


Figure 1

Product name (abbreviation)
Output voltage (symbol)
Series name — A : SOT-23-5 / auto-switching type
B : SOT-23-3 / auto-switching type
Power MOS FET — 1 : Built in
2 : Connected externally

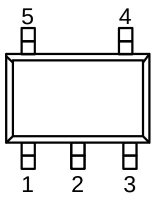
2. List of the Product

Output voltage (V) \ Products	S-8321A Series	S-8322A Series	S-8321B Series	S-8322B Series
2.2	S-8321AOMP-DNO-T2	———	———	———
2.5	S-8321AJMP-DNJ-T2	S-8322AJMP-DOJ-T2	S-8321BJMP-DTJ-T2	———
2.7	S-8321ALMP-DNL-T2	———	S-8321BLMP-DTL-T2	———
3.0	S-8321AIMP-DNI-T2	S-8322AIMP-DOI-T2	S-8321BIMP-DTI-T2	S-8322BIMP-DUI-T2
3.3	S-8321AGMP-DNG-T2	S-8322AGMP-DOG-T2	S-8321BGMP-DTG-T2	———
3.5	S-8321AFMP-DNF-T2	S-8322AFMP-DOF-T2	———	———
5.0	S-8321AAMP-DNA-T2	S-8322AAMP-DOA-T2	S-8321BAMP-DTA-T2	S-8322BAMP-DUA-T2
5.5	S-8321AMMP-DNM-T2	———	———	———

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

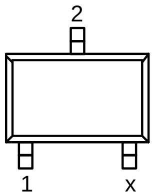
■ Pin Assignment

(1) SOT - 23 - 5
Top view



1 ON / $\overline{\text{OFF}}$
2 V_{OUT}
3 NC
4 V_{SS}
5 CONT / EXT

(2) SOT - 23 - 3
Top view



1 V_{SS}
2 V_{OUT}
3 CONT / EXT

Pin name	Functions
ON / $\overline{\text{OFF}}$	Shutdown pin "H": normal operation (stepping up operation) "L": stop stepping up (circuit stop)
V_{OUT}	Output voltage pin and IC power supply
V_{SS}	GND
CONT	External inductor connection Note 1
EXT	External transistor connection Note 2

Note 1: S-8321 Series : Open drain output
Note 2: S-8322 Series: CMOS output

Figure 2

■ Absolute Maximum Ratings

(Unless otherwise specified: Ta=25°C)

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

Output voltage	V_{OUT}		S-8321AFMP	3.416	3.500	3.584	V
			S-8321AGMP	3.221	3.300	3.379	
			S-8321AIMP	2.928	3.000	3.072	
			S-8321ALMP	2.635	2.700	2.765	
			S-8321AJMP	2.440	2.500	2.560	
			S-8321AOMP	2.147	2.200	2.253	
Input voltage	V_{IN}			—	—	9	
Operation start voltage	V_{ST1}	I_{OUT}=1mA		—	—	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	
Input voltage at no load	I_{IN}	No load	S-8321AMMP	—	9.4	15.6	µA
			S-8321AAMP	—	9.0	15.0	
			S-8321AFMP	—	7.2	12.0	
			S-8321AGMP	—	7.0	11.7	
			S-8321AIMP	—	6.8	11.4	
			S-8321ALMP	—	6.8	11.4	
			S-8321AJMP	—	6.7	11.1	
			S-8321AOMP	—	6.5	10.8	
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8321AMMP	—	54	78.3	
			S-8321AAMP	—	49	71.4	
			S-8321AFMP	—	31	50.9	
			S-8321AGMP	—	29	48.1	
			S-8321AIMP	—	26	44.0	
			S-8321ALMP	—	24	40.0	
			S-8321AJMP	—	22	37.2	
			S-8321AOMP	—	20	33.1	
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8321AMMP	—	2.8	4.6	
			S-8321AAMP	—	2.6	4.4	
			S-8321AFMP	—	2.4	4.0	
			S-8321AGMP	—	2.3	3.9	
			S-8321AIMP	—	2.3	3.8	
			S-8321ALMP	—	2.3	3.8	
			S-8321AJMP	—	2.2	3.7	
			S-8321AOMP	—	2.2	3.6	
Shutdown current	I_{SSS}	Shutdown pin=0 V		—	—	0.5	
Switching current	I_{SW}	V_{CONT}=0.4V	S-8321AMMP	99	148	—	mA
			S-8321AAMP	99	148	—	
			S-8321AFMP	82	122	—	
			S-8321AGMP	68	102	—	
			S-8321AIMP	68	102	—	
			S-8321ALMP	53	80	—	
			S-8321AJMP	53	80	—	
			S-8321AOMP	39	58	—	
Switching transistor leak current	I_{SWQ}	V_{OUT}=V_{CONT}=0.9V		—	—	1.0	µA
CONT limit voltage	$V_{CONT\ LMT}$			—	0.9	—	V
Line regulation	$\triangle V_{OUT1}$	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV
Load regulation	$\triangle V_{OUT2}$	I_{OUT}=10µA to I_{OUT}(below) ×1.25		—	30	60	
Output voltage temperature coefficient	$\triangle V_{OUT}/\triangle Ta$	Ta=- 40°C to+85°C	S-8321AMMP	—	±0.28	±1.40	mV/ C
			S-8321AAMP	—	±0.25	±1.25	
			S-8321AFMP	—	±0.18	±0.90	
			S-8321AGMP	—	±0.17	±0.85	
			S-8321AIMP	—	±0.15	±0.75	
			S-8321ALMP	—	±0.14	±0.70	
			S-8321AJMP	—	±0.13	±0.65	
			S-8321AOMP	—	±0.11	±0.55	
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measure waveform at CONT pin		90	100	110	KHz

Shutdown pin input voltage	V_{SH}	V_{OUT}=output voltage×0.95 Judge the oscillation at CONT pin		0.75	—	—	V	2
	V_{SL1}	V_{OUT}=output voltage×0.95 Judge the stop at CONT pin	When $V_{OUT} \geq 1.5V$	—	—	0.3		
	V_{SL2}		When $V_{OUT} < 1.5V$	—	—	0.2		
Efficiency	EFFI		S-8321AMMP	—	85	—	%	1
			S-8321AAMP	—	85	—		
			S-8321AFMP	—	80	—		
			S-8321AGMP	—	80	—		
			S-8321AIMP	—	80	—		
			S-8321ALMP	—	70	—		
			S-8321AJMP	—	70	—		
			S-8321AOMP	—	70	—		

External parts used:
- Coil CD54 (100µH) of Sumida Electric Co., Ltd.
- Diode MA729 (schottky type) of Matsushita Electronic Components Co., Ltd.
- Capacitor F93 (16 V, 22 µF, tantalum type) of Nichicon Corporation

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

Note: Output voltage specified above is the typical value of the output voltage.

Item	Symbol	Conditions		Min.	Typ.	Max.	Unit
			S-8321BJMP	2.440	2.500	2.560	V
Input voltage	V_{IN}			—	—	9	
Operation start voltage	V_{ST1}	I_{OUT}=1mA		—	—	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	
Input voltage at no load	I_{IN}	No load	S-8321BAMP	—	9.0	15.0	µA
			S-8321BGMP	—	7.0	11.7	
			S-8321BIMP	—	6.8	11.4	
			S-8321BLMP	—	6.8	11.4	
			S-8321BJMP	—	6.7	11.1	
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8321BAMP	—	49	71.4	
			S-8321BGMP	—	29	48.1	
			S-8321BIMP	—	26	44.0	
			S-8321BLMP	—	24	40.0	
			S-8321BJMP	—	22	37.2	
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8321BAMP	—	2.6	4.4	
			S-8321BGMP	—	2.3	3.9	
			S-8321BIMP	—	2.3	3.8	
			S-8321BLMP	—	2.3	3.8	
			S-8321BJMP	—	2.2	3.7	
Switching current	I_{SW}	V_{CONT}=0.4V	S-8321BAMP	99	148	—	mA
			S-8321BGMP	68	102	—	
			S-8321BIMP	68	102	—	
			S-8321BLMP	53	80	—	
			S-8321BJMP	53	80	—	
Switching transistor leak current	I_{SWQ}	V_{OUT}=V_{CONT}=0.9V		—	—	1.0	µA
CONT limit voltage	$V_{CONT\ LMT}$			—	0.9	—	V
Line regulation	$\triangle V_{OUT1}$	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV
Load regulation	$\triangle V_{OUT2}$	I_{OUT}=10µA to I_{OUT}(below) ×1.25		—	30	60	
Output voltage temperature coefficient	$\triangle V_{OUT}/\triangle Ta$	Ta=- 40°C to+85°C	S-8321BAMP	—	±0.25	±1.25	mV/°C
			S-8321BGMP	—	±0.17	±0.85	
			S-8321BIMP	—	±0.15	±0.75	
			S-8321BLMP	—	±0.14	±0.70	
			S-8321BJMP	—	±0.13	±0.65	
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measure waveform at CONT pin		90	100	110	KHz
Duty ratio 1	Duty1	V_{OUT}=output voltage×0.95 Measure waveform at CONT pin		70	75	80	%
Duty ratio 2	Duty2			—	50	—	
Efficiency	EFFI		S-8321BAMP	—	85	—	
			S-8321BGMP	—	80	—	
			S-8321BIMP	—	80	—	
			S-8321BLMP	—	70	—	
			S-8321BJMP	—	70	—	

External parts used:
- Coil CD54 (100µH) of Sumida Electric Co., Ltd.
- Diode MA729 (schottky type) of Matsushita Electronic Components Co., Ltd.
- Capacitor F93 (16 V, 22 µF, tantalum type) of Nichicon Corporation

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

Note: Output voltage specified above is the typical value of the output voltage.

			S-8322AJMP	2.440	2.500	2.560	V	
Input voltage	V_{IN}			—	—	9		
Operation start voltage	V_{ST1}	I_{OUT}=1mA		—	—	0.9		
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT}		—	—	0.8		4
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8322AAMP	—	31	52.0	µA	4
			S-8322AFMP	—	20	33.0		
			S-8322AGMP	—	19	31.5		
			S-8322AIMP	—	17	28.9		
			S-8322AJMP	—	15	24.6		
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8322AAMP	—	2.6	4.4		
			S-8322AFMP	—	2.4	4.0		
			S-8322AGMP	—	2.3	3.9		
			S-8322AIMP	—	2.3	3.8		
			S-8322AJMP	—	2.2	3.7		
Shutdown current	I_{SSS}	Shutdown pin=0 V		—	—	0.5		
EXT pin output current	I_{EXTH}	EVEXT=V_{OUT}-0.4V	S-8322AAMP	-5.3	-8.0	—	mA	—
			S-8322AFMP	-3.5	-5.3	—		
			S-8322AGMP	-3.5	-5.3	—		
			S-8322AIMP	-3.5	-5.3	—		
			S-8322AJMP	-2.7	-4.0	—		
	I_{EXTL}	EVEXT=0.4V	S-8322AAMP	10.7	16.0	—		
			S-8322AFMP	7.0	10.5	—		
			S-8322AGMP	7.0	10.5	—		
			S-8322AIMP	7.0	10.5	—		
			S-8322AJMP	5.3	8.0	—		
Line regulation	$\triangle V_{OUT1}$	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV	3
Load regulation	$\triangle V_{OUT2}$	I_{OUT}=10µA to I_{OUT}(below) ×1.25		—	30	60		
Output voltage temperature coefficient	$\triangle V_{OUT}/\triangle Ta$	Ta=-40°C to+85°C	S-8322AAMP	—	±0.25	±1.25	mV/°C	
			S-8322AFMP	—	±0.18	±0.90		
			S-8322AGMP	—	±0.17	±0.85		
			S-8322AIMP	—	±0.15	±0.75		
			S-8322AJMP	—	±0.13	±0.65		
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measure waveform at EXT pin		90	100	110	KHz	4
Duty ratio 1	Duty1	V_{OUT}=output voltage×0.95 Measure waveform at EXT pin		70	75	80	%	
Duty ratio 2	Duty2			—	50	—		—
Shutdown pin input voltage	V_{SH}	V_{OUT}=output voltage×0.95 Judge the oscillation at EXT pin		0.75	—	—	V	4
	V_{SL1}	V_{OUT}=output voltage×0.95 Judge the stop at EXT pin	When V_{OUT}≥1.5V	—	—	0.3		
	V_{SL2}		When V_{OUT}<1.5V	—	—	0.2		
Efficiency	EFFI		S-8322AAMP	—	85	—	%	3
			S-8322AFMP	—	80	—		
			S-8322AGMP	—	80	—		
			S-8322AIMP	—	80	—		
			S-8322AJMP	—	70	—		

External parts used:

- Coil CD54 (100µH) of Sumida Electric Co., Ltd.
- Diode MA720 (schottky type) of Matsushita Electronic Components Co., Ltd.
- Capacitor F93 (16 V, 47 µF, tantalum type) of Nichicon Corporation
- Transistor: 2SD1628G, SANYO
- Base resistance (Rb): 300Ω

V_{IN}=output voltage ×0.6 applied, I_{OUT}=output voltage / 100Ω

Note: Output voltage specified above is the typical value of the output voltage.

Operation start voltage	V_{ST1}	I_{OUT}=1mA		—	—	0.9	
Oscillation start voltage	V_{ST2}	No external parts, voltage applied to V_{OUT}		—	—	0.8	
Current consumption 1	I_{SS1}	V_{OUT}=output voltage×0.95	S-8322BAMP	—	31	52.0	µA
			S-8322BIMP	—	17	28.9	
Current consumption 2	I_{SS2}	V_{OUT}=output voltage+0.5	S-8322BAMP	—	2.6	4.4	
			S-8322BIMP	—	2.3	3.8	
EXT pin output current	I_{EXTH}	EVEXT=V_{OUT}-0.4V	S-8322BAMP	-5.3	-8.0	—	mA
			S-8322BIMP	-3.5	-5.3	—	
	I_{EXTL}	EVEXT=0.4V	S-8322BAMP	10.7	16.0	—	
			S-8322BIMP	7.0	10.5	—	
Line regulation	ΔV_{OUT1}	V_{IN}=output voltage×0.4 to ×0.6		—	30	60	mV
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-8322BAMP	—	±0.25	±1.25	mV/°C
			S-8322BIMP	—	±0.15	±0.75	
Oscillation frequency	fosc	V_{OUT}=output voltage×0.95 Measure waveform at EXT pin		90	100	110	KHz
Duty ratio 1	Duty1	V_{OUT}=output voltage×0.95 Measure waveform at EXT pin		70	75	80	%
Duty ratio 2	Duty2			—	50	—	
Efficiency	EFFI		S-8322BAMP	—	85	—	%
			S-8322BIMP	—	80	—	

External parts used:

- Coil CD54 (100µH) of Sumida Electric Co., Ltd.
- Diode MA720 (schottky type) of Matsushita Electronic Components Co., Ltd.
- Capacitor F93 (16 V, 47 µF, tantalum type) of Nichicon Corporation
- Transistor: 2SD1628G, SANYO
- Base resistance (Rb): 300Ω

V_{IN}=output voltage ×0.6 applied, I_{OUT}=output voltage / 100Ω

Note: Output voltage specified above is the typical value of the output voltage.

■ Test Circuits

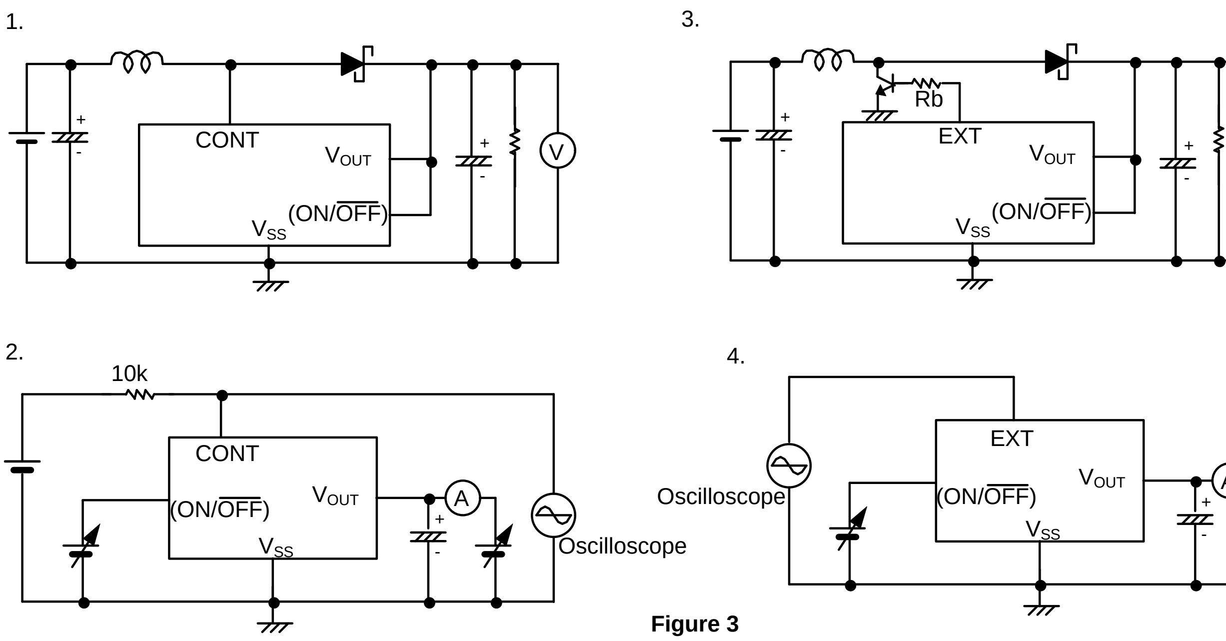


Figure 3

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-8321/8322 Series ensures load drive capacity in the region of large output load current by making duty ratio 75%, whereas in the region of small output load current the S-8321/8322 Series lowers the load drive capacity by automatically switching the duty ratio to 50% (It may range from 50% to less than 75% depending upon coil and load conditions.) and thereby reduces pulse skip. This controls drop in ripple frequency and limits the increase in ripple voltage.

Figure 4 and Figure 5 show ripple voltage vs. output current characteristic. For example in the S-8321 AIMP, at V_{IN} = 2.0 V, a sudden change in ripple voltage around Iout = 40 mA is seen in Figure 4. This means that if the load switches from large current to small current, ripple voltage does not decrease in conventional fixed-duty type converter, whereas ripple voltage significantly decreases in duty ratio automatic switching type PFM type converter.

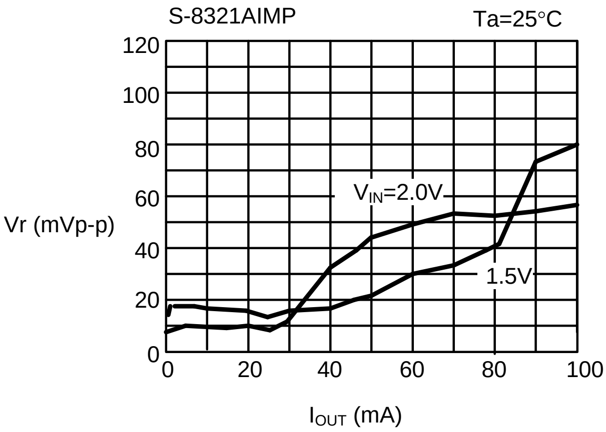


Figure4

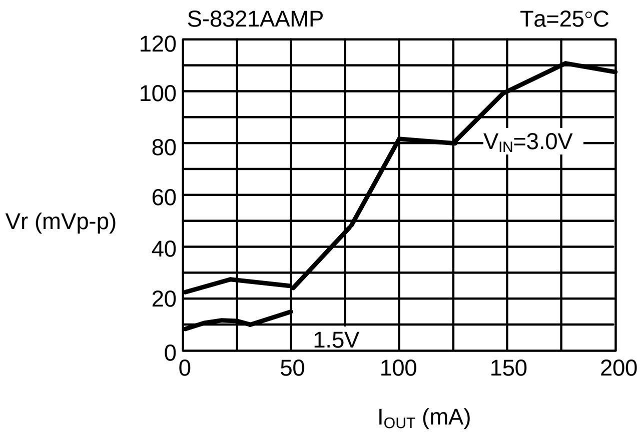


Figure5

Shutdown pin: Stops or starts step-up operation.

(A series only) 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 6 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 VOUT pin.

The shutdown pin doesn't have hysteresis.

Shutdown pin	CR oscillation circuit	Output voltage
"H"	Operation	Fixed
"L"	Stop	$\approx V_{IN}$*

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

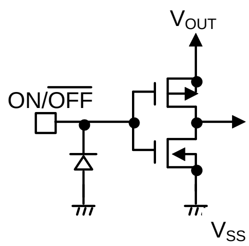


Figure 6

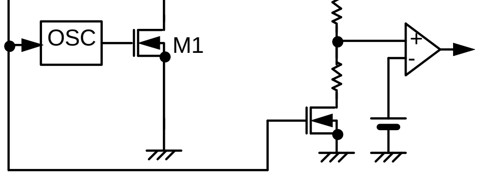


Figure 7

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

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:

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

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

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

The energy stored in L is represented with $\frac{1}{2}$ 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 re
voltage (V_L) is generat ed.

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

(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}:

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

Integration of the above equation is as follows:

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

Next, the ripple voltage is found out as follows:

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

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

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

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

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

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

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

Electric charge $\Delta Q1$ which is charged in C_{OUT} during t1:

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

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

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

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

A rise in voltage (V_{P-P}) due to $\Delta Q1$:

$$V_{P-P}=\frac{\Delta Q_1}{C_{OUT}}=\frac{1}{C_{OUT}}\left(\frac{I_{PK}+I_{OUT}}{2}\right)\cdot t1 \qquad (14)$$

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

$$V_{P-P}=\frac{\Delta Q}{C_{OUT}}=\frac{1}{C_{OUT}}\left(\frac{I_{PK}+I_{OUT}}{2}\right)t1+\left(\frac{I_{PK}+I_{OUT}}{2}\right)\cdot R_{ESR}-\frac{I_{OUT}\cdot t_1}{C_{OUT}} \qquad (15)$$

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

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

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.

To make the average value of the output voltage (V_{OUT}) constant, it is necessary to supply the energy corresponding output current (I_{OUT}) from the inductor. The amount of charge required for I_{OUT} is $I_{OUT} \times (t_{ON}+t_{OFF})$. Because the induct supply the energy only during t_{OFF}, the charge is obtained by integrating equation (7) with $0 \rightarrow t_{OFF}$, namely,

$$\frac{I_{PK}}{2} \cdot t_{OFF}$$ Thus,

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

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

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

The S-8321 Series includes a switching current control circuit which monitors the current flowing into the CONT pin b voltage (CONT control voltage) and controls the current. This circuit prevents the IC destruction due to excess curren

If an inductor with a large value of L is selected, both I_{PK} and I_{OUT} decrease. Since the energy stored in the indu equal to ½ L · $(I_{PK})^2$, the energy decreases because I_{PK} decreases in steps of squares offsetting the increase of L. result, stepping up at low voltage becomes difficult and the minimum operating input voltage becomes high. Howeve resistance loss in L and the M1 transistor becomes small because of decreased I_{PK}, and inductance efficiency improv

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

[CAUTION] An excessively large I_{PK} may cause magnetic saturation for some core materials, leading to the destruc the IC. Use a core of material satisfies $I_{sat}>I_{PK}$ (I_{sat}: level of current that causes magnetic saturation).

2. Diode

Use an external diode that meets the following requirements:

- Low forward voltage ($V_F<0.3V$)
- High switching speed (500 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 current. Select a C_{IN} value according to the impedance of the power supply used. The capacitor value should be arou µF.

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

A circuit example using a bipolar transistor (NPN), Sanyo 2SD1628G is shown in Figure 11. The Rb value determines the driving capacity to increase the output current using a bipolar transistor. A peripheral circuit example of the transistor is shown in Figure 8 to determine the Rb value.

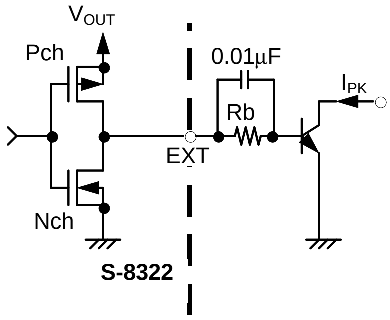


Figure 8 External transistor peripheral circuit

Stepping up capacity characteristics does not show much difference with the Rb value between 100 and 750 Ω, but 300 Ω is recommended. 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 8 decreases the switching loss and improves the efficiency.

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. In particular the EXT pin of the S-8322 can drive a MOS FET with a gate capacity of around 1000 pF. Because the gate voltage and current of the external power MOS FET are supplied from the stepped out output voltage V_{OUT}, the MOS FET is driven more effectively.

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 2.5 V the same as in the S-8322AJMP, the circuit operates only when the MOS FET has the threshold voltage lower than 2.5 V.

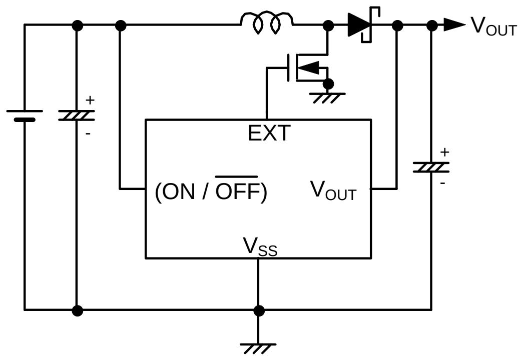


Figure 9 Circuit example using 2SK1959

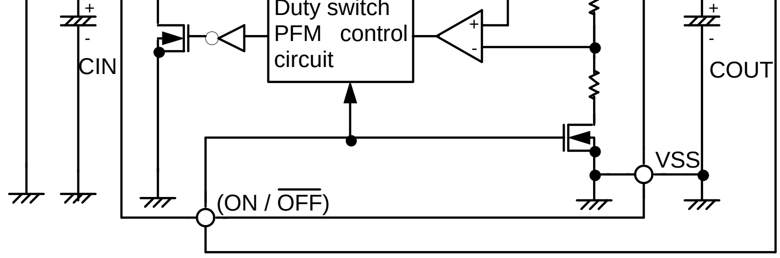


Figure 10

(2) 8322 Series

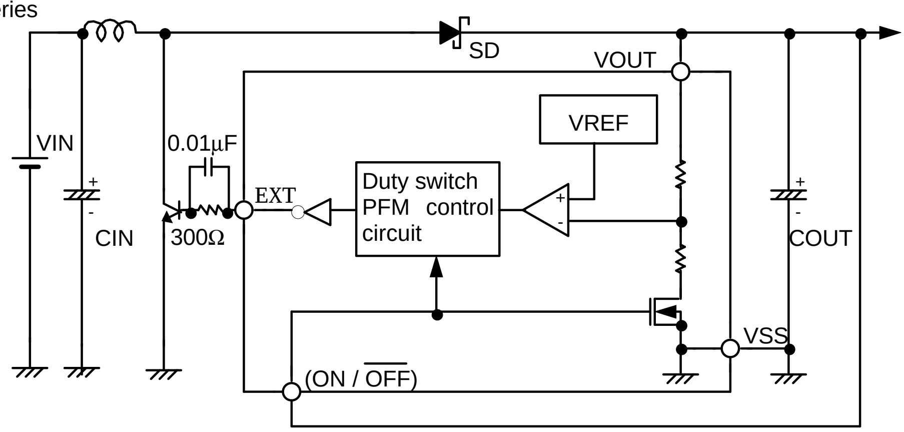


Figure 11

■ 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 ar capacitor used, check them using an actually mounted model.
- Seiko Instruments shall not be responsible for any patent infringement by products including S-8321/8322 Se connection with the method of using S-8321/8322 Series in such products, the specification of such products, country of destination thereof.
- Make sure dissipation of the switching transistor (especially at a high temperatures) does not exceed the allo power dissipation of the package.

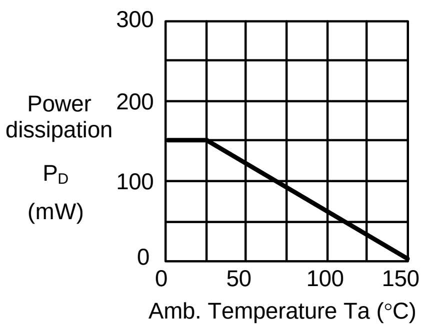
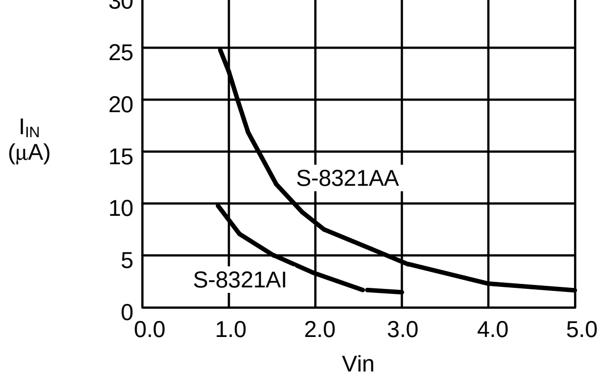


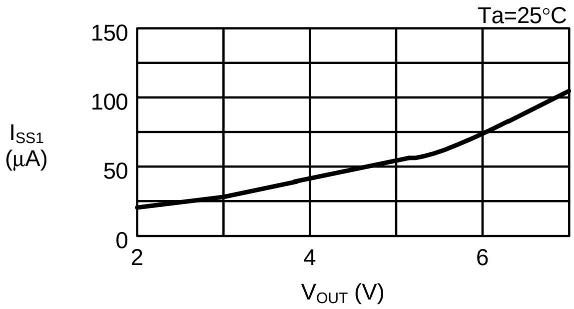
Figure 12 Power dissipation of the package (before mounting)

- When the impedance of the power supply is high, the shutdown pin is turned from "L" to "H" or VIN is connected power supply, note that the power supply voltage drops temporarily because the rush current flows into the supply.

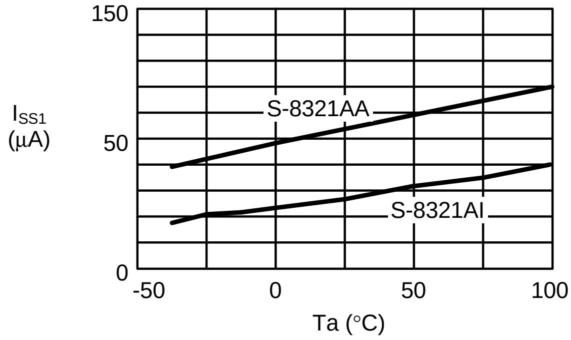


- I_{SS1} vs. V_{OUT}, Ta

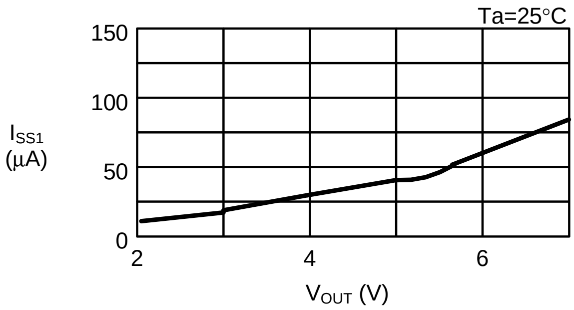
S-8321A



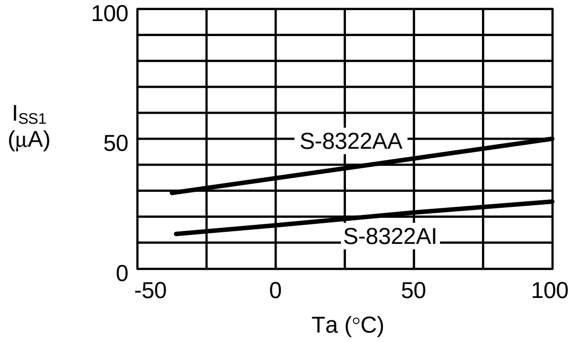
S-8321A



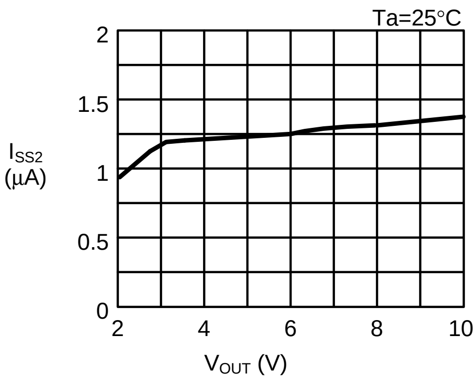
S-8322A

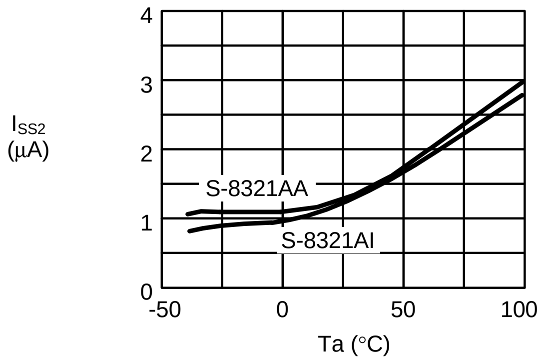


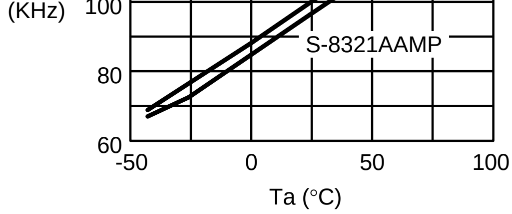
S-8322A

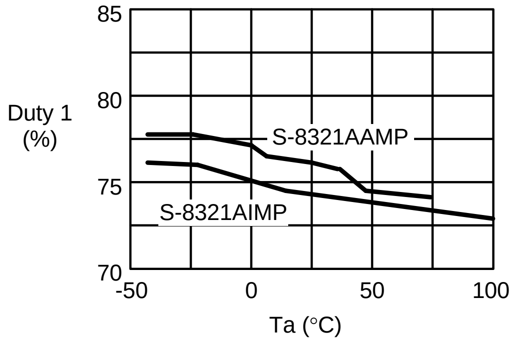


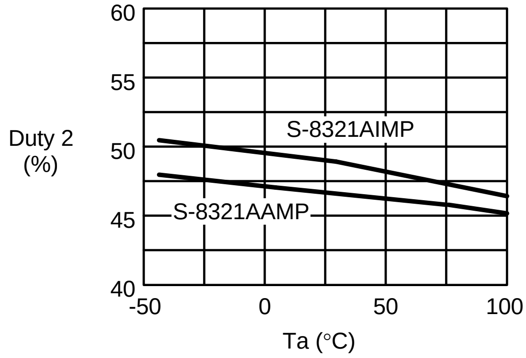
- I_{SS2} vs. V_{OUT}, Ta





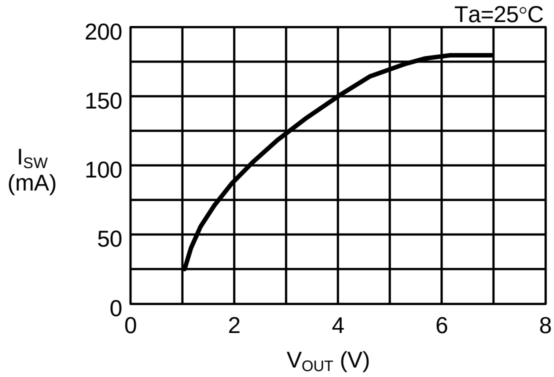


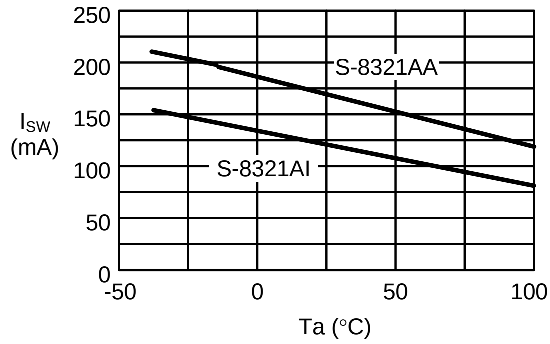




3. Switching current - Output voltage

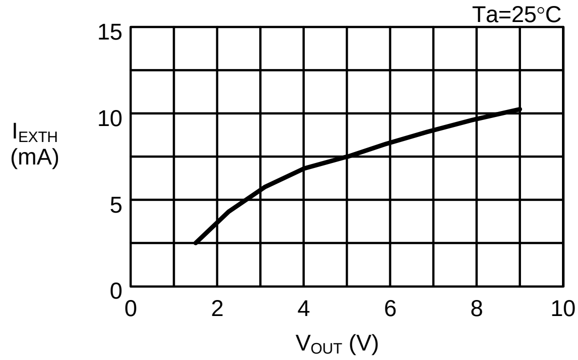
- I_{SW} vs.V_{OUT}

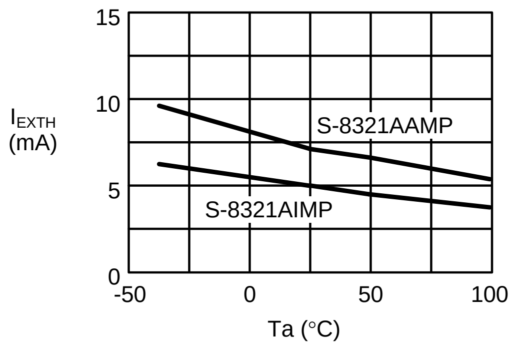


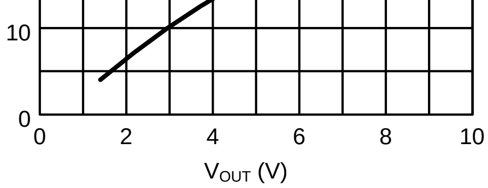


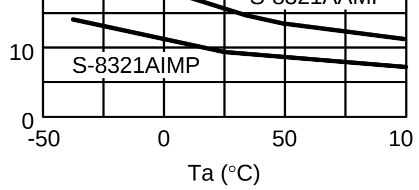
4. EXT pin output current - Output voltage

- I_{EXTH} vs.V_{OUT}, Ta



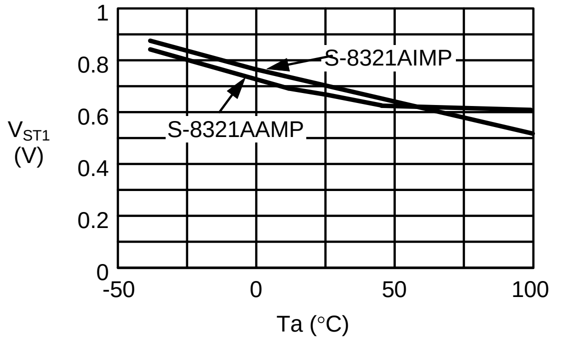




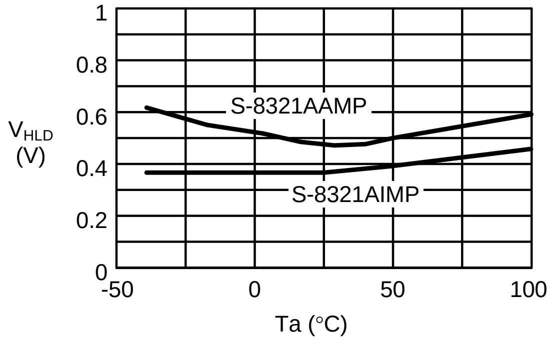


5. Operation start voltage, retention voltage - Temperature

- V_{ST1} vs. Ta



- V_{HLD} vs. Ta



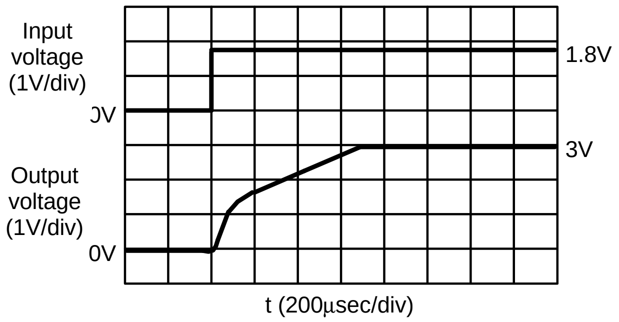
■ Reference Data (1)

1. Transit response characteristics

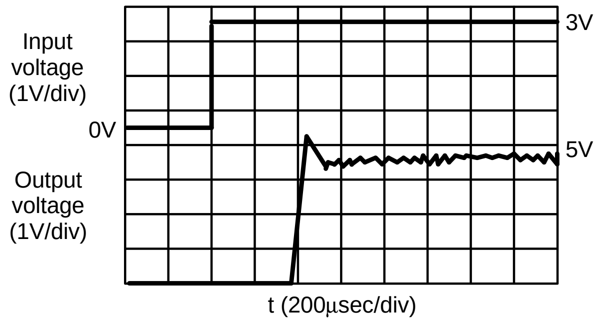
The conditions for the external parts are the same as specified in electrical characteristics.

1.1 Powering on (Ta=25°C)

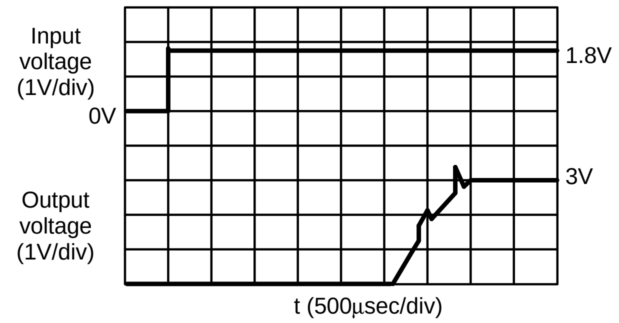
S-8321AI V_{IN}=0 1.8 V, R_L=250Ω



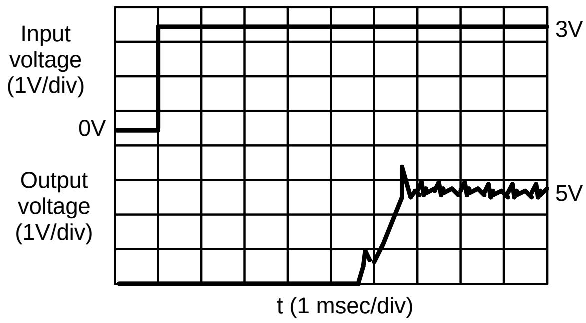
S-8321AA V_{IN}=0 3 V, R_L=250Ω

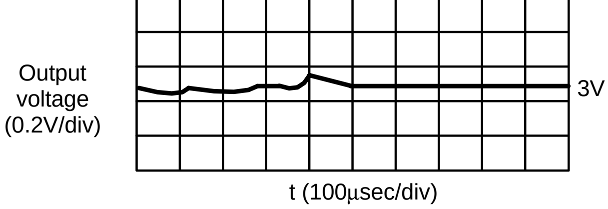


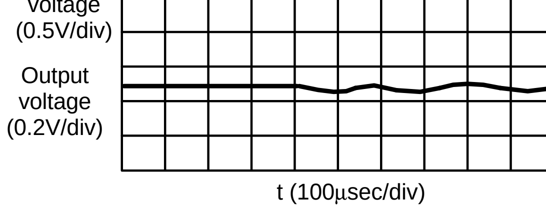
S-8322AI V_{IN}=0 1.8 V, R_L=250Ω



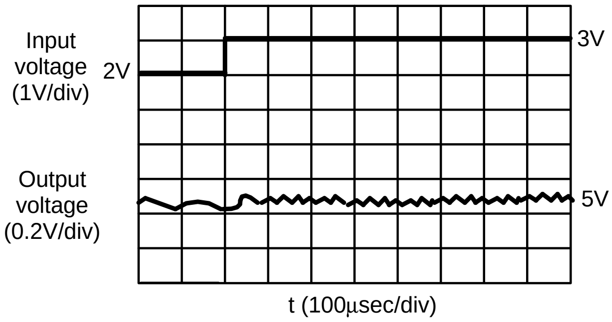
S-8322AA V_{IN}=0 3 V, R_L=250Ω



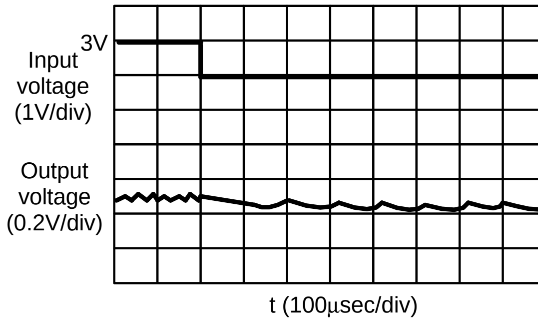




S-8321AA V_{IN}=2→3 V, R_L=250Ω



S-8321AA V_{IN}=3→2 V, R_L=250Ω



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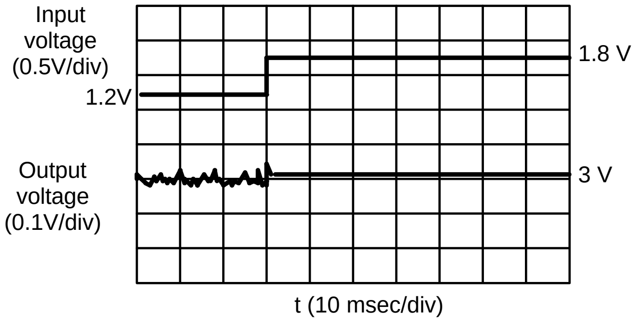

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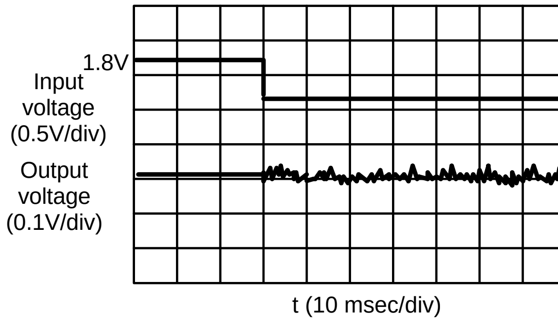
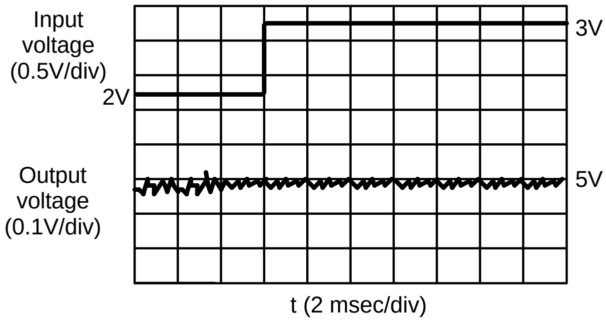
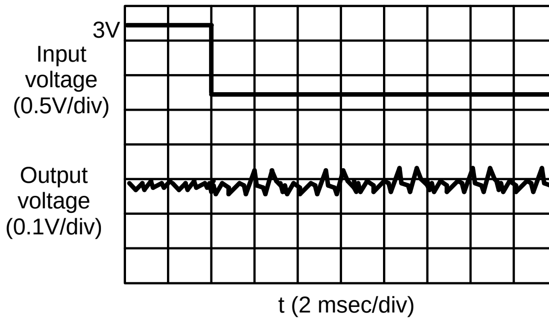
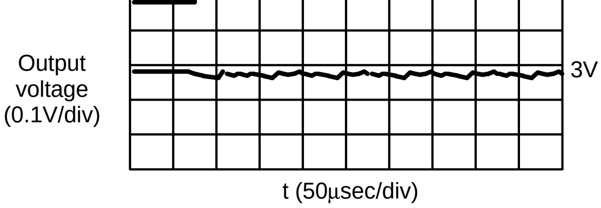


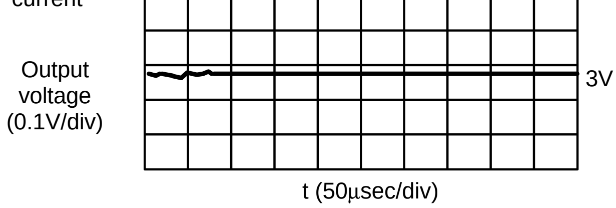
S-8322AA V_{IN}=2→3 V, R_L=250Ω



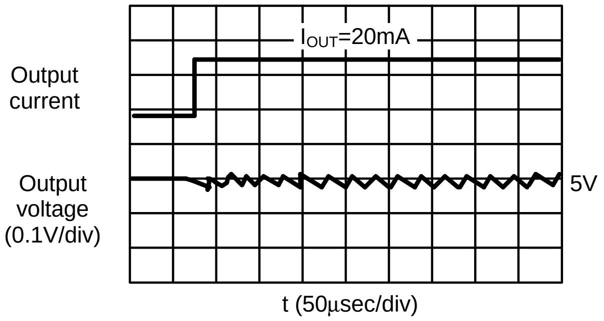
S-8322AA V_{IN}=3→2 V, R_L=250Ω



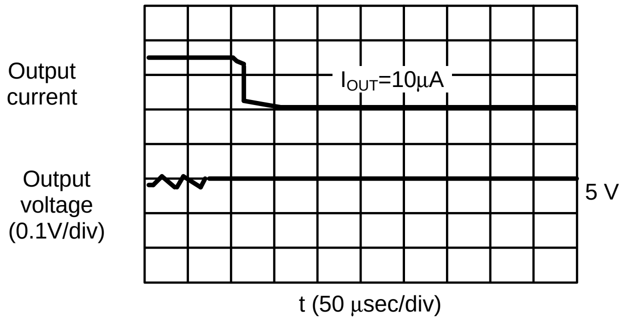




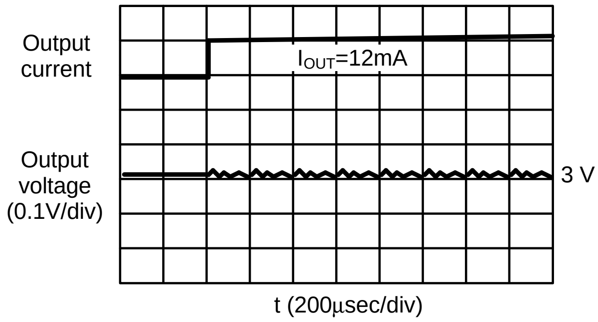
S-8321AA V_{IN}=3 V, I_{OUT}=10µA→20mA



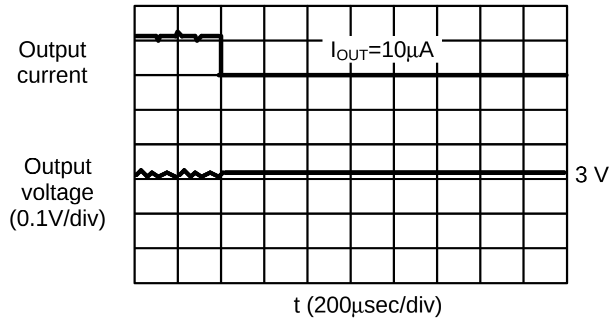
S-8321AA V_{IN}=3 V, I_{OUT}=20mA→10µA



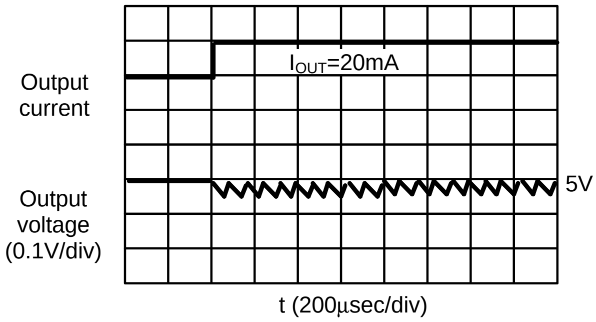
S-8322AI V_{IN}=1.8 V, I_{OUT}=10µA→12mA



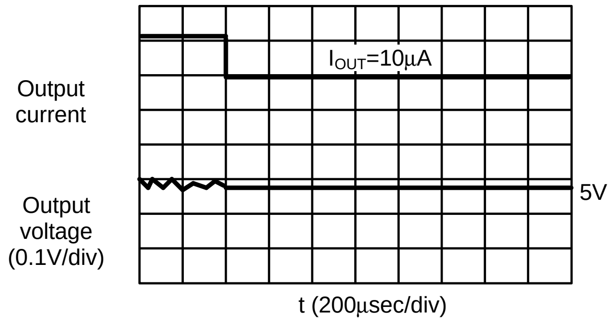
S-8322AI V_{IN}=1.8 V, I_{OUT}=12mA→10µA

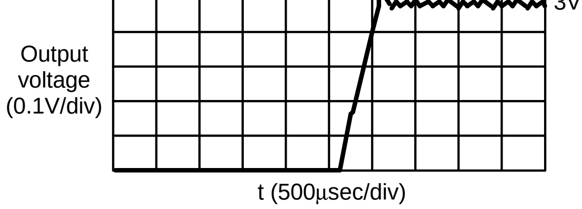


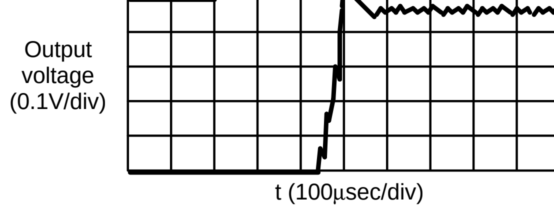
S-8322AA V_{IN}=3 V, I_{OUT}=10µA→20mA



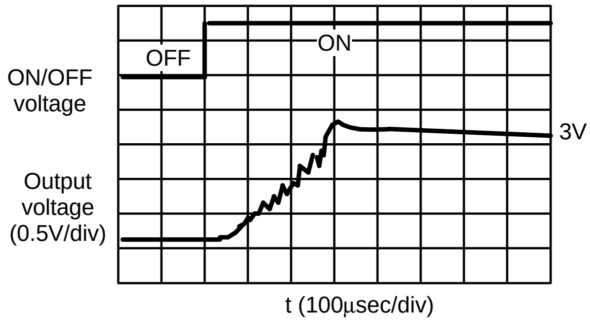
S-8322AA V_{IN}=3 V, I_{OUT}=20mA→10µA



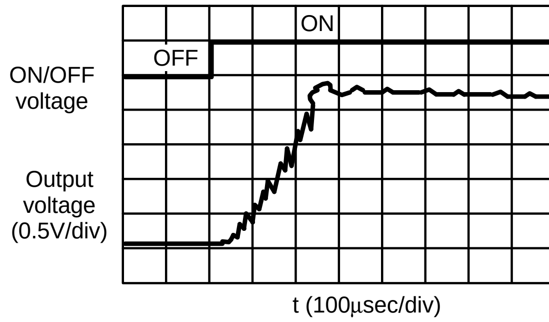




S-8322AI V_{IN}=1.8 V, R_L=250Ω



S-8322AA V_{IN}=3 V, R_L=250Ω



■ Reference Data (2)

The following are step-up characteristics when the coils shown in the following list are used

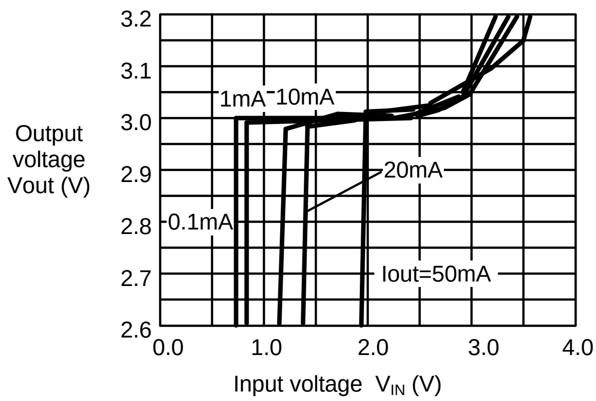
Evaluated coils:

Model	Manufacturer	Value	Max. DC resistance	Allowable current
CD54	Sumida Electric	22µH	0.18Ω	1110 mA
CD54	Sumida Electric	47µH	0.37Ω	720 mA
CD54	Sumida Electric	100µH	0.7Ω	520 mA
CD54	Sumida Electric	220µH	1.57Ω	350 mA
CP4LBM	Sumida Electric	100µH	6.4Ω	130 mA

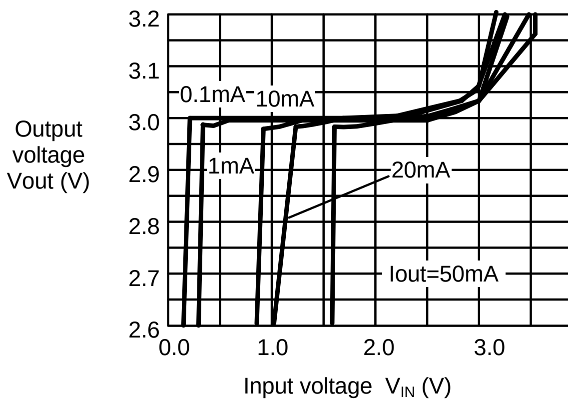
[I] S-8321AI (Built-in, V_{OUT}=3V)

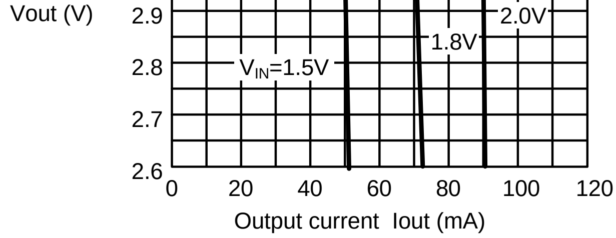
1.1 CD54 (47µH), Ta=25°C

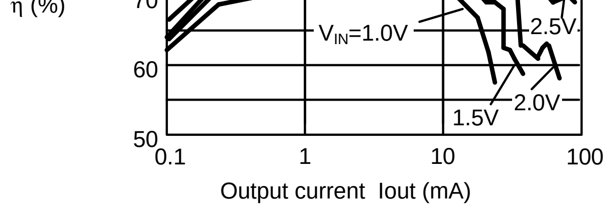
(a) Input voltage - Output voltage (rise in input voltage)



(b) Input voltage-Output voltage (fall in input voltage

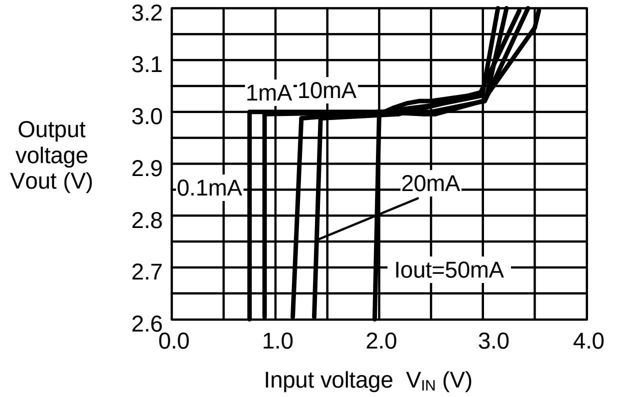




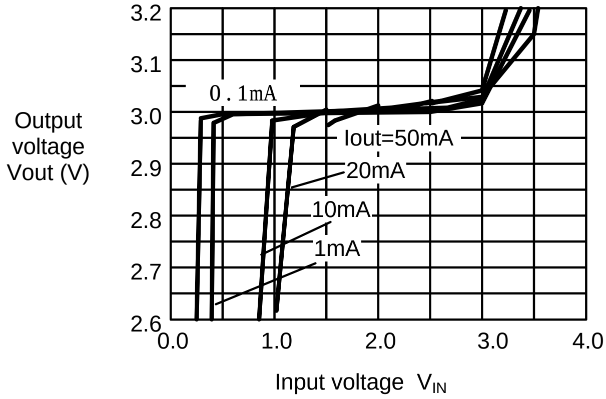


1.2 CD54 (100µH), Ta=25°C

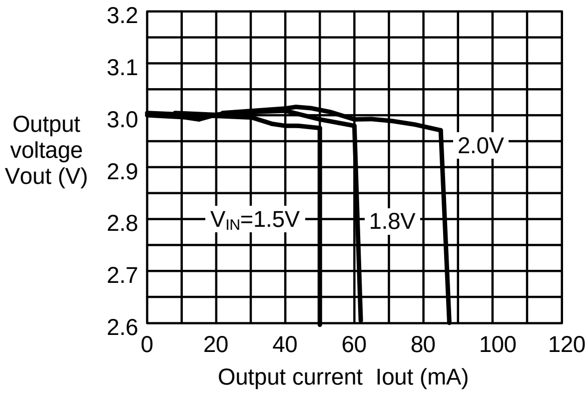
(a) Input voltage - Output voltage (rise in input voltage)



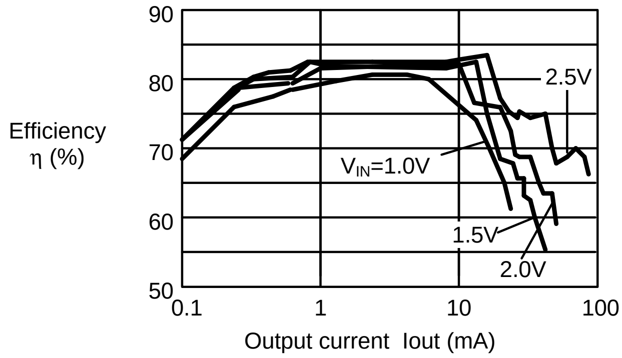
(b) Input voltage-Output voltage (fall in input voltage)



(c) Output current - Output voltage characteristics

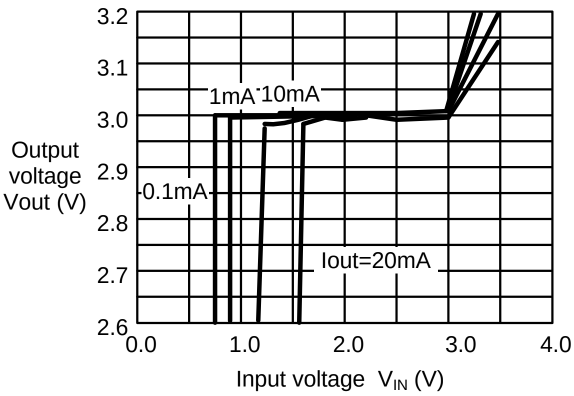


(d) Efficiency - Output current characteristics

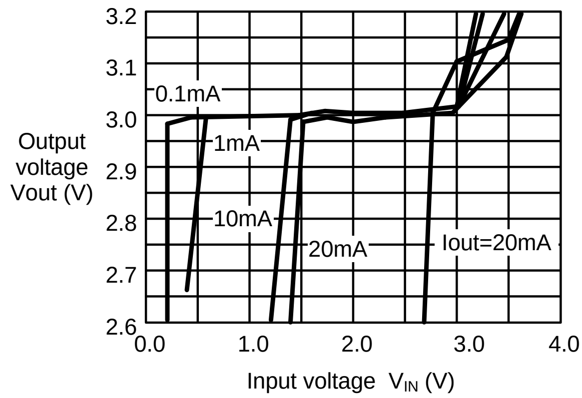


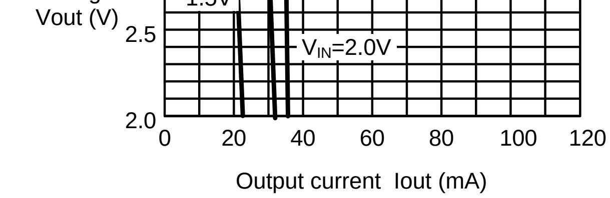
1.3 CP4LBM (100µH), Ta=25°C

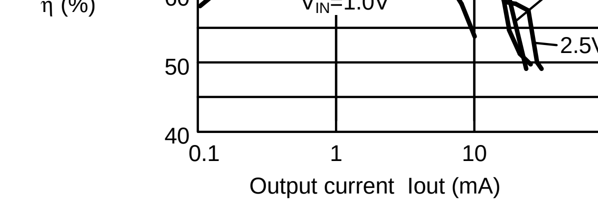
(a) Input voltage - Output voltage (rise in input voltage)



(b) Input voltage-Output voltage (fall in input voltage)



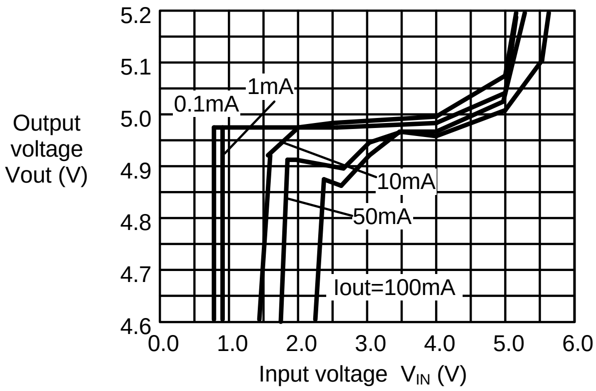




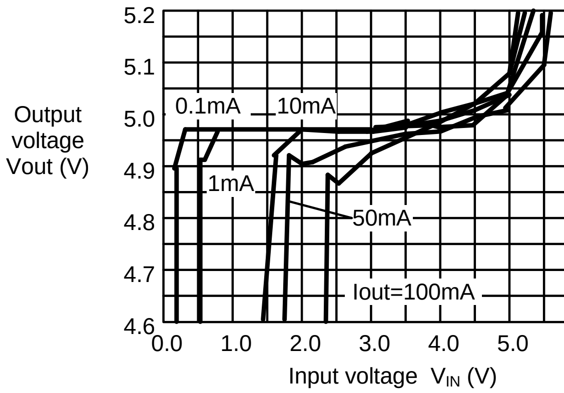
[II] S-8321AA (Built-in, V_{out}=5V)

1.1 CD54 (100µH), Ta=25°C

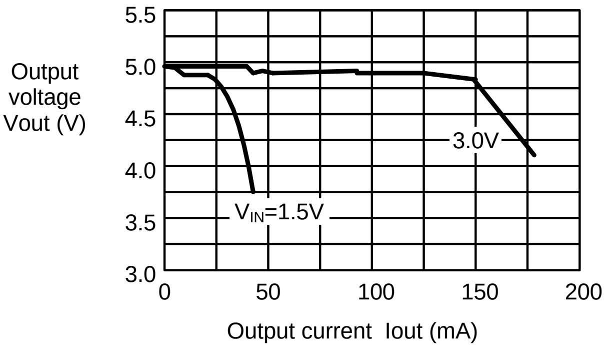
(a) Input voltage - Output voltage (rise in input voltage)



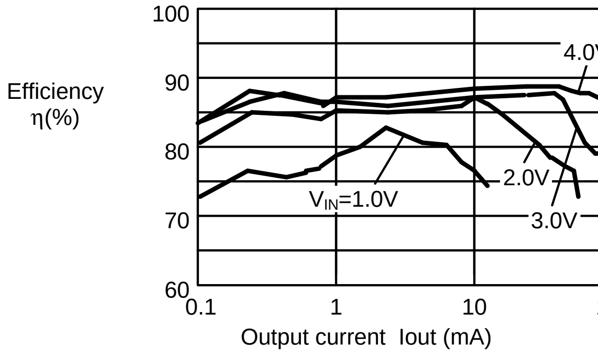
(b) Input voltage-Output voltage (fall in input voltage



(c) Output current - Output voltage characteristics

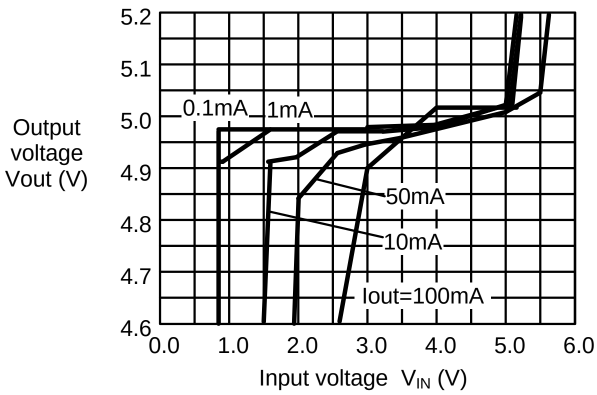


(d) Efficiency - Output current characteristics

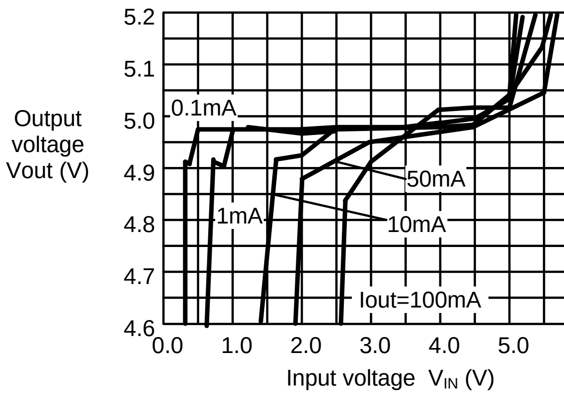


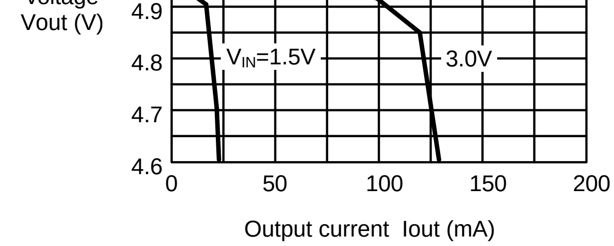
1.2 CD54 (220µH), Ta=25°C

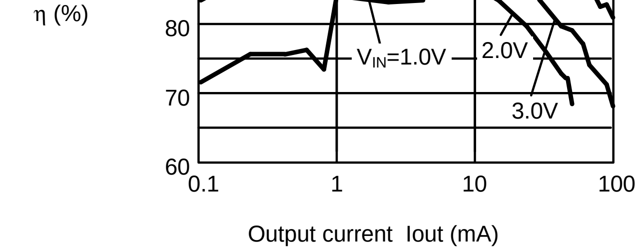
(a) Input voltage - Output voltage (rise in input voltage)



(b) Input voltage-Output voltage (fall in input voltage

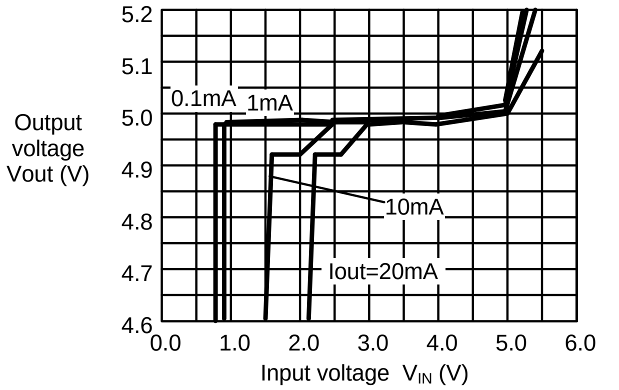




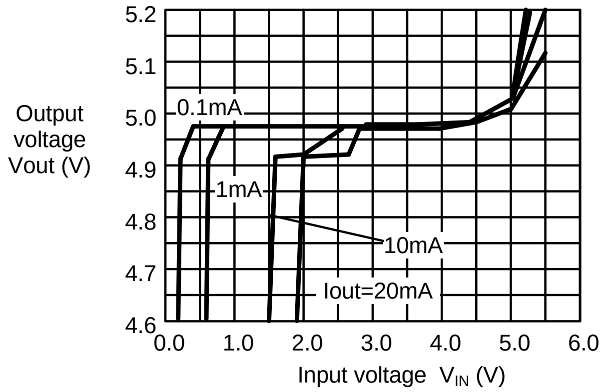


1.3 CP4LBM (100µH), Ta=25°C

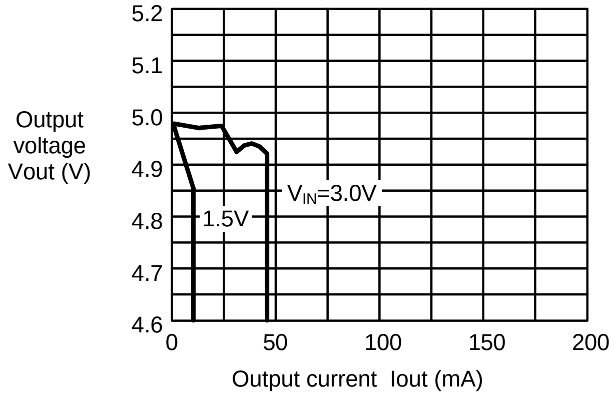
(a) Input voltage - Output voltage (rise in input voltage)



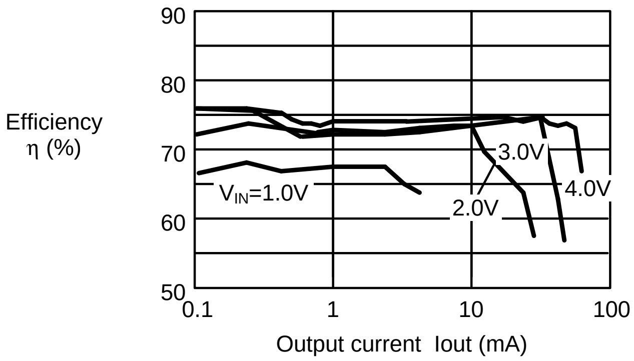
(b) Input voltage-Output voltage (fall in input voltage)

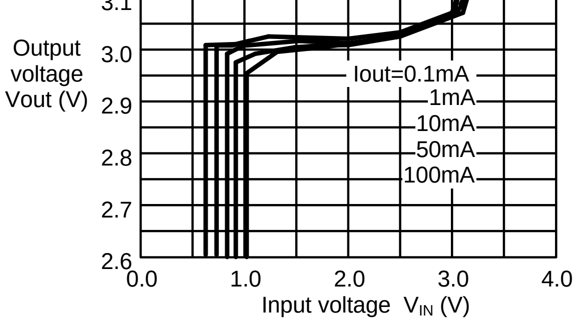


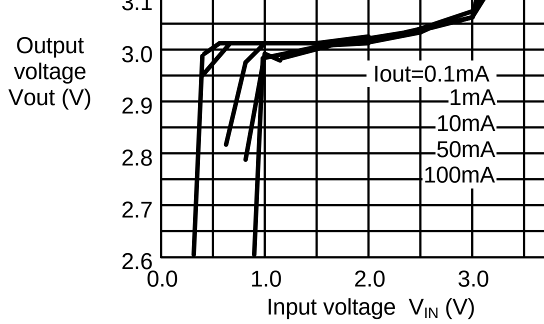
(c) Output current - Output voltage characteristics



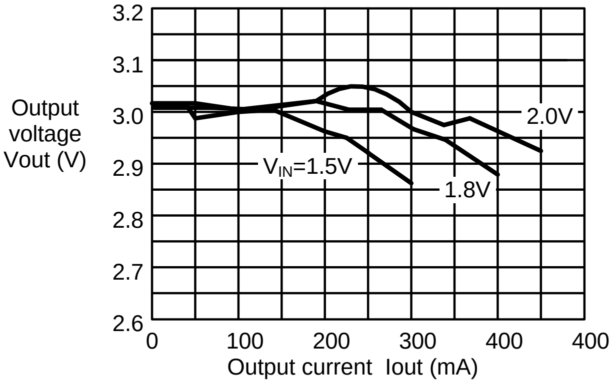
(d) Efficiency - Output current characteristics



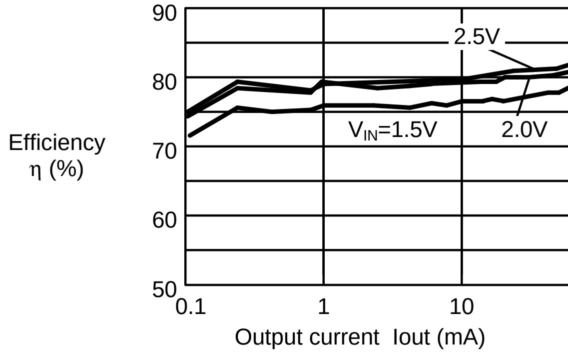




(c) Output current - Output voltage characteristics

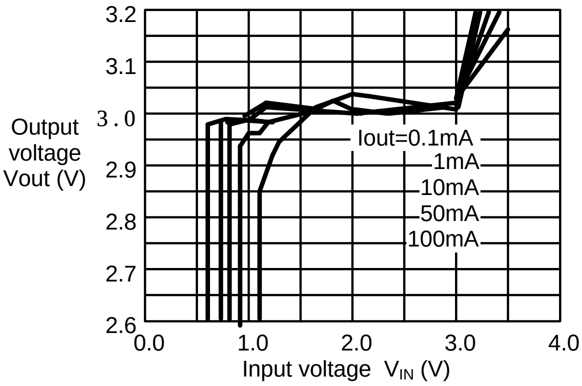


(d) Efficiency - Output voltage characteristics

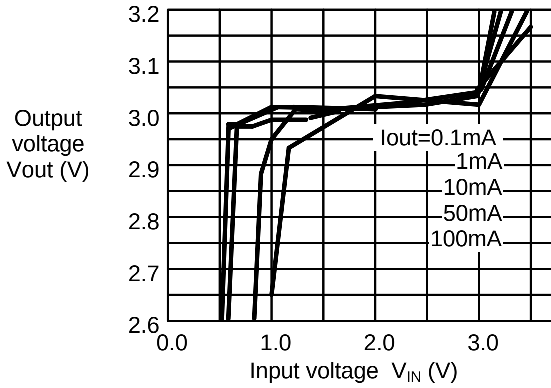


1.2 CD54 (100μH), Ta=25°C

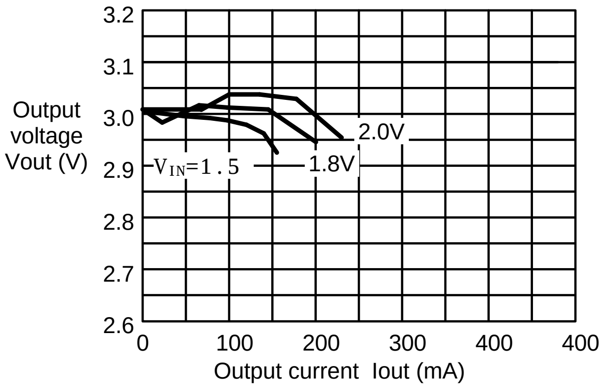
(a) Input voltage - Output voltage (rise in input voltage)



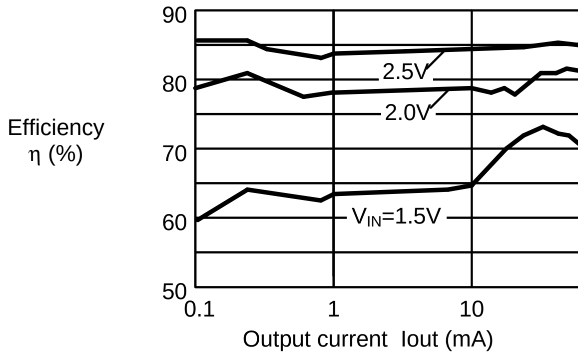
(b) Input voltage-Output voltage (fall in input voltage

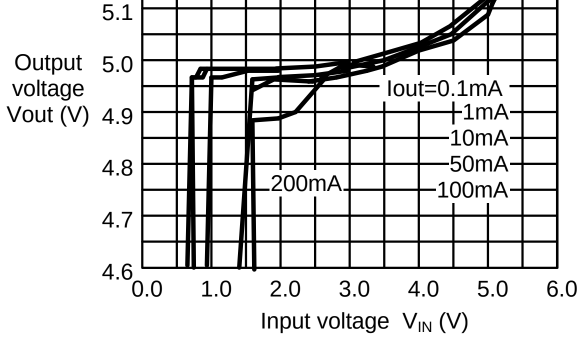


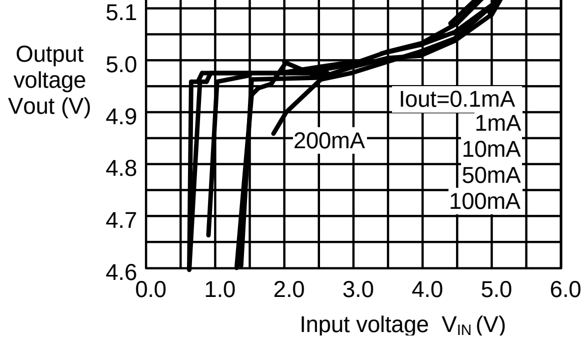
(c) Output current - Output voltage characteristics



(d) Efficiency - Output voltage characteristics

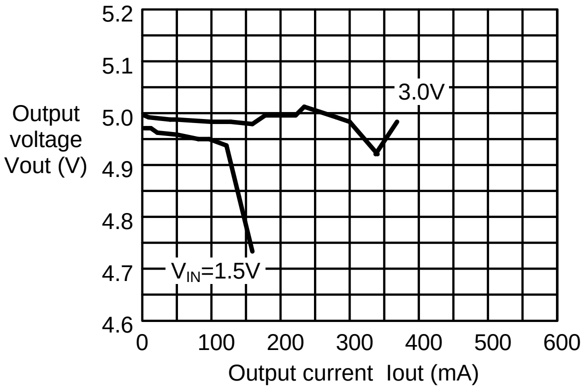


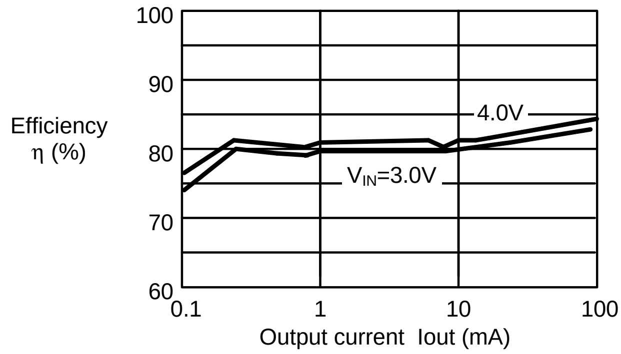




(c) Output current - Output voltage characteristics

(d) Efficiency - Output voltage characteristics

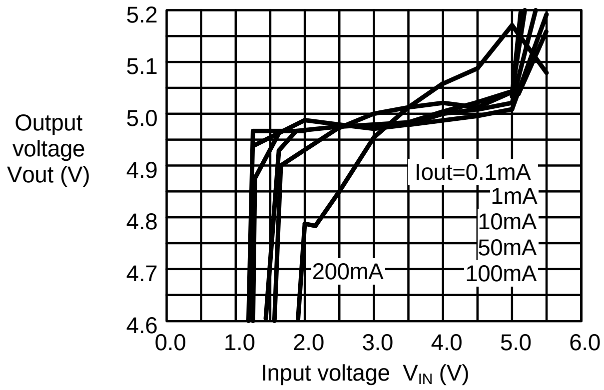


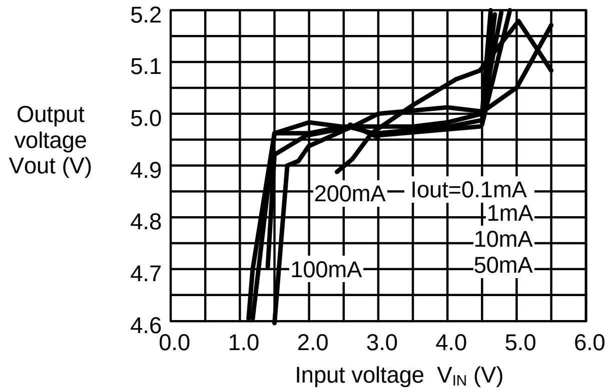


1.2 CD54 (100µH), Ta=25°C

(a) Input voltage - Output voltage (rise in input voltage)

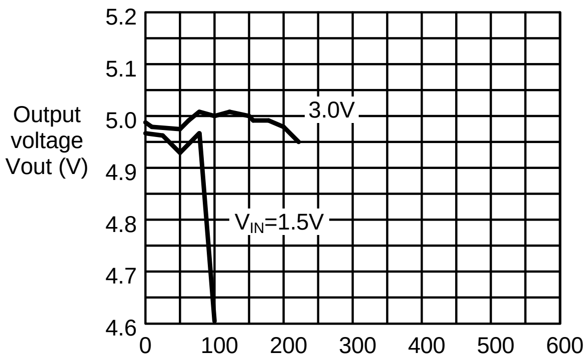
(b) Input voltage-Output voltage (fall in input voltage)

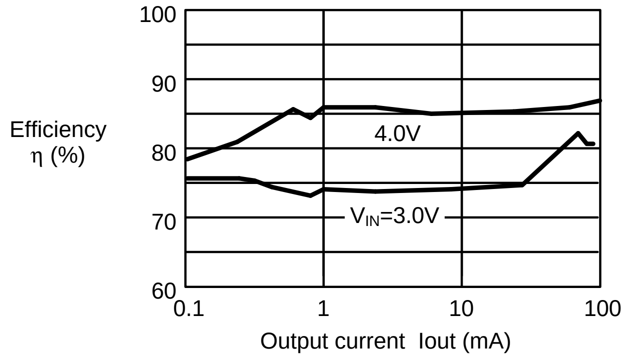




(c) Output current - Output voltage characteristics

(d) Efficiency - Output voltage characteristics



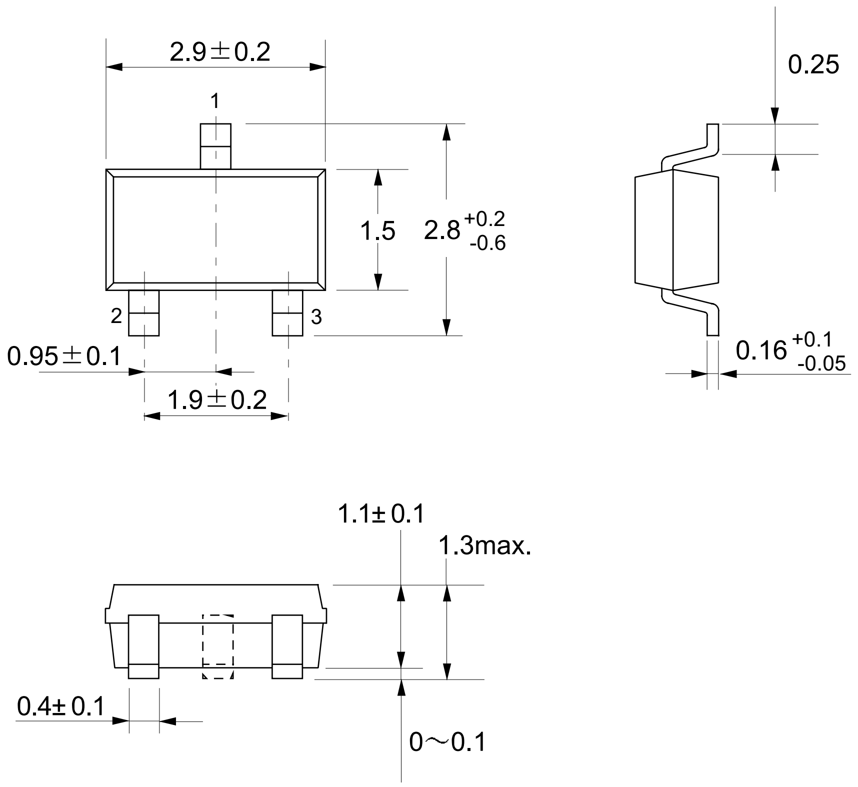


■ SOT-23-3

MP003-A　990531

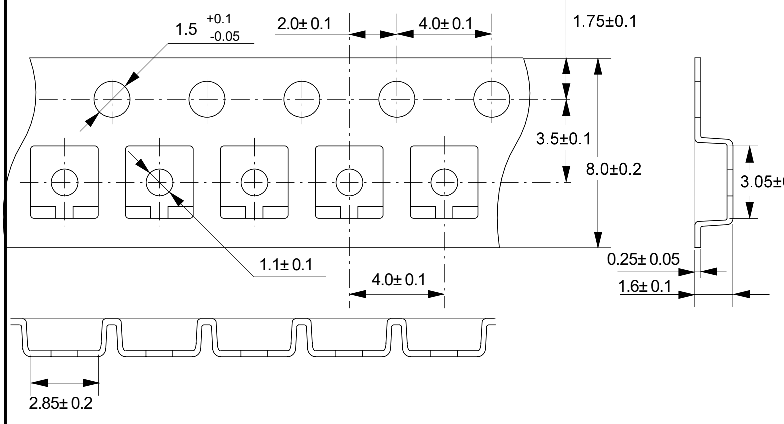
●Dimensions

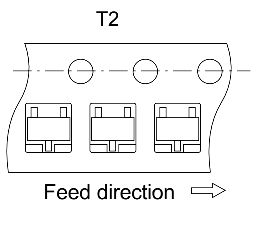
Unit:mm



No.：MP003－A－P－SD－1．0

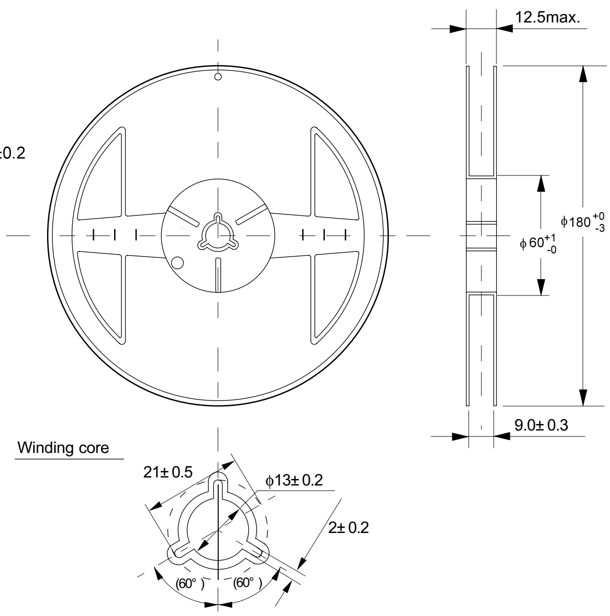
●Taping Specifications





●Reel Specifications

1 reel holds 3000 ICs.



003－A－C－SD－1．0

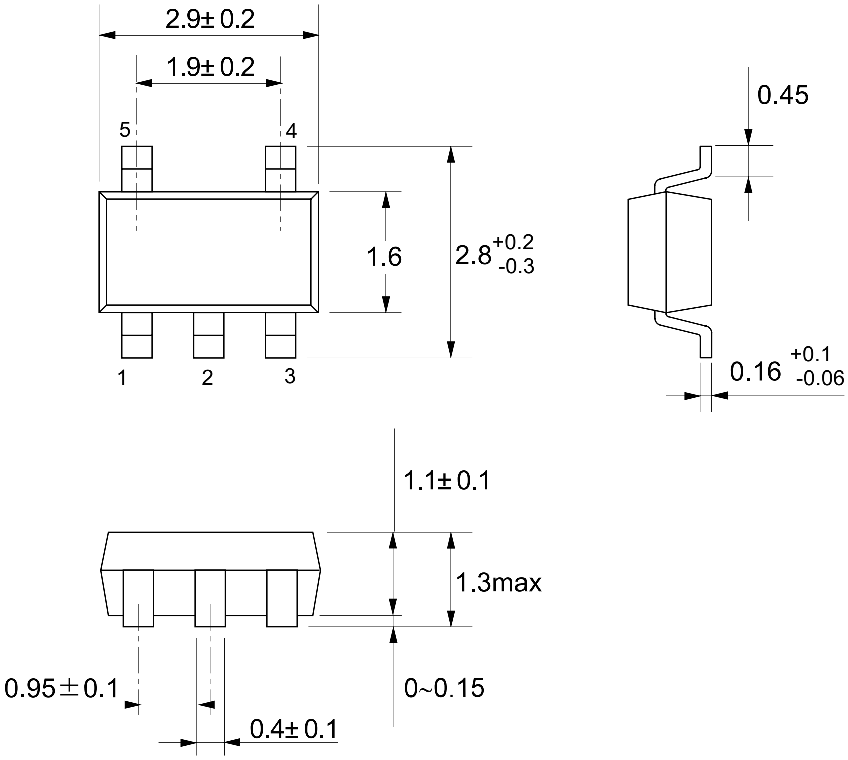
No.：MP003－A－R－SD－1．0

■ SOT-23-5

MP005-A　990531

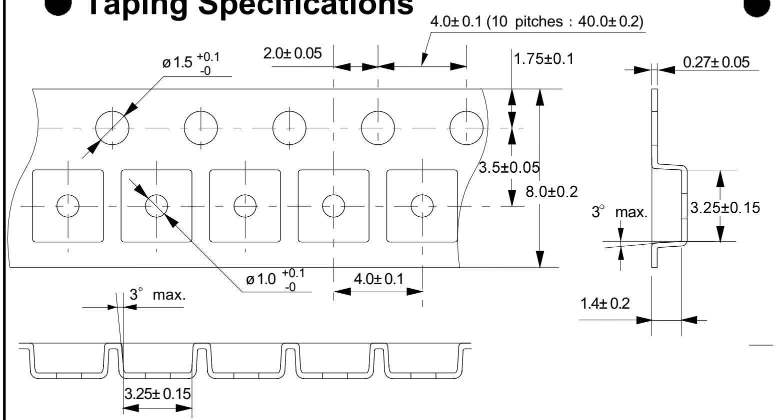
Unit : mm

● Dimensions

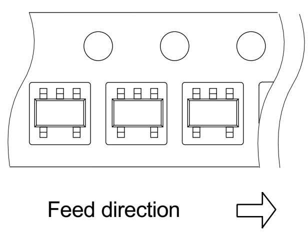


No. : MP005－A－P－SD－1. 0

● Taping Specifications



T 2

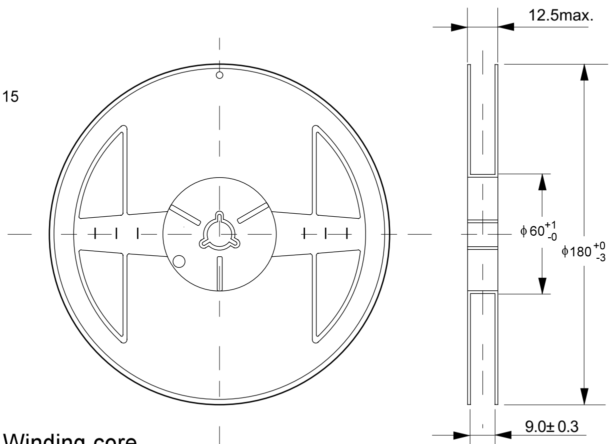


Feed direction

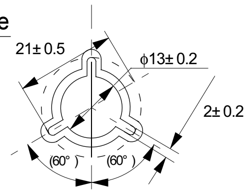
No. : MP005－A－C－SD－1. 0

● Reel Specifications

1 reel holds 3000 ICs.



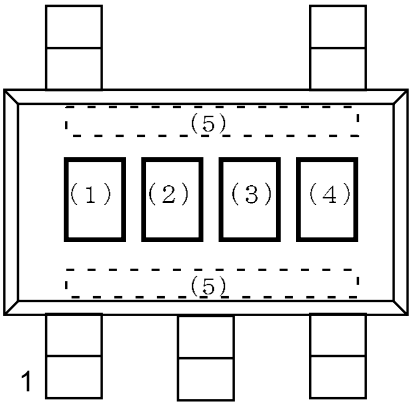
Winding core



No. : MP005－A－R－SD－1. 0

■Markings

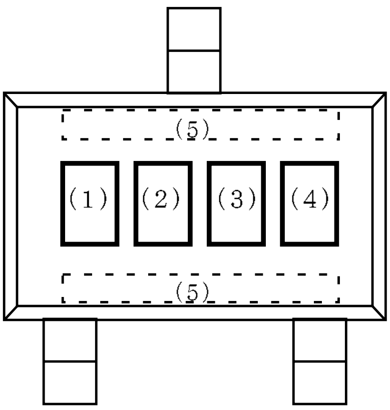
● SOT-23-5



(1) to (3)	:	Product name (abbreviation)
(4)	:	Month of assembly
(5)	:	Dot on one side (year and week of assembly)

No.：MP005－A－M－S1－1．0

● SOT-23-3



(1) to (3)	:	Product name (abbreviation)
(4)	:	Month of assembly
(5)	:	Dot on one side (year and week of assembly)

No.：MP003－A－M－S1－1．0