

# CMOS Switching Regulator (PWM controlled) Monolithic IC MM3005~MM3010

## Outline

This IC is a PWM controlled switching regulator developed using the CMOS process. Low ripple and high efficiency of 83% typ. (MM3005E) are achieved through PWM control. Further, output voltage is high precision output  $\pm 2.4\%$ .

## Features

1. Ultra low consumption current 17.2 $\mu$ A typ. (during operation) (MM3005E)
2. High efficiency 83% typ. (MM3005E)
3. High precision output voltage  $\pm 2.4\%$
4. Wide operating temperature range  $-30^{\circ}\text{C}\sim+85^{\circ}\text{C}$
5. Output voltage 2~5.5V (0.1V can be set in 0.1V steps)

## Package

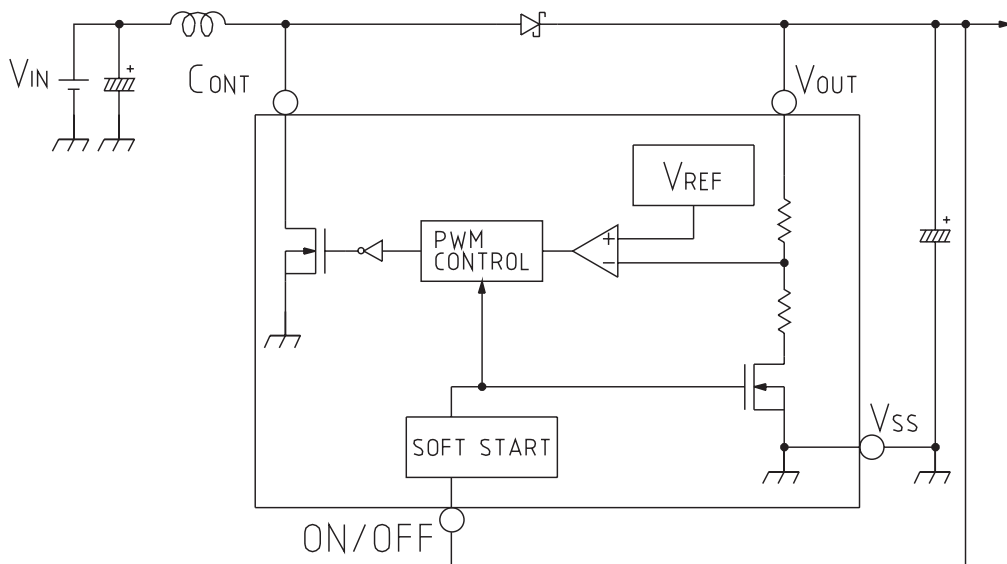
SOT-25A (Mini mold)

## Applications

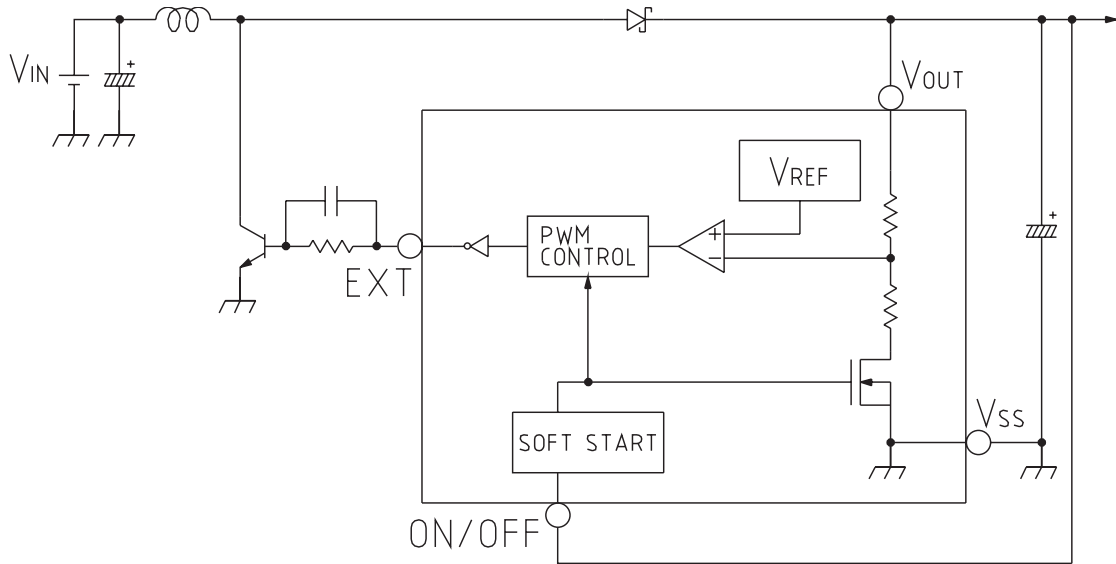
1. Mobile phones, PHS
2. Portable MD
3. Other battery-operated portable equipment

## Block Diagram

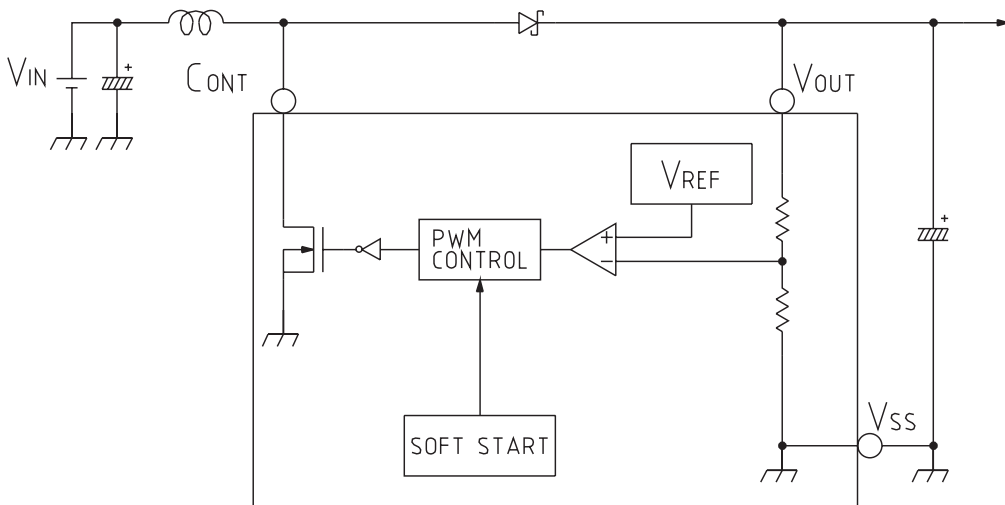
### ■ MM3005



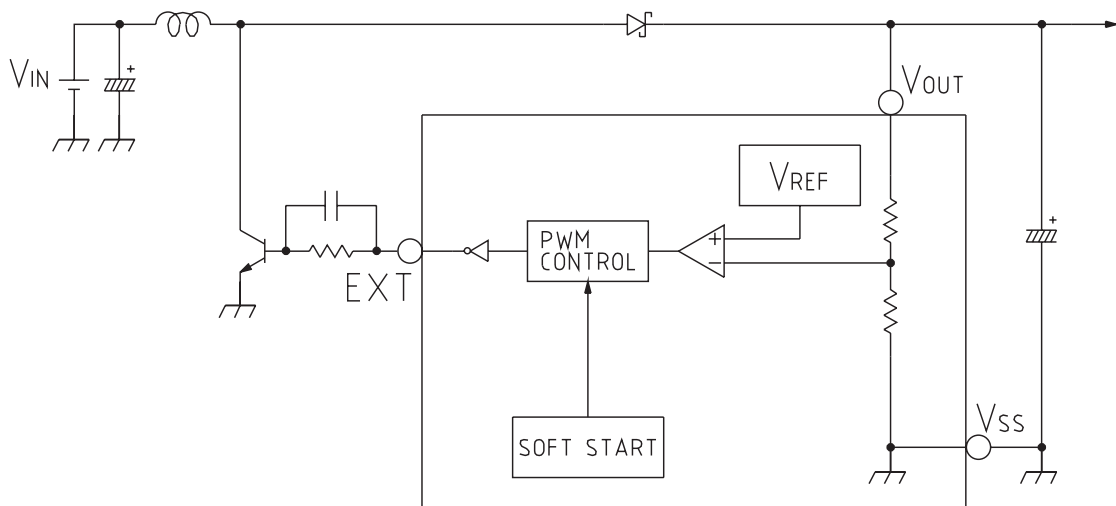
■ MM3006



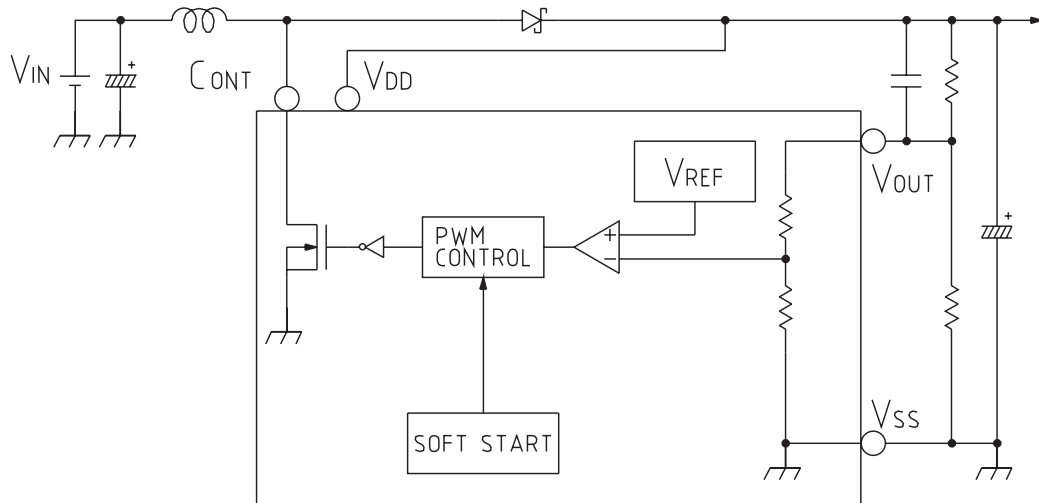
■ MM3007



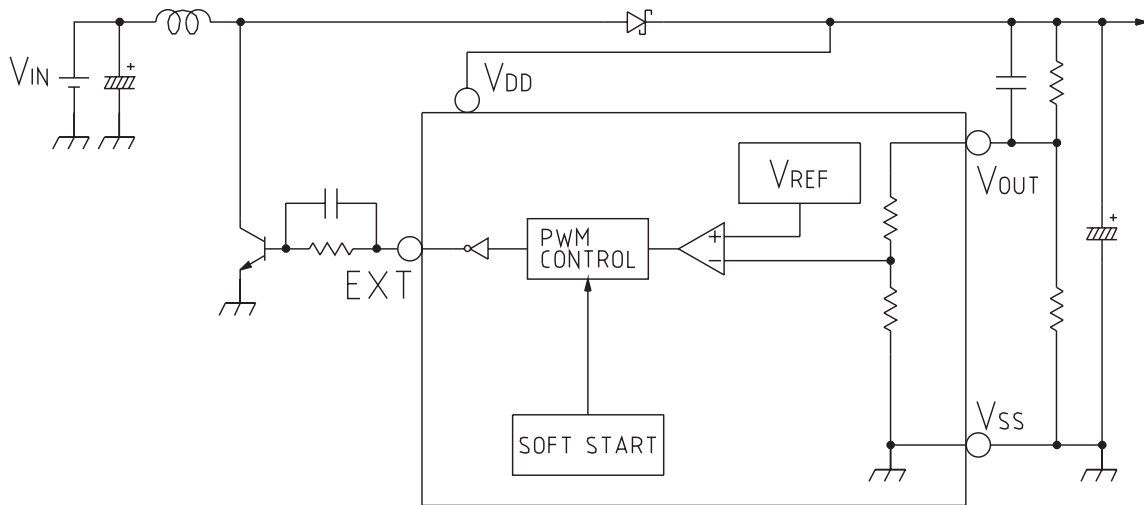
■ MM3008



■ MM3009

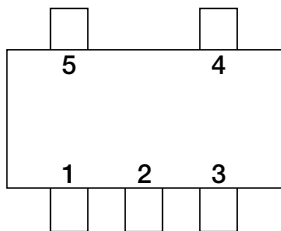


■ MM3010



Pin Assignment

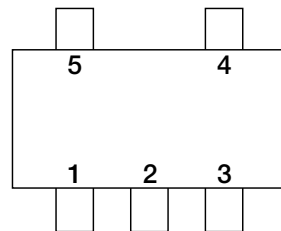
■ MM3005



SOT-25A  
(TOP VIEW)

1	ON/OFF
2	V <sub>OUT</sub>
3	NC
4	V <sub>SS</sub>
5	CONT

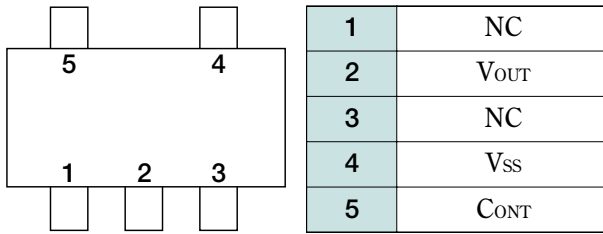
■ MM3006



SOT-25A  
(TOP VIEW)

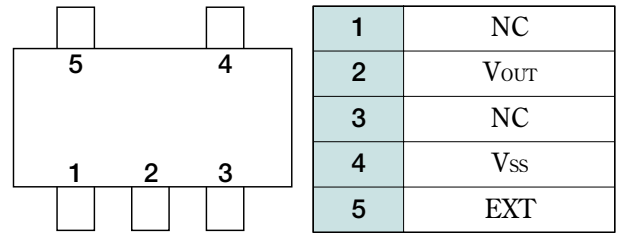
1	ON/OFF
2	V <sub>OUT</sub>
3	NC
4	V <sub>SS</sub>
5	EXT

■ MM3007



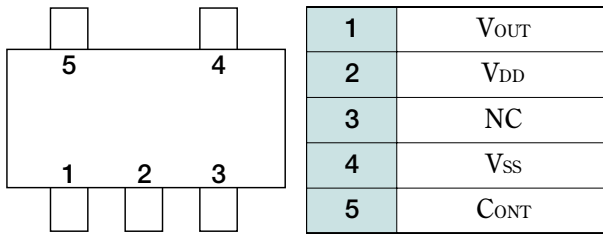
SOT-25A  
(TOP VIEW)

■ MM3008



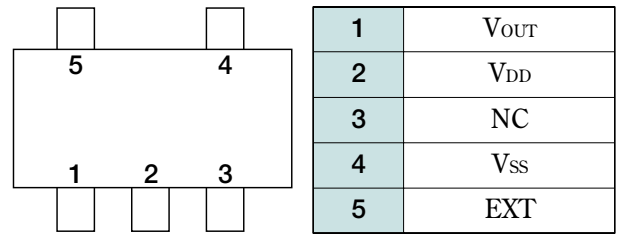
SOT-25A  
(TOP VIEW)

■ MM3009



SOT-25A  
(TOP VIEW)

■ MM3010



SOT-25A  
(TOP VIEW)

Absolute Maximum Ratings

Item	Symbol	Rating	Unit
Storage Temperature	T <sub>STG</sub>	-40~+125	°C
Operating Temperature	T <sub>OPR</sub>	-30~+85	°C
Power Supply Voltage	V <sub>DDmax.</sub>	-0.3~+11	V
Allowable loss	P <sub>d</sub>	150	mW
V <sub>OUT</sub> pin voltage	V <sub>OUT</sub>	-0.3~+11	V
ON/OFF pin voltage	ON/OFF	-0.3~+11	V
CONT pin voltage	V <sub>CONT</sub>	-0.3~+11	V
CONT pin current	I <sub>CONT</sub>	300	mA

Recommended Operating Conditions

Item	Symbol	Rating	Unit
Operating Temperature	T <sub>OPR</sub>	-30~+85	°C
Input voltage	V <sub>IN</sub>	+0.9~+9	V

Rank expand table Ta=25°C

MM3005A	2.0V±2.4%	MM3005B	2.5V±2.4%
MM3005C	2.7V±2.4%	MM3005D	2.8V±2.4%
MM3005E	3.0V±2.4%	MM3005F	3.3V±2.4%
MM3005G	3.6V±2.4%	MM3005H	5.0V±2.4%
MM3005J	5.2V±2.4%	MM3005K	5.4V±2.4%

\*In addition to MM3005, MM3006 ~ MM3010 also have rank indications from A ~ K, as above.

**Electrical Characteristics** (Except where noted otherwise, Ta=25°C)

■ MM3005, MM3007, MM3009 (It is L rank only MM3009.)

Item	Symbol	Measurement circuit	Measuring Circuit	Rank	Min.	Typ.	Max.	Unit
Input voltage	V <sub>IN</sub>	1					9	V
Operating start voltage	V <sub>ST1</sub>	1	I <sub>OUT</sub> =1mA				0.9	V
Oscillation start voltage	V <sub>ST2</sub>	2					0.8	V
Operation hold voltage	V <sub>HLD</sub>	1	I <sub>OUT</sub> =1mA		0.7			V
Consumption current 1	I <sub>SS1</sub>	2	V <sub>OUT</sub> = Output voltage × 0.95	A		11.6	19.4	μA
				B		14.3	23.9	
				C		15.5	25.9	
				D		16.1	26.8	
				E		17.2	28.7	
				F		19.1	31.8	
				G		22.4	37.3	
				H		38.5	64.1	
				J		43.9	73.1	
				K		45.0	74.9	
				L		13.2	22.8	
Consumption current 2	I <sub>SS2</sub>		V <sub>OUT</sub> = Output voltage+0.5V	A		3.1	6.2	μA
				B		3.2	6.3	
				C		3.2	6.4	
				D		3.2	6.4	
				E		3.2	6.4	
				F		3.3	6.5	
				G		3.3	6.5	
				H		3.5	6.9	
				J		3.5	6.9	
				K		3.5	6.9	
				L		3.1	6.2	
Switching current	I <sub>SW</sub>		V <sub>CONT</sub> =0.4V	A	45	71		mA
				B	61	98		
				C	61	98		
				D	61	98		
				E	78	125		
				F	78	125		
				G	78	125		
				H	114	182		
				J	114	182		
				K	114	182		
				L	45	71		
Switching transistor leak current	I <sub>SWO</sub>		V <sub>OUT</sub> =V <sub>CONT</sub> =9V				1	μA
Input stability	ΔV <sub>OUT1</sub>	1	V <sub>IN</sub> = Output voltage × 0.4 × 0.6		30	60		mV
Load stability	ΔV <sub>OUT2</sub>	1	I <sub>OUT</sub> =10μA-I <sub>OUT</sub> (Following) × 1.25		30	60		mV
Output voltage temperature coefficient	$\frac{\Delta V_{OUT}}{\Delta T_a}$	1	T <sub>a</sub> = -30~85°C			±50		ppm/°C
Oscillation frequency	f <sub>osc</sub>	2	V <sub>OUT</sub> = Output voltage × 0.95		42.5	50	57.5	kHz
Maximum duty ratio	MaxDuty	2	V <sub>OUT</sub> = Output voltage × 0.96		75	83	90	%
Soft start	T <sub>SS</sub>		I <sub>OUT</sub> =1mA		3	6	12	ms

Item	Symbol	Measurement circuit	Measuring Circuit	Rank	Min.	Typ.	Max.	Unit
Efficiency	EFFI	1		A		75		%
				B		79		
				C		79		
				D		79		
				E		83		
				F		83		
				G		83		
				H		87		
				J		87		
				K		87		
				L		75		
Consumption current while power off*	I <sub>SSS</sub>	2	ON/OFF pin=0V				0.5	μA
ON/OFF pin input voltage	V <sub>SH</sub>	2	V <sub>OUT</sub> =Output voltage × 0.95		0.75			V
	V <sub>SL</sub>	2	V <sub>OUT</sub> =Output voltage × 0.95				0.3	V

Note 1: \*Consumption current when ON/OFF and power OFF pin input voltage apply only to MM3005.

Note 2: If rank is not filled in, applies to all ranks.

Note 3: I<sub>OUT</sub>=Output voltage/250Ω

Note 4: The V<sub>DD</sub> pin and V<sub>OUT</sub> pin are connected for the V<sub>DD</sub>/V<sub>OUT</sub> separated type.

## Electrical Characteristics2 (Except where noted otherwise, Ta=25°C)

### ■ MM3006, MM3008, MM3010

Item	Symbol	Measurement circuit	Measuring Circuit	Rank	Min.	Typ.	Max.	Unit
Input voltage	V <sub>IN</sub>	1					9	V
Operating start voltage	V <sub>ST1</sub>	1	I <sub>OUT</sub> =1mA				0.9	V
Oscillation start voltage	V <sub>ST2</sub>	2					0.8	V
Operation hold voltage	V <sub>HLD</sub>	1	I <sub>OUT</sub> =1mA		0.7			V
Consumption current 1	I <sub>SS1</sub>	2	V <sub>OUT</sub> =Output voltage × 0.95	A		14.5	24.1	μA
				B		17.8	29.7	
				C		19.2	32	
				D		20	33.3	
				E		21.4	35.7	
				F		23.7	39.5	
				G		28.8	48	
				H		54	89.9	
				J		56.2	93.6	
				K		58.9	98.1	
				Consumption current 2	I <sub>SS2</sub>	2	V <sub>OUT</sub> =Output voltage+0.5V	
B		3.9	7.7					
C		3.9	7.7					
D		3.9	7.8					
E		3.9	7.8					
F		4	7.9					
G		4	7.9					
H		4.2	8.3					
J		4.2	8.3					
K		4.2	8.3					

Item	Symbol	Measurement circuit	Measuring Circuit	Rank	Min.	Typ.	Max.	Unit
EXT pin output current	I <sub>EXTH</sub>		V <sub>EXT</sub> =V <sub>OUT</sub> -0.4V	A	-1.9	-2.9		mA
				B	-2.7	-4		
				C	-2.7	-4		
				D	-2.7	-4		
				E	-3.5	-5.3		
				F	-3.5	-5.3		
				G	-3.5	-5.3		
				H	-5.3	-8		
				J	-5.3	-8		
	K	-5.3	-8					
	I <sub>EXTL</sub>		V <sub>EXT</sub> =0.4V	A	3.8	5.7		mA
				B	5.3	8		
				C	5.3	8		
				D	5.3	8		
				E	7	10.5		
				F	7	10.5		
				G	7	10.5		
				H	10.7	16		
J				10.7	16			
K	10.7	16						
Input stability	$\Delta V_{OUT1}$	3	V <sub>IN</sub> =Output voltage×0.4~0.6			30	60	mV
Load stability	$\Delta V_{OUT2}$	3	I <sub>OUT</sub> =10μA~I <sub>OUT</sub> (Following)×1.25			30	60	mV
Output voltage temperature coefficient	$\frac{\Delta V_{OUT}}{\Delta T_a}$	3	T <sub>a</sub> =-30~85°C			±50		ppm/°C
Oscillation frequency	f <sub>osc</sub>	4	V <sub>OUT</sub> =Output voltage×0.95		85	100	115	kHz
Maximum duty ratio	MaxDuty	4	V <sub>OUT</sub> =Output voltage×0.96		75	83	90	%
Soft start	T <sub>ss</sub>		I <sub>OUT</sub> =1mA		3	6	12	ms
Efficiency	EFFI	3		A		76		%
				B		80		
				C		80		
				D		80		
				E		84		
				F		84		
				G		84		
				H		88		
				J		88		
K		88						
Consumption current while power off	I <sub>SS</sub>	4	Power off pin=0V				0.5	μA
ON/OFF pin input voltage	V <sub>SH</sub>	4	V <sub>OUT</sub> Output voltage×0.95		0.75			V
	V <sub>SL</sub>						0.3	

Notes: 1. The current consumption when powering down and input voltage at the ON/OFF pin apply only to the MM3006.

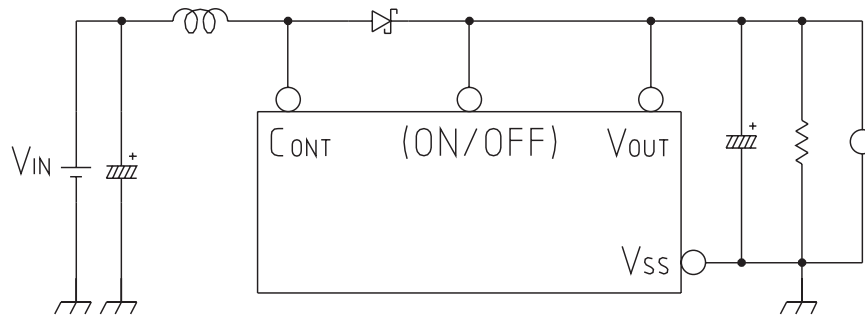
Notes: 2. Where the rank is omitted, the figure is common to all ranks.

Notes: 3. I<sub>OUT</sub>=output voltage 250Ω

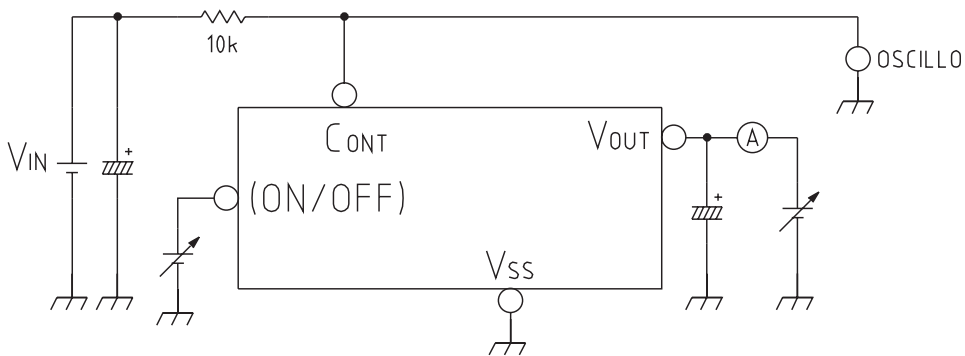
Notes: 4. Connect both V<sub>DD</sub> and V<sub>OUT</sub> pins in models with separate V<sub>DD</sub> and V<sub>OUT</sub> pins.

Measuring Circuit

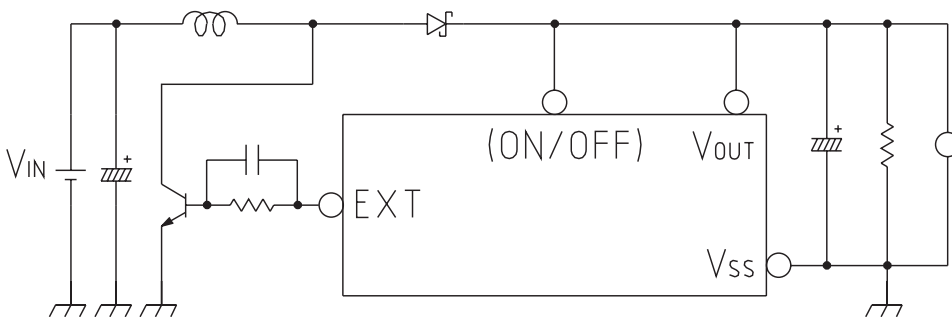
■ 1



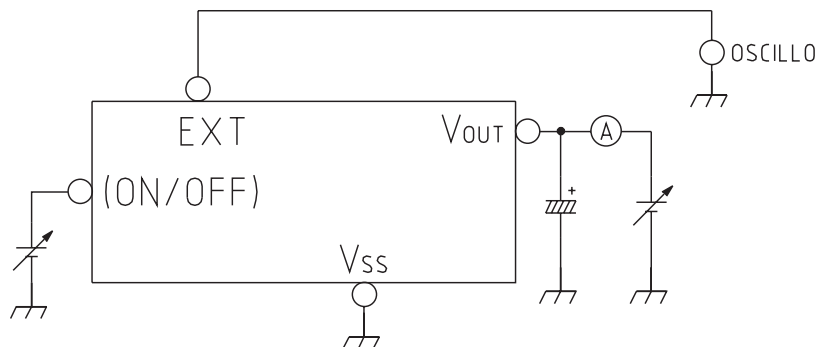
■ 2



■ 3



■ 4

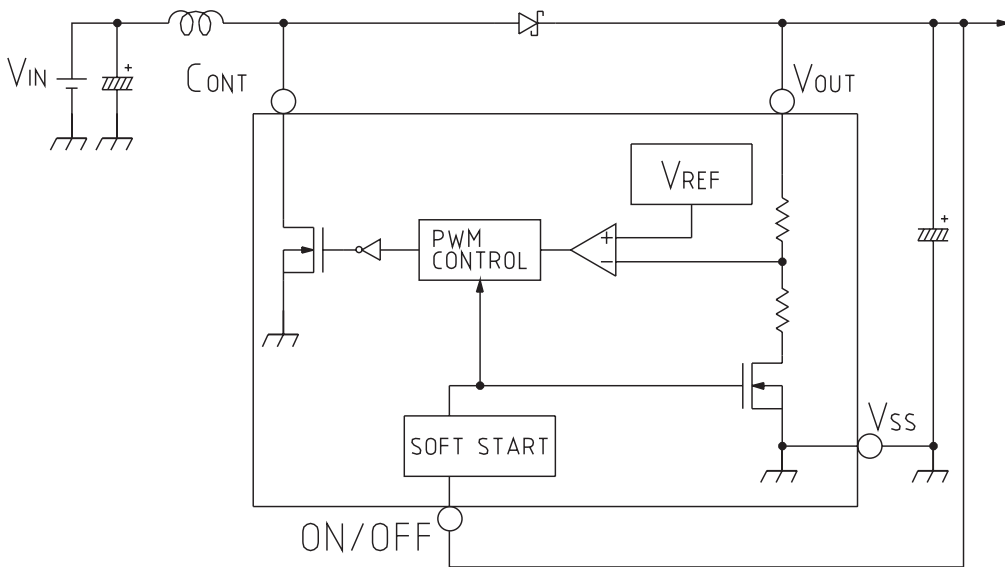


Note 1: Coil: L=100μH (Mitsumi C5-K3L) transistor: SANYO 2SD1628  
 Condenser: C=33μF (tantal condenser) Base resistor (Rb) : 1.0kΩ  
 Shot key barrier diode: ROHM RB491D Base resistor (Cb) : 2200pF

Note 2: The cause of oscillation is due to set wiring and capacitance changes in capacitor caused by temperatures changes, so please take extra care in placing the wires.



Description of Operation



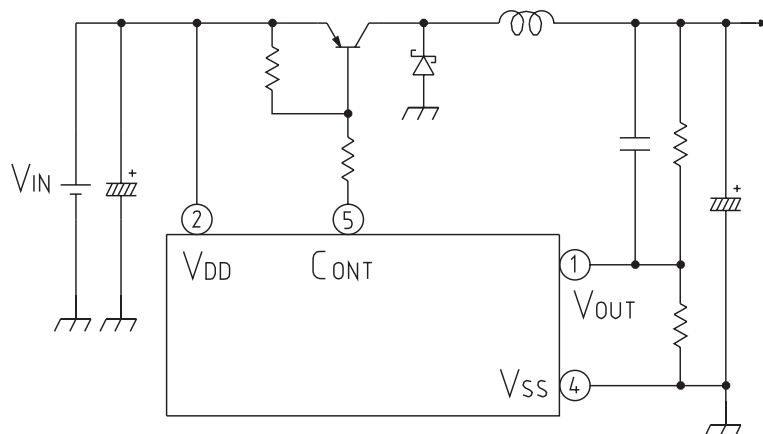
The MM3005 series are pulse width modulation type DC/DC converters.

- 1: PWM control uses load to change the duty ratio automatically from 0 ~ 83%.
- 2: A built-in soft start circuit softens the current inrush at start-up.
- 3: Power OFF pin: Stops or starts voltage rise operation.

When the power OFF pin is at low level the internal circuits all stop operating and consumption current is greatly reduced. Note that the power OFF pin structure is open and unstable, so please be sure not to use it open. Further, do not impress voltage of 0.3 ~ 0.75V, as this causes consumption current to increase. When not using the power OFF pin, please connect it to the V<sub>OUT</sub> pin.

Power off pin	Operating condition
H	ON
L	OFF
Open	Irregular

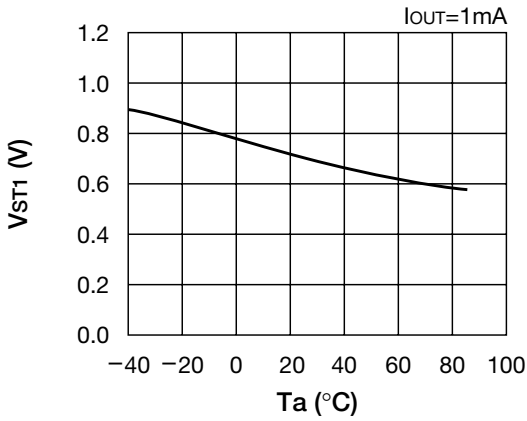
Application Circuits



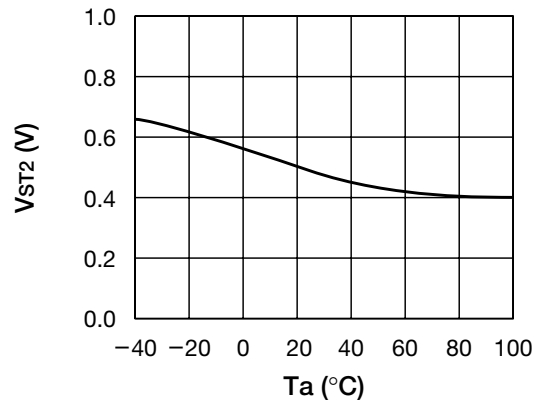
When used as voltage drop DC-DC converter.

**Characteristics** MM3005EN Output voltage 3V typ. product

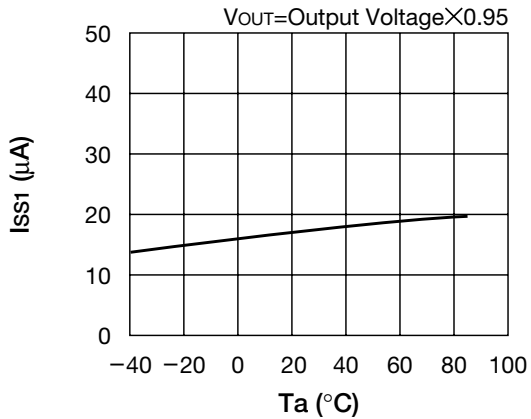
■ Starting output voltage – temperature



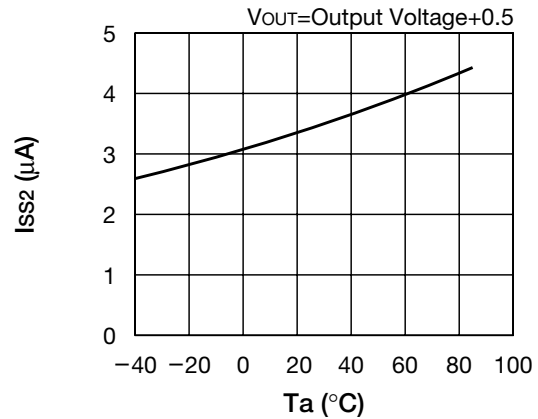
■ Starting oscillator voltage (VST2) – temperature



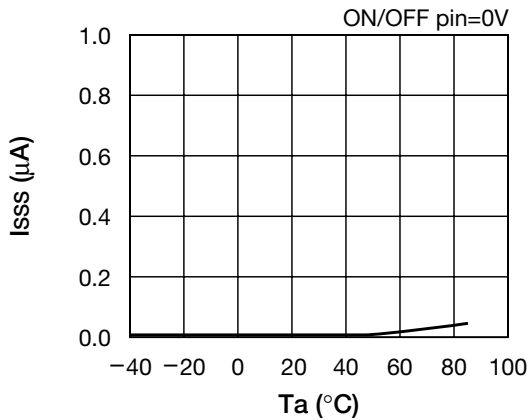
■ Supply current 1 (ISS1) – temperature



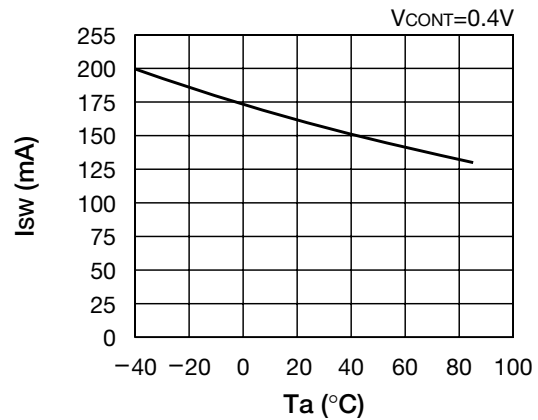
■ Supply current 2 (ISS2) – temperature



■ Supply current (OFF) (ISSS) – temperature

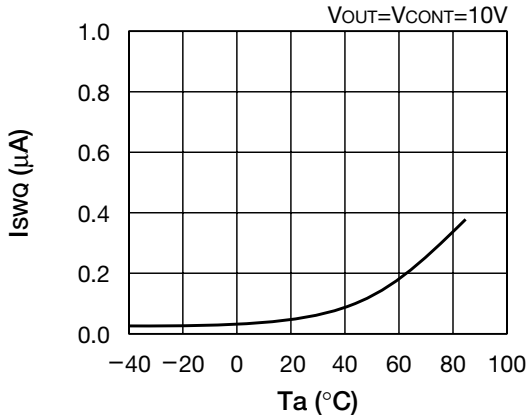


■ Switch current (ISW) – temperature

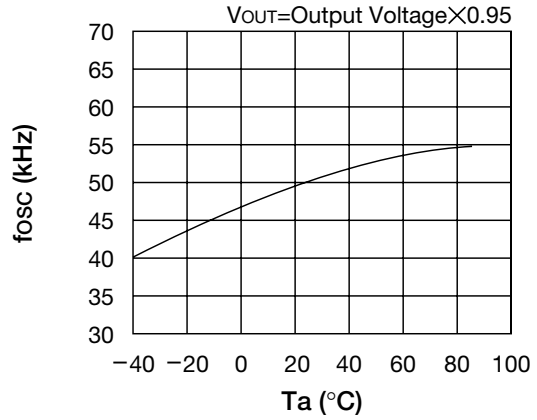


Note: these are typical characteristics.

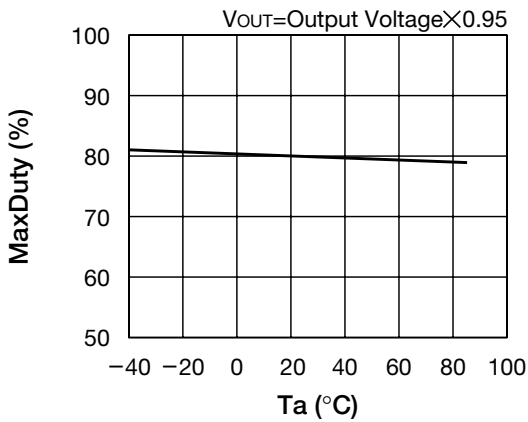
■ Switch transistor leak current – temperature



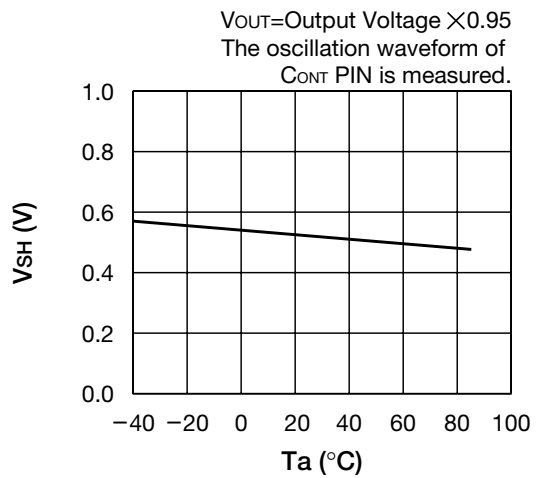
■ Oscillator frequency – temperature



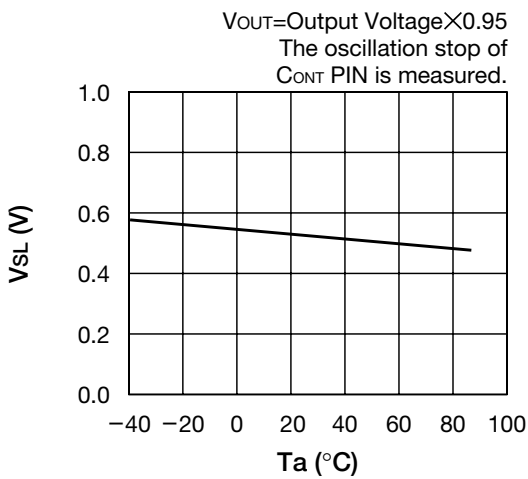
■ Maximum duty cycle – temperature



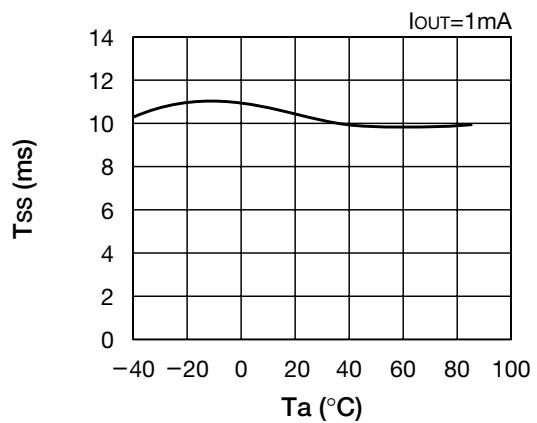
■ ON/OFF Pin input voltage (VSH) – temperature



■ ON/OFF Pin input voltage (VSL) – temperature

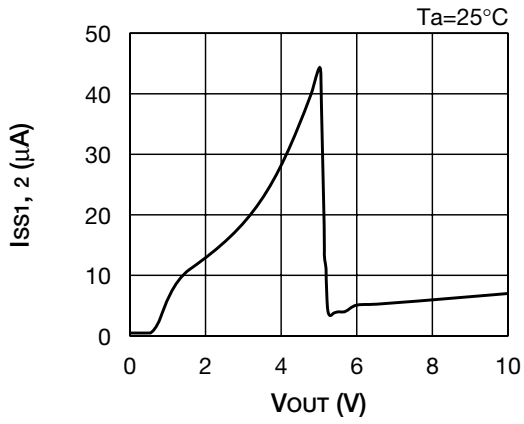


■ Soft start time – temperature

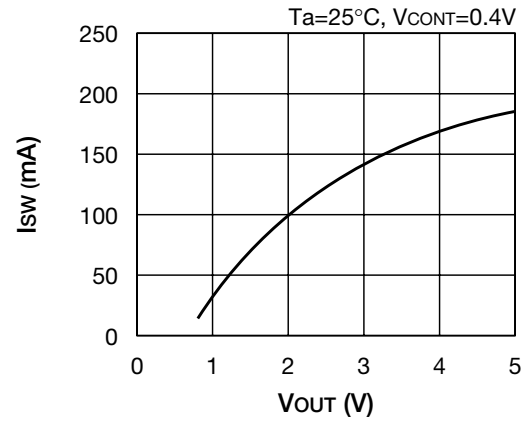


Note: these are typical characteristics.

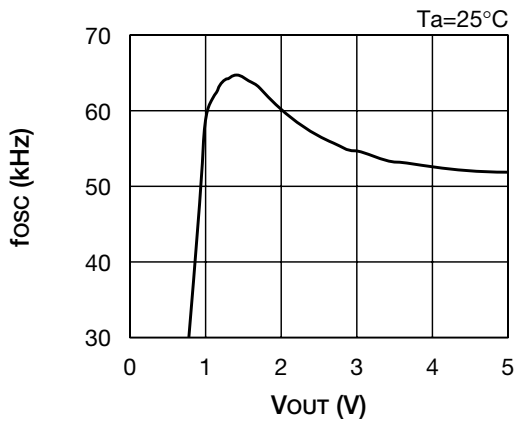
■ Supply Current 1, 2 – V<sub>OUT</sub>



■ Switch current – V<sub>OUT</sub>



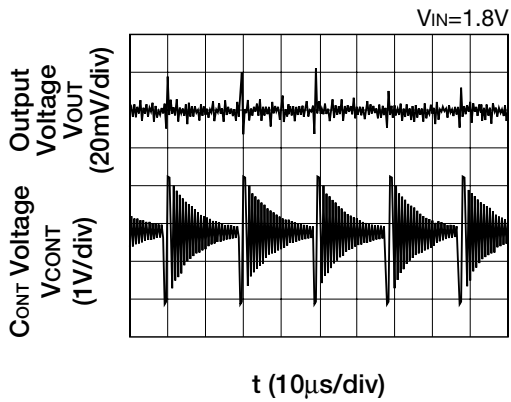
■ Oscillator frequency – V<sub>OUT</sub>



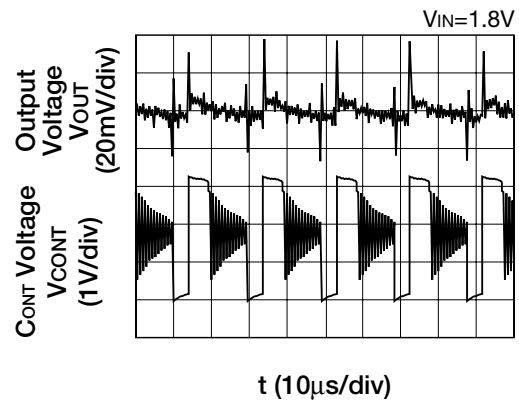
Note: these are typical characteristics.

## Ripple voltage characteristic (MM3005EN)

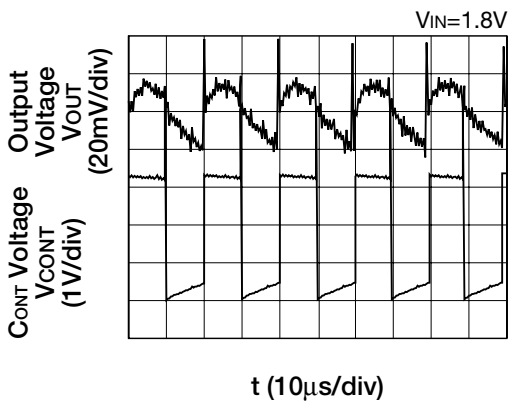
### 1. $I_{OUT}=200\mu A$



### 2. $I_{OUT}=10mA$



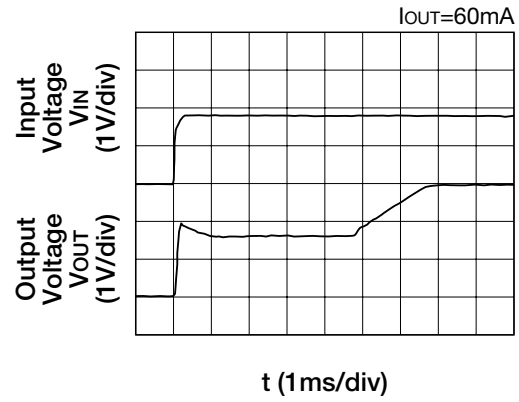
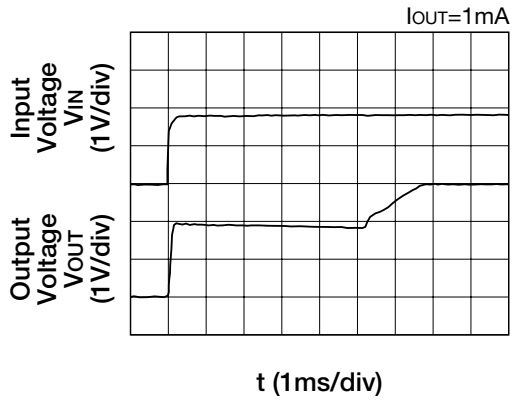
### 3. $I_{OUT}=60mA$



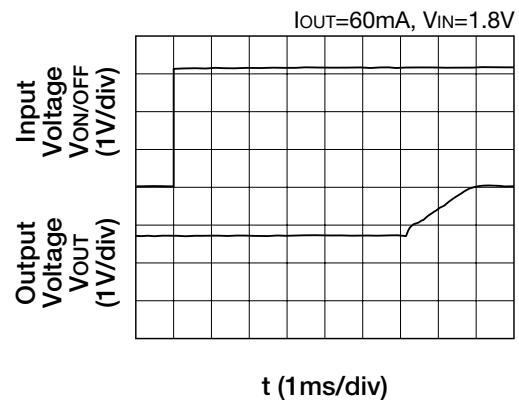
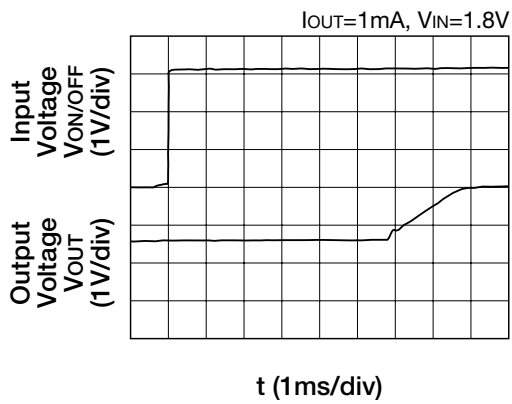
Note: these are typical characteristics.

### ■ Transient Response (MM3005EN)

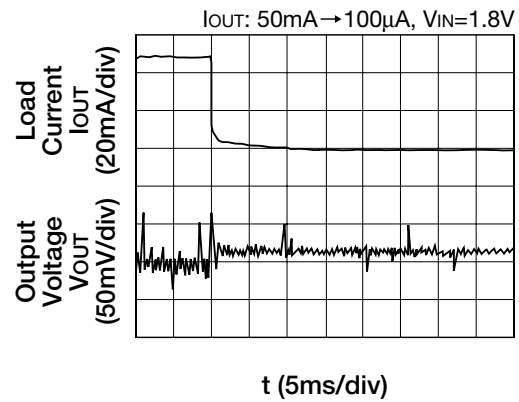
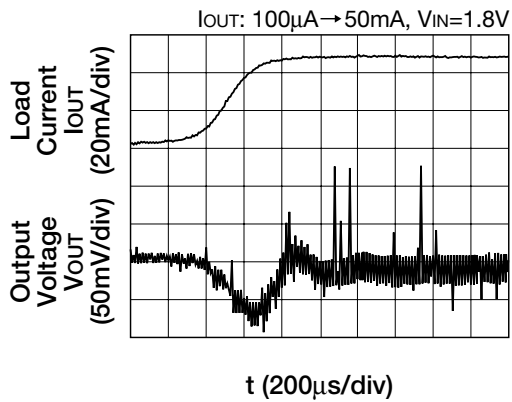
#### ■ 1. $V_{IN} : 0V \rightarrow 1.8V$



#### ■ 2. $V_{ON/OFF} : 0V \rightarrow 3.0V$

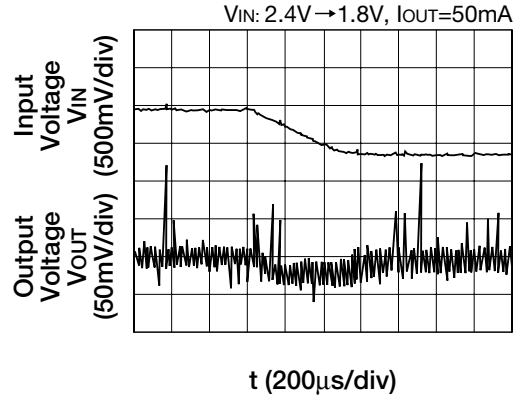
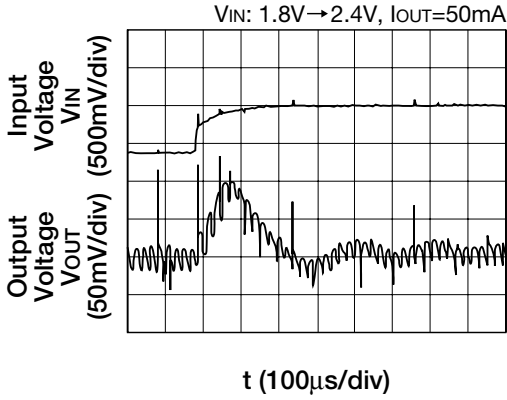


#### ■ 3. Load regulation



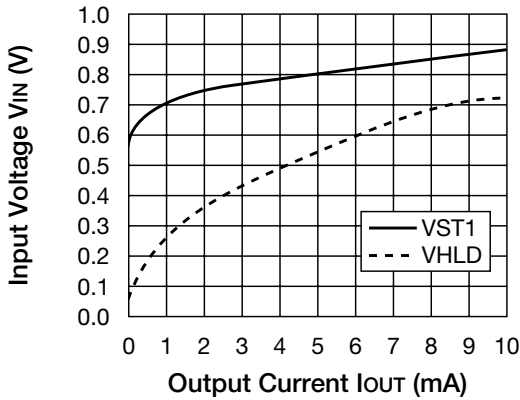
Note: these are typical characteristics.

4. Line regulation

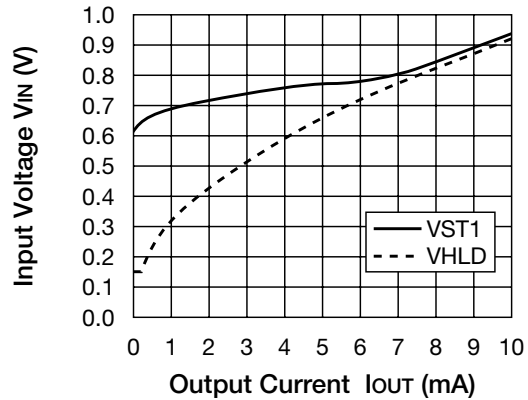


Output current – starting output voltage and holding output voltage dependence characteristic

MM3005EN

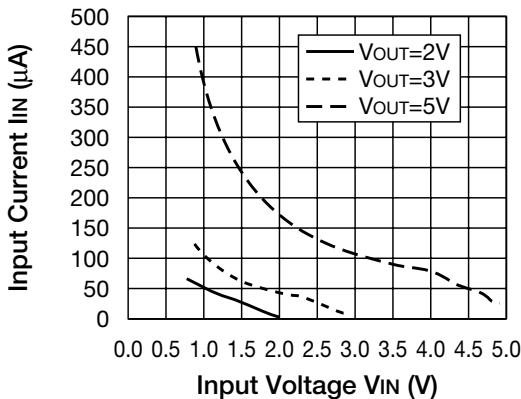


MM3005H



Input voltage – supply current dependency characteristic

MM3005

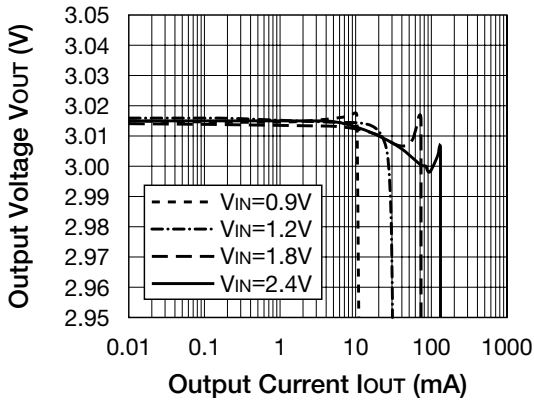


Note: these are typical characteristics.

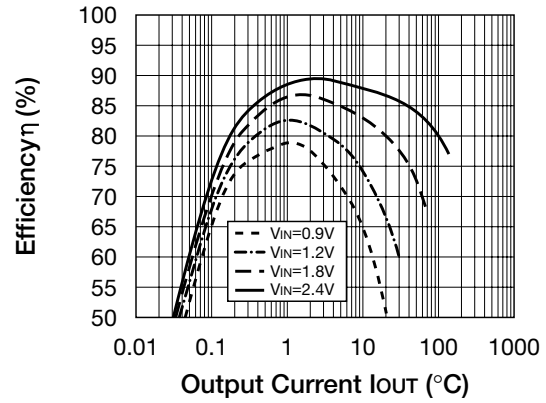
Reference Data

(1) MM3005EN (C5-K3L : 47μH)

■ Output current – output voltage

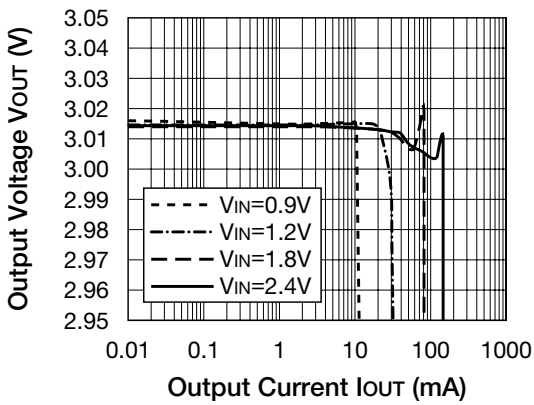


■ Output current – efficiency

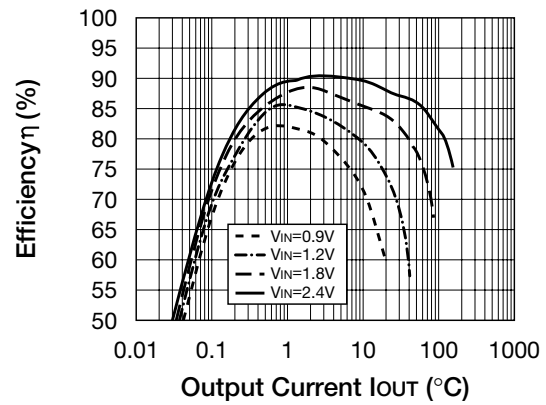


(2) MM3005EN (C5-K3L : 100μH)

■ Output current – output voltage

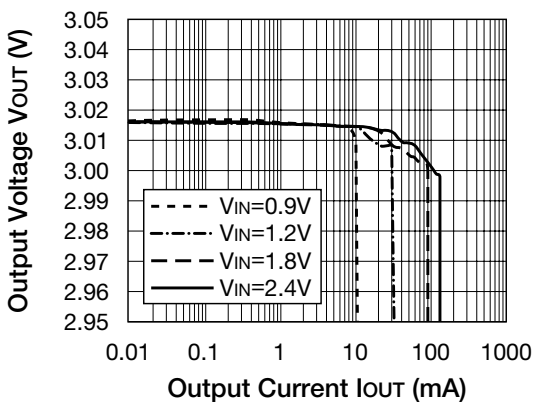


■ Output current – efficiency

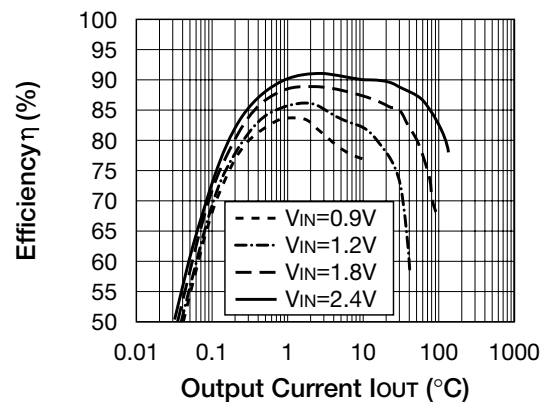


(3) MM3005EN (C5-K3L : 150μH)

■ Output current – output voltage



■ Output current – efficiency

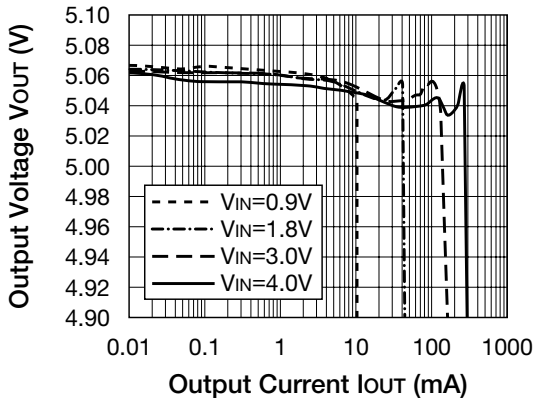


Note: these are typical characteristics.

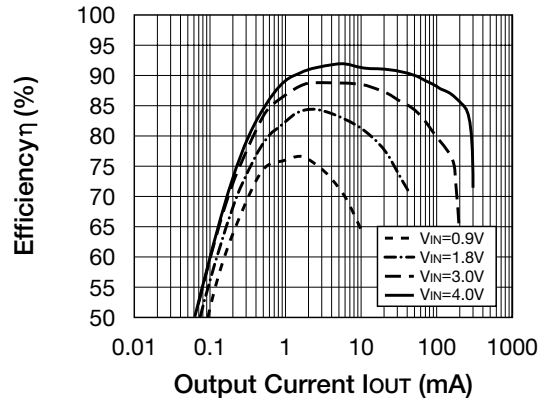


(4) MM3005HN (C5-K3L : 47 $\mu$ H)

■ Output current – output voltage

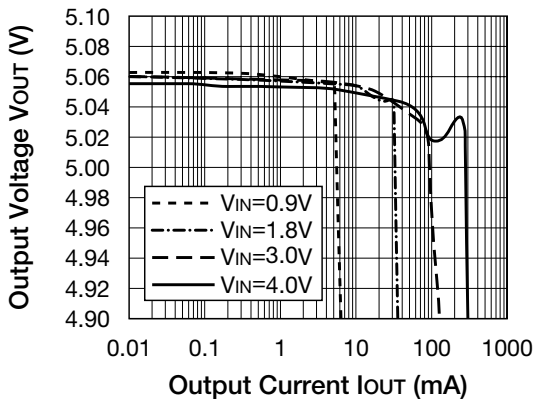


■ Output current – efficiency

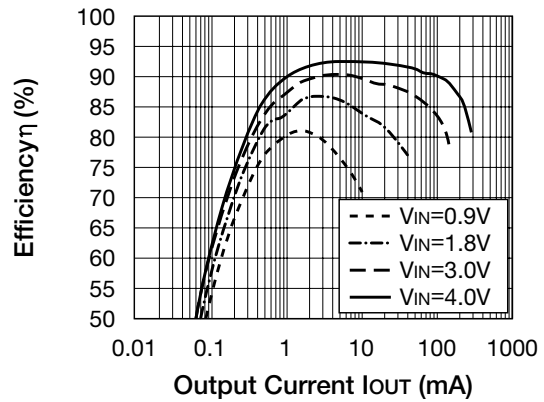


(5) MM3005HN (C5-K3L : 100 $\mu$ H)

■ Output current – output voltage

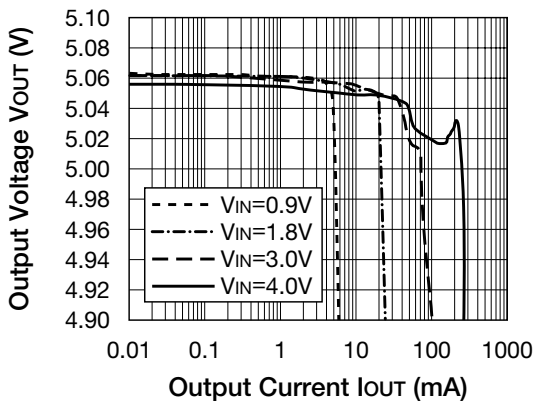


■ Output current – efficiency

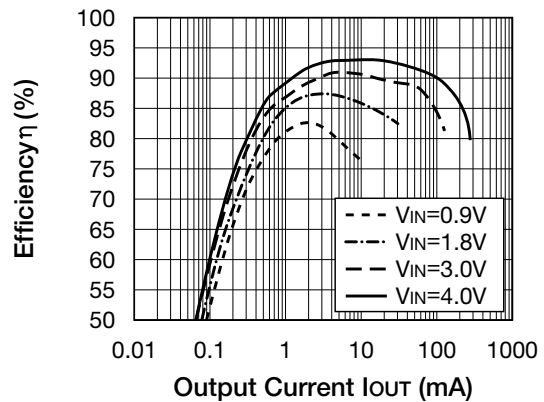


(6) MM3005HN (C5-K3L : 150 $\mu$ H)

■ Output current – output voltage



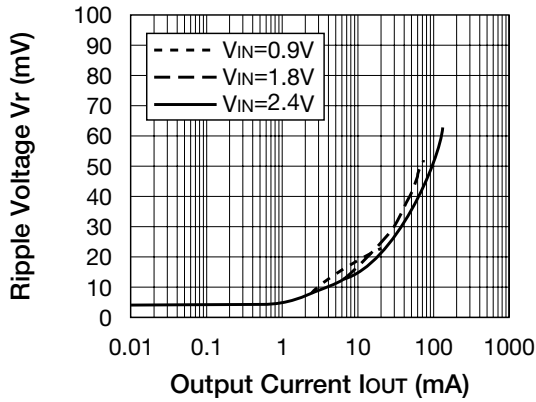
■ Output current – efficiency



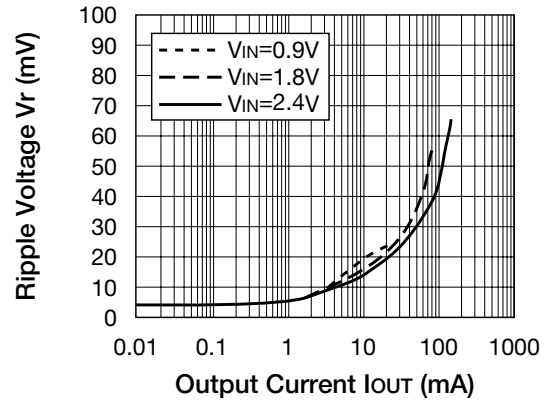
Note: these are typical characteristics.

(7) MM3005EN (C5-K3L : 47 $\mu$ H, C<sub>OUT</sub> : 33 $\mu$ F) (8) MM3005EN (C5-K3L : 100 $\mu$ H, C<sub>OUT</sub> : 33 $\mu$ F)

■ Output current – ripple voltage

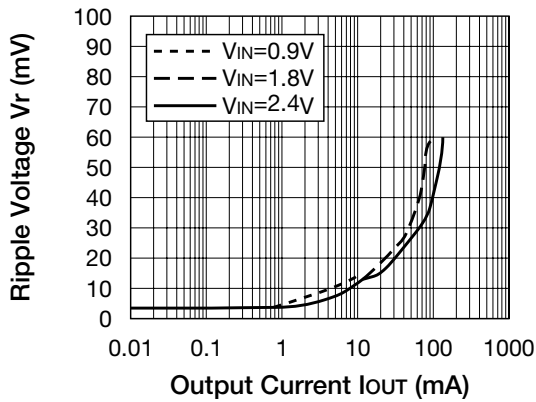


■ Output current – ripple voltage

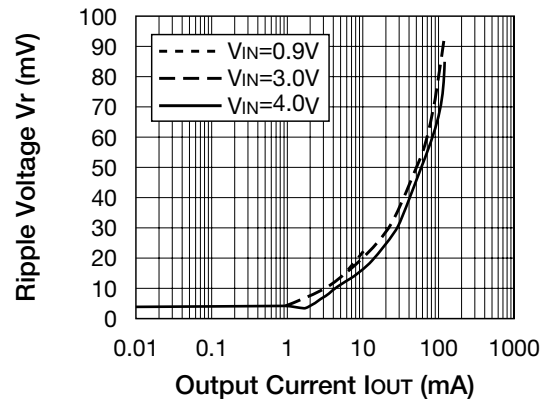


(9) MM3005EN (C5-K3L : 150 $\mu$ H, C<sub>OUT</sub> : 33 $\mu$ F) (10) MM3005HN (C5-K3L : 47 $\mu$ H, C<sub>OUT</sub> : 33 $\mu$ F)

■ Output current – ripple voltage

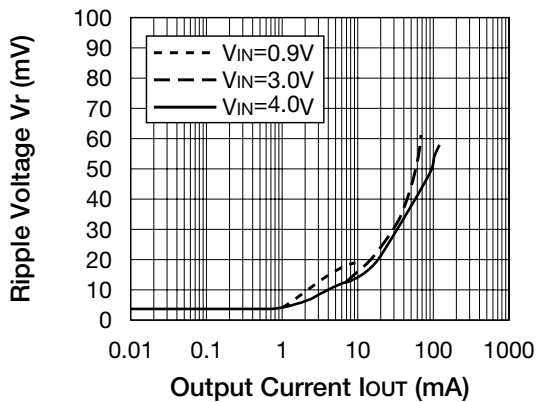


■ Output current – ripple voltage

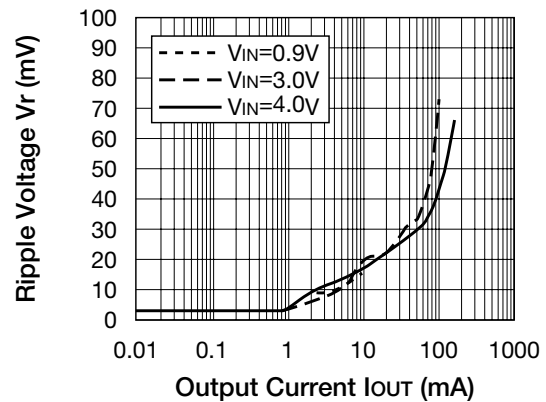


(11) MM3005HN (C5-K3L : 100 $\mu$ H, C<sub>OUT</sub> : 33 $\mu$ F) (12) MM3005HN (C5-K3L : 150 $\mu$ H, C<sub>OUT</sub> : 33 $\mu$ F)

■ Output current – ripple voltage



■ Output current – ripple voltage



Note: these are typical characteristics.