# 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 ±2.4%.

## Features

1. Ultra low consumption current   17.2μA typ. (during operation) (MM3005E)
2. High efficiency   83% typ. (MM3005E)
3. High precision output voltage   ±2.4%
4. Wide operating temperature range   −30°C~+85°C
5. Output voltage   2~5.5V (0.1V can be set in 0.1V steps)
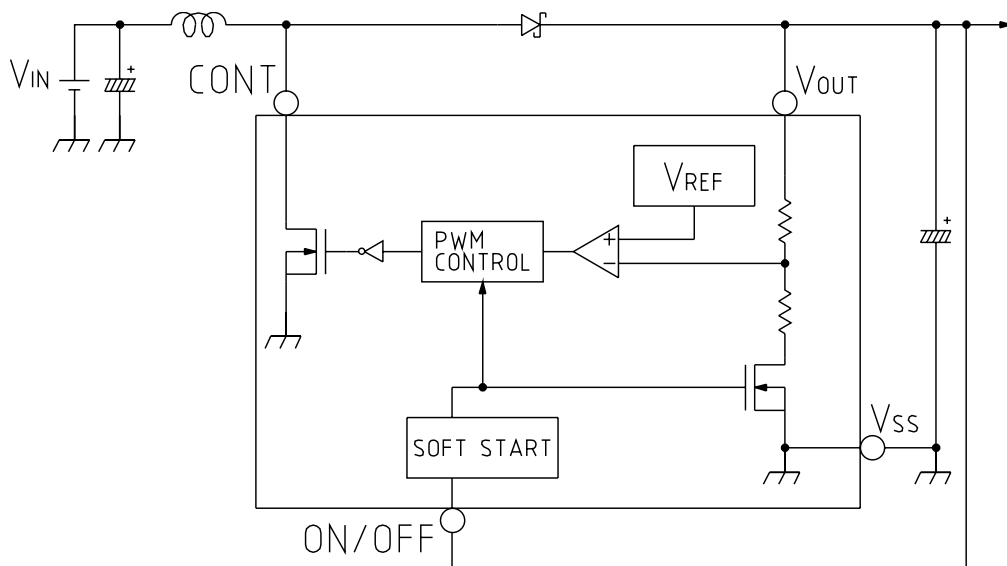
## Package
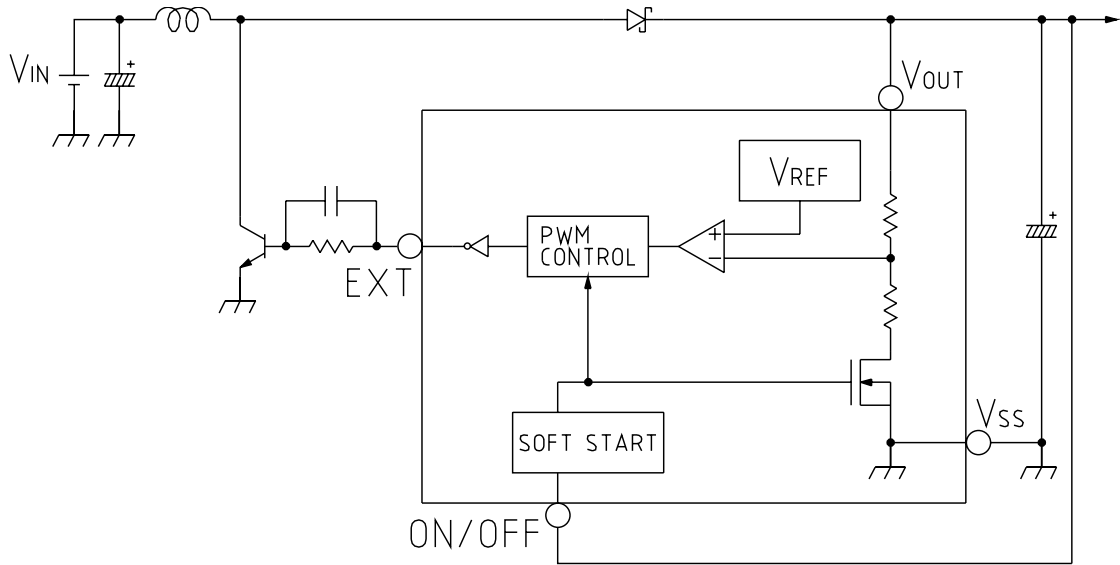
SOT-25A (Mini mold)

## Applications

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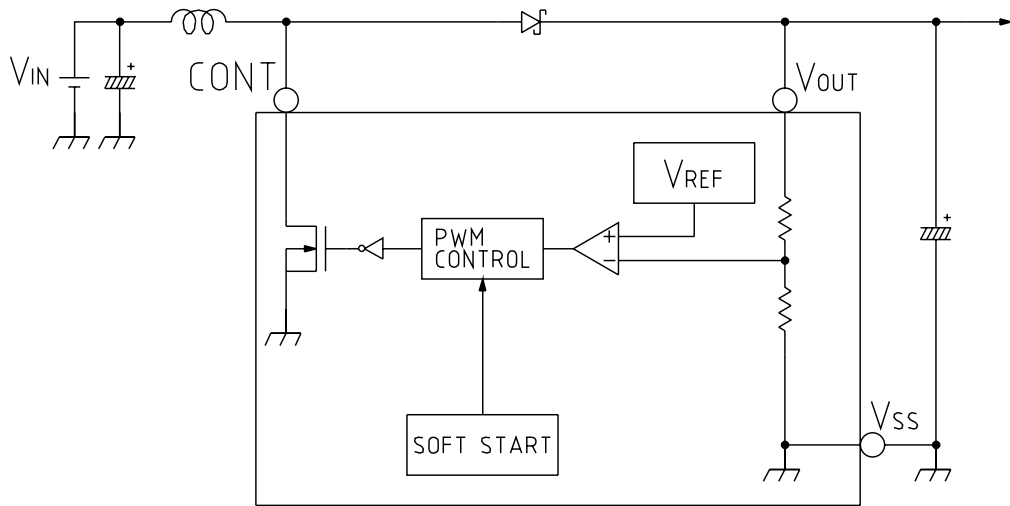3. Other battery-operated portable equipment

## Block Diagram

■ MM3005
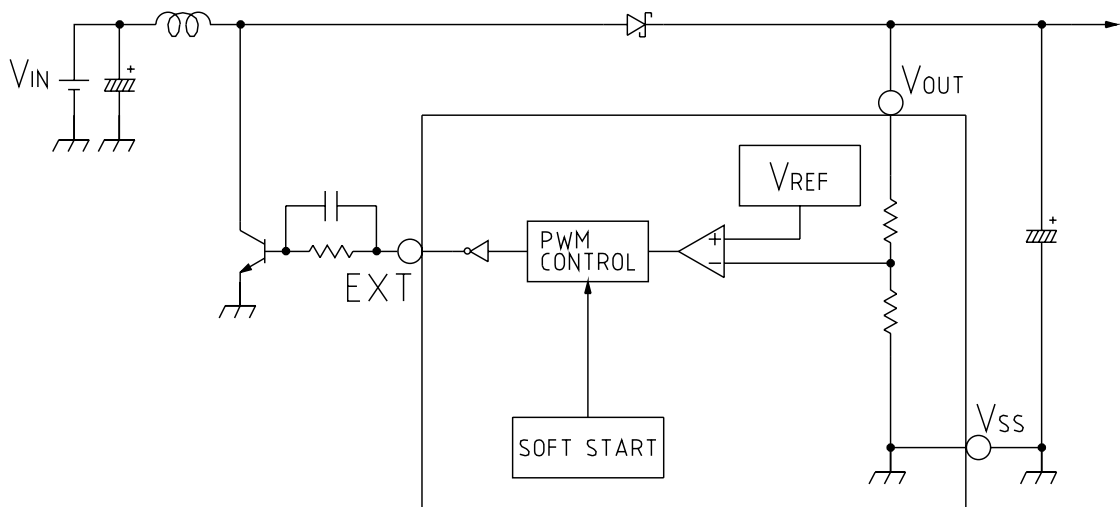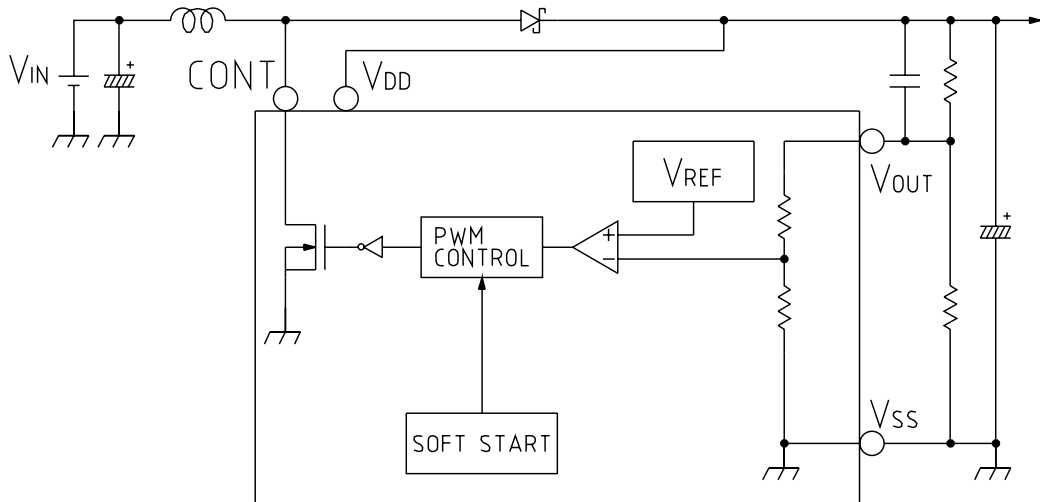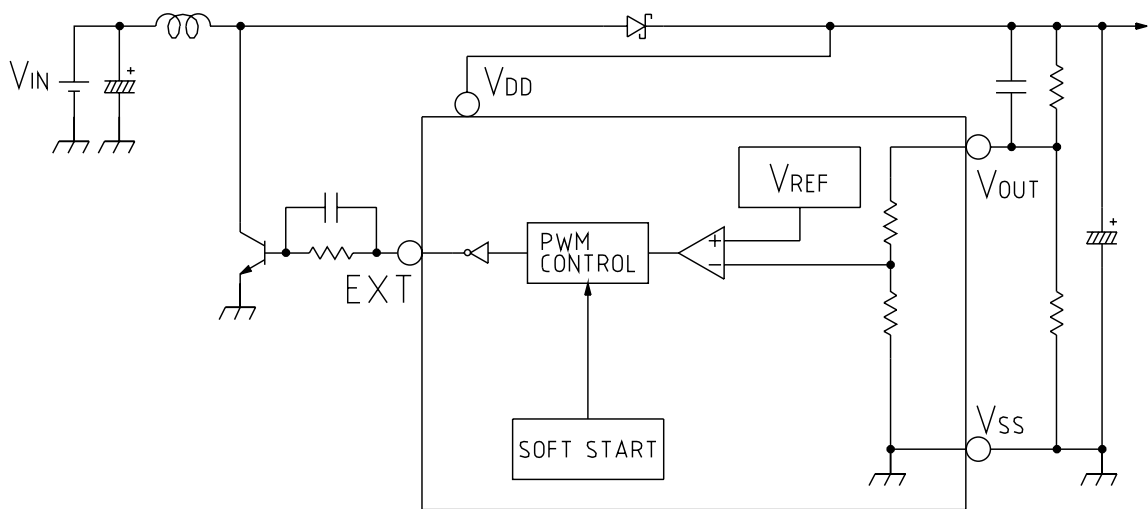
■ MM3006



■ MM3007
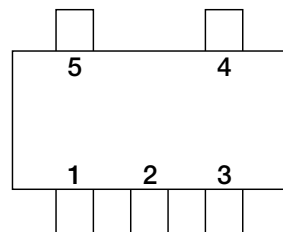


■ MM3008

## ■ MM3009



## ■ MM3010



# Pin Assignment

## ■ MM3005
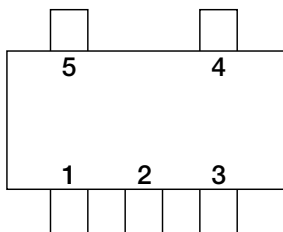


| 1 | ON/OFF |
|---|--------|
| 2 | $V_{OUT}$ |
| 3 | NC |
| 4 | $V_{SS}$ |
| 5 | CONT |

SOT-25A
(TOP VIEW)

## ■ MM3006



| 1 | ON/OFF |
|---|--------|
| 2 | $V_{OUT}$ |
| 3 | NC |
| 4 | $V_{SS}$ |
| 5 | EXT |

SOT-25A
(TOP VIEW)
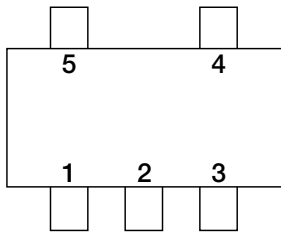
### ■ MM3007



| 1 | NC |
|---|-----|
| 2 | V$_{OUT}$ |
| 3 | NC |
| 4 | V$_{SS}$ |
| 5 | CONT |

SOT-25A
(TOP VIEW)

### ■ MM3008
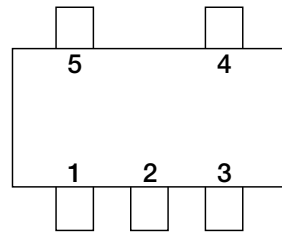


| 1 | NC |
|---|-----|
| 2 | V$_{OUT}$ |
| 3 | NC |
| 4 | V$_{SS}$ |
| 5 | EXT |

SOT-25A
(TOP VIEW)

### ■ MM3009
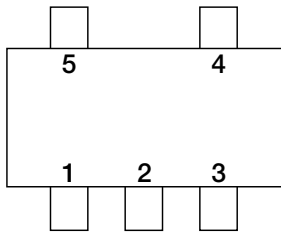


| 1 | V$_{OUT}$ |
|---|-----|
| 2 | V$_{DD}$ |
| 3 | NC |
| 4 | V$_{SS}$ |
| 5 | CONT |

SOT-25A
(TOP VIEW)

### ■ MM3010
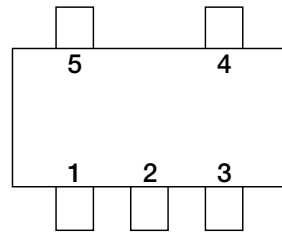


| 1 | V$_{OUT}$ |
|---|-----|
| 2 | V$_{DD}$ |
| 3 | NC |
| 4 | V$_{SS}$ |
| 5 | EXT |

SOT-25A
(TOP VIEW)

## Absolute Maximum Ratings

| Item | Symbol | Rating | Unit |
|------|--------|--------|------|
| Storage Temperature | T$_{STG}$ | −40~+125 | °C |
| Operating Temperature | T$_{OPR}$ | −30~+85 | °C |
| Power Supply Voltage | V$_{DD}$max. | −0.3~+11 | V |
| Allowable loss | Pd | 150 | mW |
| V$_{OUT}$ pin voltage | V$_{OUT}$ | −0.3~+11 | V |
| ON/OFF pin voltage | ON/OFF | −0.3~+11 | V |
| CONT pin voltage | V$_{CONT}$ | −0.3~+11 | V |
| CONT pin current | I$_{CONT}$ | 300 | mA |

## Recommended Operating Conditions

| Item | Symbol | Rating | Unit |
|------|--------|--------|------|
| Operating Temperature | T$_{OPR}$ | −30~+85 | °C |
| Input voltage | V$_{IN}$ | +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 | $V_{IN}$ | 1 | | | | | 9 | V |
| Operating start voltage | $V_{ST1}$ | 1 | $I_{OUT}$=1mA | | | | 0.9 | V |
| Oscillation start voltage | $V_{ST2}$ | 2 | | | | | 0.8 | V |
| Operation hold voltage | $V_{HLD}$ | 1 | $I_{OUT}$=1mA | | 0.7 | | | V |
| Consumption current 1 | $I_{SS1}$ | 2 | $V_{OUT}$= 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 | $I_{SS2}$ | | $V_{OUT}$= 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 | $I_{SW}$ | | $V_{CONT}$=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 | $I_{SWO}$ | | $V_{OUT}$=$V_{CONT}$=9V | | | | 1 | μA |
| Input stability | $\triangle V_{OUT1}$ | 1 | $V_{IN}$= Output voltage×0.4×0.6 | | | 30 | 60 | mV |
| Load stability | $\triangle V_{OUT2}$ | 1 | $I_{OUT}$=10μA~$I_{OUT}$ (Following)×1.25 | | | 30 | 60 | mV |
| Output voltage temperature coefficient | $\dfrac{\triangle V_{OUT}}{\triangle Ta}$ | 1 | Ta= −30~85°C | | | ±50 | | ppm/°C |
| Oscillation frequency | fosc | 2 | $V_{OUT}$= Output voltage×0.95 | | 42.5 | 50 | 57.5 | kHz |
| Maximum duty ratio | MaxDuty | 2 | $V_{OUT}$= Output voltage×0.96 | | 75 | 83 | 90 | % |
| Soft start | Tss | | $I_{OUT}$=1mA | | 3 | 6 | 12 | ms |

| Item | Symbol | Measurement circuit | Measuring Circuit | Rank | Min. | Typ. | Max. | Unit |
|------|--------|---------------------|-------------------|------|------|------|------|------|
| Efficiency | $E_{FFI}$ | 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★ | $I_{SSS}$ | 2 | ON/OFF pin=0V | | | | 0.5 | μA |
| ON/OFF pin input voltage | $V_{SH}$ | 2 | $V_{OUT}$=Output voltage×0.95 | | 0.75 | | | V |
| | $V_{SL}$ | 2 | $V_{OUT}$=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: $I_{OUT}$=Output voltage/250Ω

Note 4: The $V_{DD}$ pin and $V_{OUT}$ pin are connected for the $V_{DD}$/$V_{OUT}$ 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 | $V_{IN}$ | 1 | | | | | 9 | V |
| Operating start voltage | $V_{ST1}$ | 1 | $I_{OUT}$=1mA | | | | 0.9 | V |
| Oscillation start voltage | $V_{ST2}$ | 2 | | | | | 0.8 | V |
| Operation hold voltage | $V_{HLD}$ | 1 | $I_{OUT}$=1mA | | 0.7 | | | V |
| Consumption current 1 | $I_{SS1}$ | 2 | $V_{OUT}$=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 | $I_{SS2}$ | | $V_{OUT}$=Output voltage+0.5V | A | | 3.8 | 7.6 | μA |
| | | | | 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 | $I_{EXTH}$ | | $V_{EXT}=V_{OUT}-0.4V$ | 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 | | |
| | $I_{EXTL}$ | | $V_{EXT}=0.4V$ | 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 | $\triangle V_{OUT1}$ | 3 | $V_{IN}=$Output voltage$\times 0.4\sim 0.6$ | | | 30 | 60 | mV |
| Load stability | $\triangle V_{OUT2}$ | 3 | $I_{OUT}=10\mu A\sim I_{OUT}$ (Following)$\times 1.25$ | | | 30 | 60 | mV |
| Output voltage temperature coefficient | $\dfrac{\triangle V_{OUT}}{\triangle Ta}$ | 3 | $Ta=-30\sim 85°C$ | | | ±50 | | ppm/°C |
| Oscillation frequency | fosc | 4 | $V_{OUT}=$Output voltage$\times 0.95$ | | 85 | 100 | 115 | kHz |
| Maximum duty ratio | MaxDuty | 4 | $V_{OUT}=$Output voltage$\times 0.96$ | | 75 | 83 | 90 | % |
| Soft start | Tss | | $I_{OUT}=1mA$ | | 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 | Isss | 4 | Power off pin=0V | | | | 0.5 | μA |
| ON/OFF pin input voltage | $V_{SH}$ | 4 | $V_{OUT}$ Output voltage$\times 0.95$ | | 0.75 | | | V |
| | $V_{SL}$ | | $V_{OUT}$ Output voltage$\times 0.95$ | | | | 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. $I_{OUT}$=output voltage 250Ω

Notes: 4. Connect both $V_{DD}$ and $V_{OUT}$ pins in models with separate $V_{DD}$ and $V_{OUT}$ pins.

## Measuring Circuit

■1
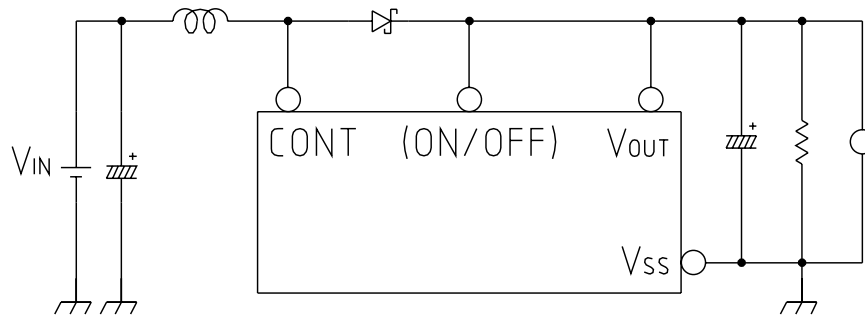


■2



■3



■4
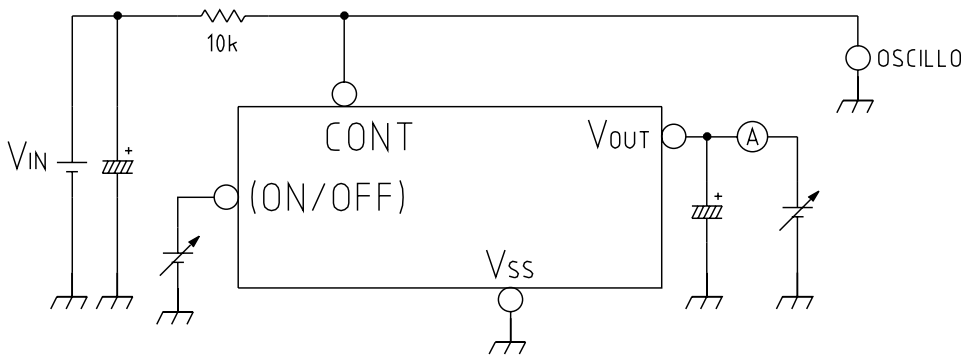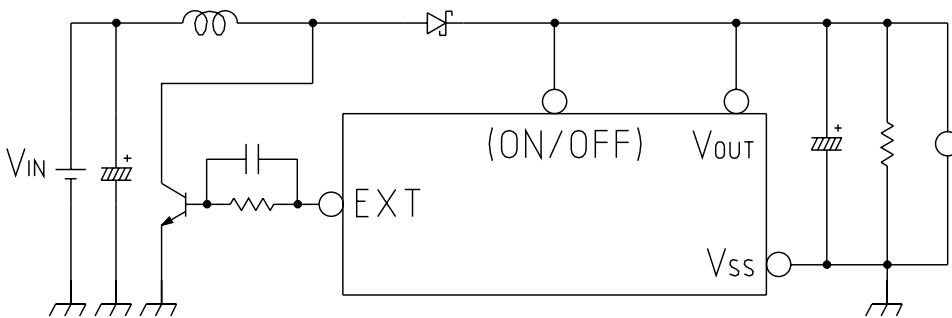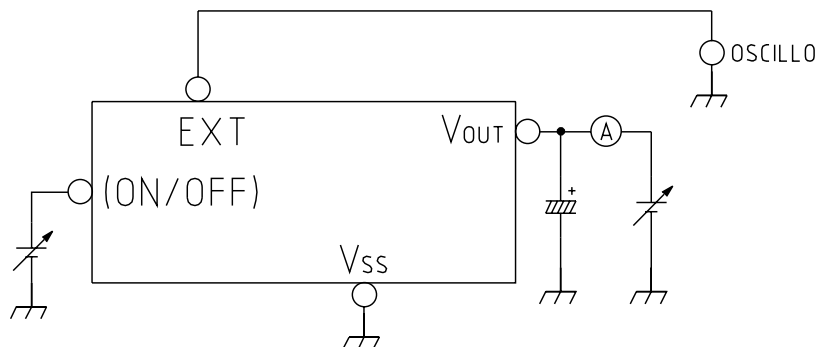


Note 1:  Coil:  L=100μH (Mitsumi   C5-K3L)   transistor: SANYO   2SD1628
         Condenser: C=33μF (tantal condenser)   Base resistor (Rb) :  1.0kΩ
         Shot key barrier diode:  ROHM   RB491D   Base resistor (Cb) :  2200pF

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
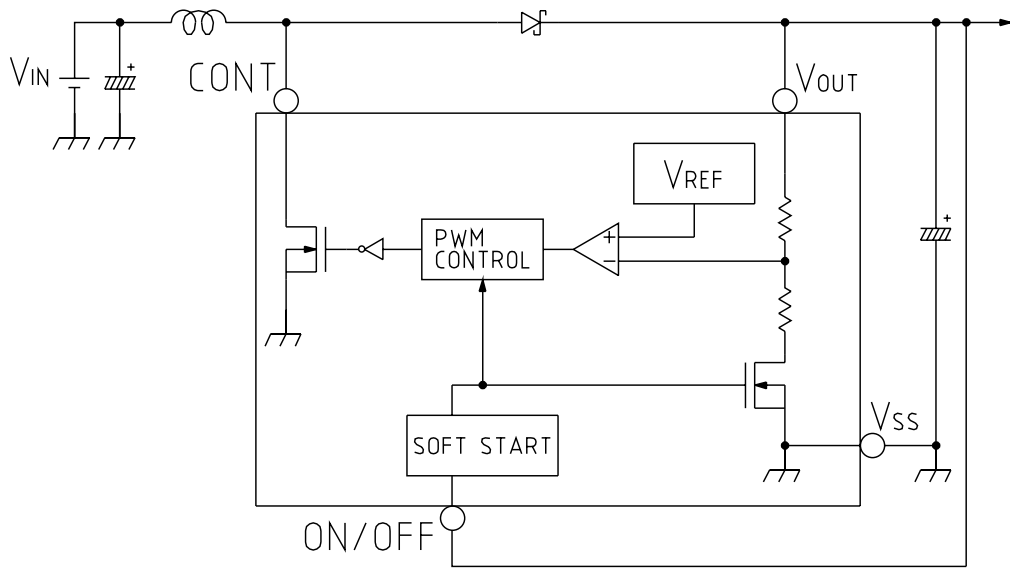


The MM3005 series are pulse width modulation type DC/DC converters.

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$_{OUT}$ pin.

| Power off pin | Operating condition |
|---|---|
| H | ON |
| L | OFF |
| Open | Irregular |

## Application Circuits
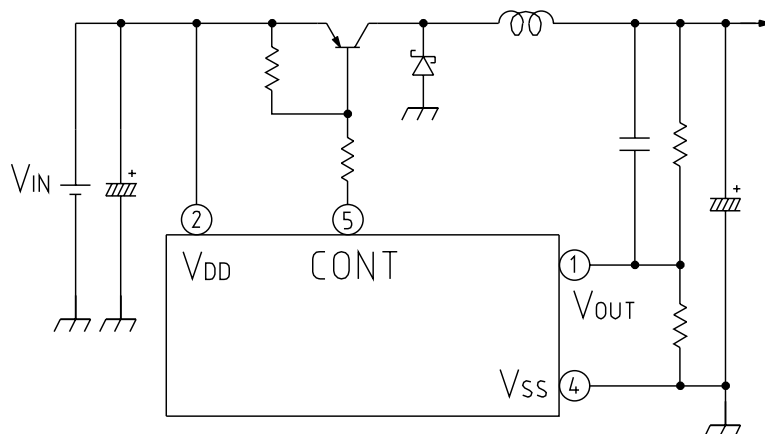


When used as voltage drop DC-DC converter.

## Characteristics MM3005EN Output voltage3V typ. product

### ■ Starting output voltage vs temperature

$I_{OUT}=1mA$
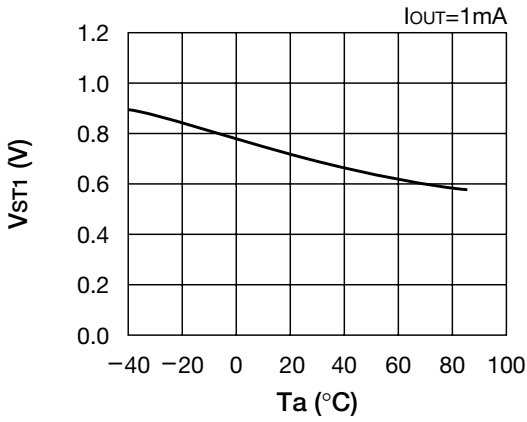
### ■ Starting oscillator voltage vs temperature
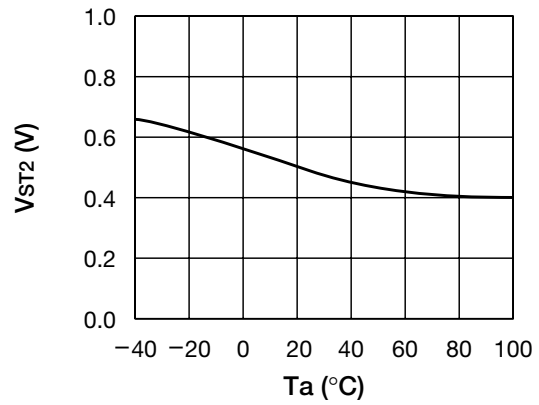
### ■ Supply current 1 vs temperature

$V_{OUT}=Output Voltage×0.95$
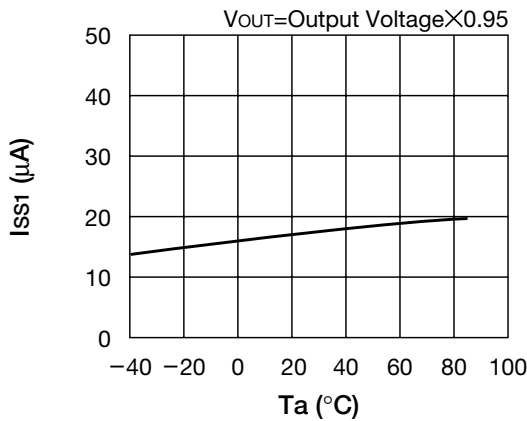
### ■ Supply current 2 vs temperature

$V_{OUT}=Output Voltage+0.5$
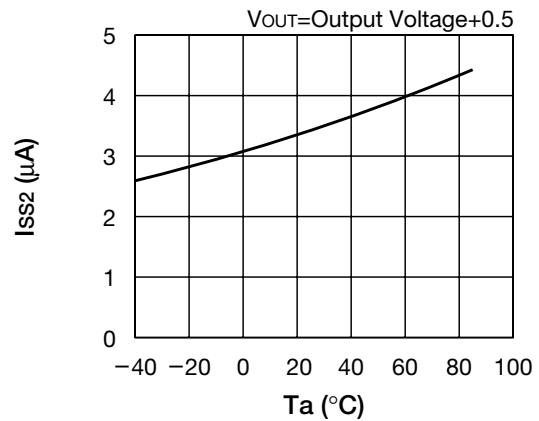
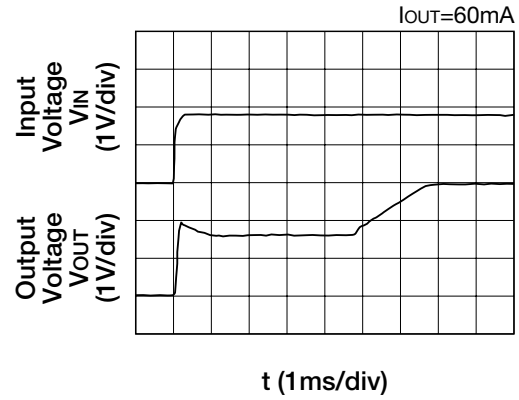### ■ Supply current (OFF) vs temperature
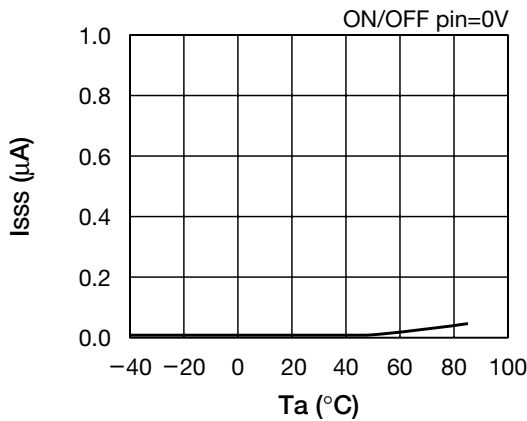
ON/OFF pin=0V

### ■ Switch current vs temperature

$V_{CONT}=0.4V$
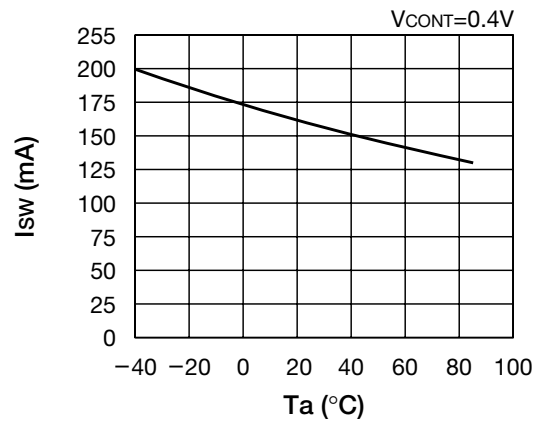
Note: these are typical characteristics.

■ Switch transistor leak current vs temperature

V$_{OUT}$=V$_{CONT}$=10V

I$_{SWQ}$ (μA) vs Ta (°C)
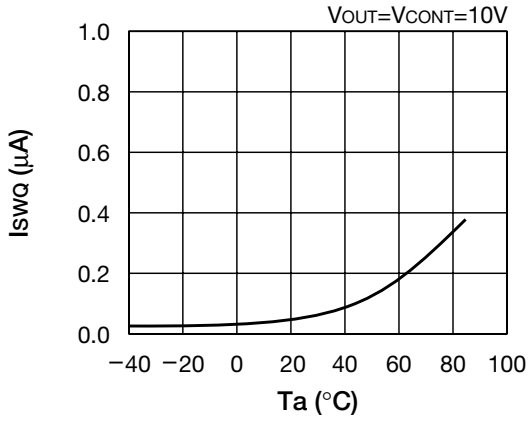
■ Oscillator frequency vs temperature

V$_{OUT}$=Output Voltage×0.95

f$_{OSC}$ (kHz) vs Ta (°C)
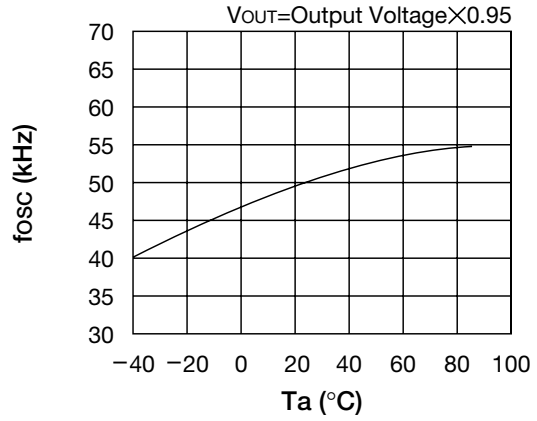
■ Maximum duty cycle vs temperature

V$_{OUT}$=Output Voltage×0.95

MaxDuty (%) vs Ta (°C)
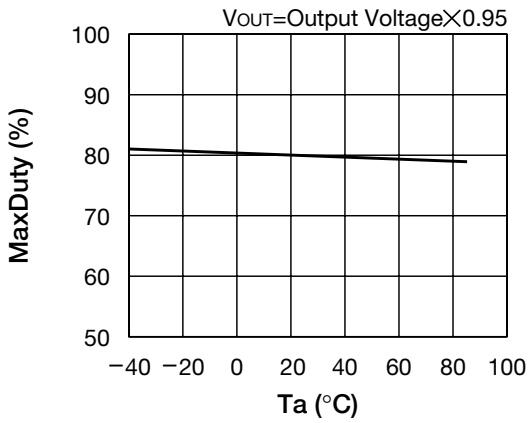
■ ON/OFF Pin input voltage (V$_{SH}$) vs temperature

V$_{OUT}$=Output Voltage ×0.95
The oscillation waveform of
CONT PIN is measured.

V$_{SH}$ (V) vs Ta (°C)
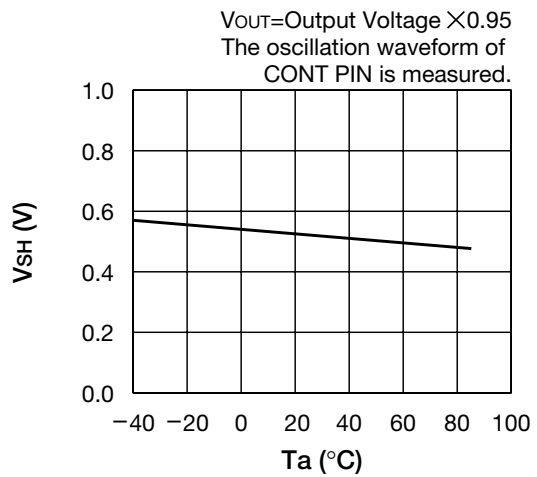
■ ON/OFF Pin input voltage (V$_{SL}$) vs temperature

V$_{OUT}$=Output Voltage×0.95
The oscillation stop of
CONT PIN is measured.

V$_{SL}$ (V) vs Ta (°C)
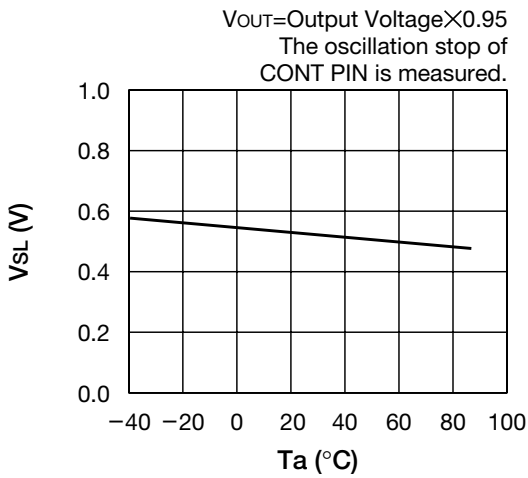
■ Soft start time vs temperature

I$_{OUT}$=1mA

T$_{SS}$ (ms) vs Ta (°C)
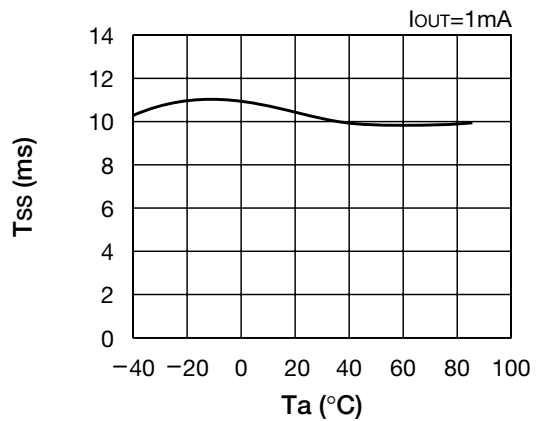
Note: these are typical characteristics.

■ Supply Current 1, 2 vs V$_{OUT}$

Ta=25°C

I$_{SS1, 2}$ (μA) vs V$_{OUT}$ (V)

■ Switch current vs V$_{OUT}$

Ta=25°C, V$_{CONT}$=0.4V

I$_{SW}$ (mA) vs V$_{OUT}$ (V)
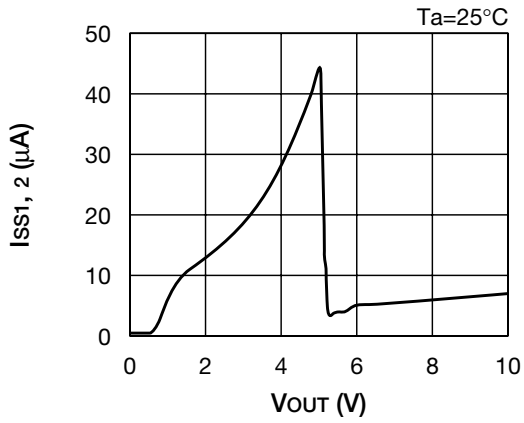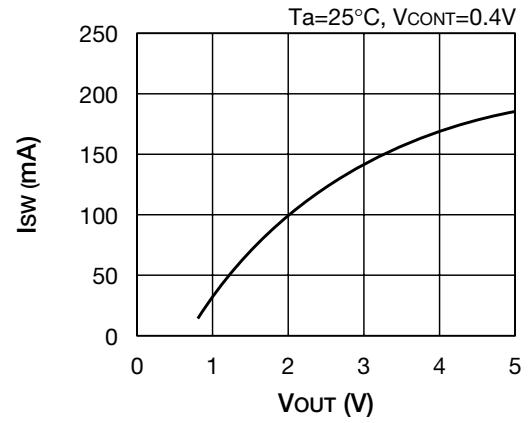
■ Oscillator frequency vs V$_{OUT}$

Ta=25°C

fosc (kHz) vs V$_{OUT}$ (V)
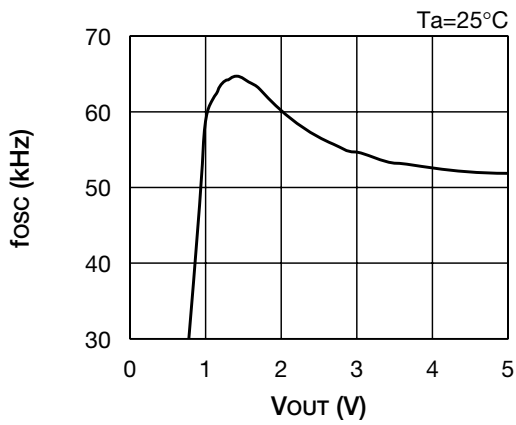
Note: these are typical characteristics.

## ■Ripple voltage characteristic (MM3005EN)

■ 1. $I_{OUT}$=200µA

$V_{IN}$=1.8V

Output Voltage $V_{OUT}$ (20mV/div)

CONT Voltage $V_{CONT}$ (1V/div)

t (10µs/div)

■ 2. $I_{OUT}$=10mA

$V_{IN}$=1.8V

Output Voltage $V_{OUT}$ (20mV/div)

CONT Voltage $V_{CONT}$ (1V/div)

t (10µs/div)

■ 3. $I_{OUT}$=60mA

$V_{IN}$=1.8V

Output Voltage $V_{OUT}$ (20mV/div)

CONT Voltage $V_{CONT}$ (1V/div)

t (10µs/div)
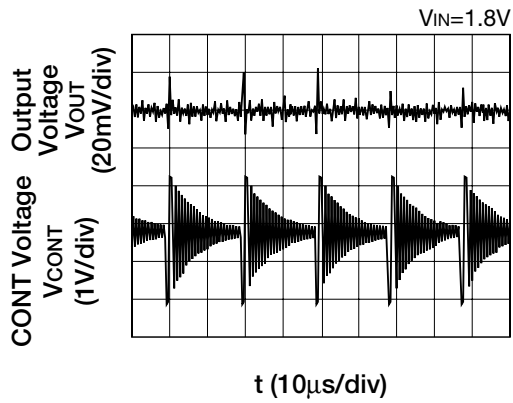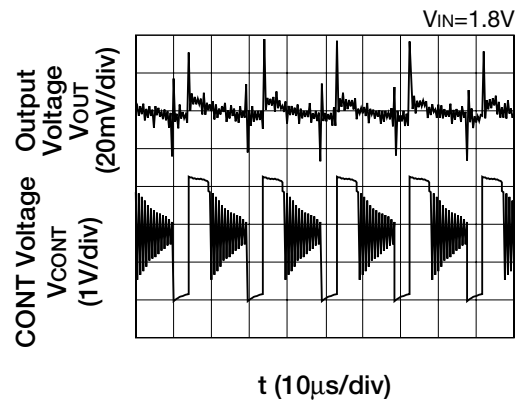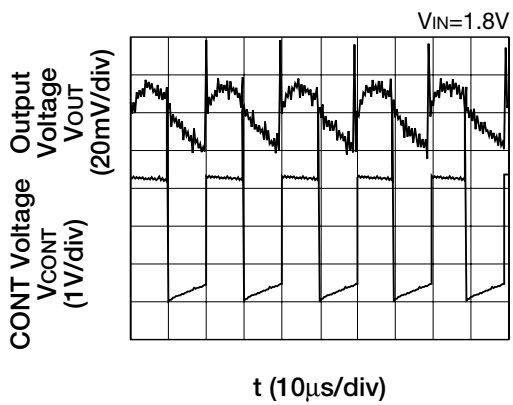
Note: these are typical characteristics.

# ■ Transient Response (MM3005EN)

## ■ 1. V$_{IN}$ : 0V→1.8V

I$_{OUT}$=1mA

Input Voltage V$_{IN}$ (1V/div)

Output Voltage V$_{OUT}$ (1V/div)

t (1ms/div)

I$_{OUT}$=60mA

Input Voltage V$_{IN}$ (1V/div)

Output Voltage V$_{OUT}$ (1V/div)

t (1ms/div)

## ■ 2. V$_{ON/OFF}$ : 0V→3.0V

I$_{OUT}$=1mA, V$_{IN}$=1.8V

Input Voltage V$_{ON/OFF}$ (1V/div)

Output Voltage V$_{OUT}$ (1V/div)

t (1ms/div)

I$_{OUT}$=60mA, V$_{IN}$=1.8V

Input Voltage V$_{ON/OFF}$ (1V/div)

Output Voltage V$_{OUT}$ (1V/div)

t (1ms/div)

## ■ 3. Load regulation

I$_{OUT}$: 100μA→50mA, V$_{IN}$=1.8V

Load Current I$_{OUT}$ (20mA/div)

Output Voltage V$_{OUT}$ (50mV/div)

t (200μs/div)

I$_{OUT}$: 50mA→100μA, V$_{IN}$=1.8V

Load Current I$_{OUT}$ (20mA/div)

Output Voltage V$_{OUT}$ (50mV/div)

t (5ms/div)

Note: these are typical characteristics.

## ■ 4. Line regulation

V$_{IN}$: 1.8V→2.4V, I$_{OUT}$=50mA

t (100μs/div)

V$_{IN}$: 2.4V→1.8V, I$_{OUT}$=50mA

t (200μs/div)
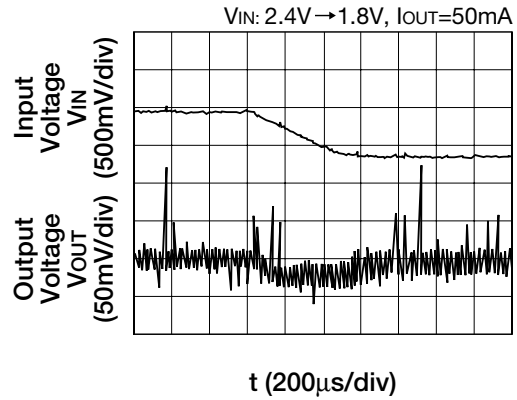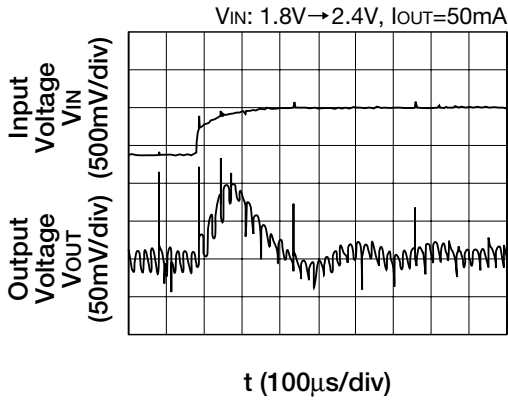
## ■ Output current vs starting output voltage and holding output voltage dependence characteristic
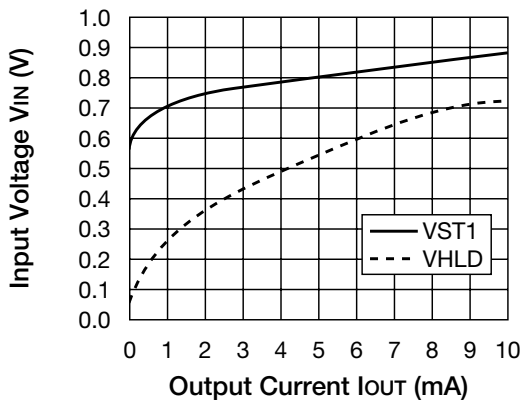
### ■ MM3005EN

### ■ MM3005H
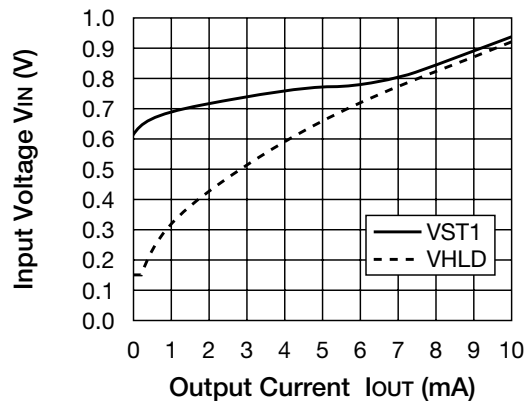
## ■ Input voltage vs supply current dependency charavteristic
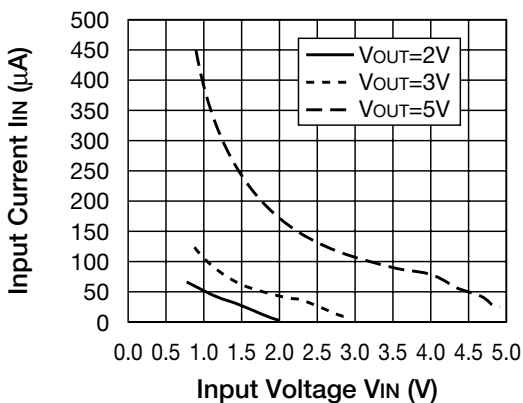
### ■ MM3005

Note: these are typical characteristics.

## Reference Data

### (1) MM3005EN (C5-K3L : 47µH)

■ Output current vs output voltage
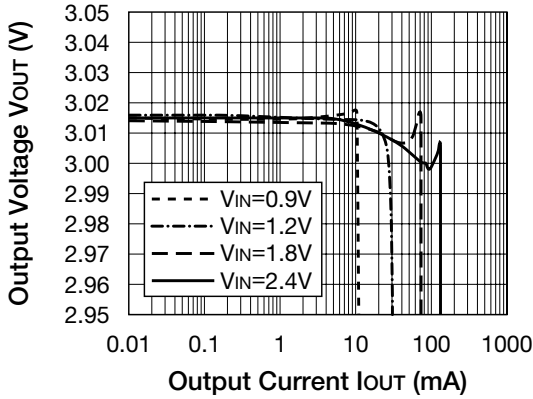
■ Output current vs efficiency
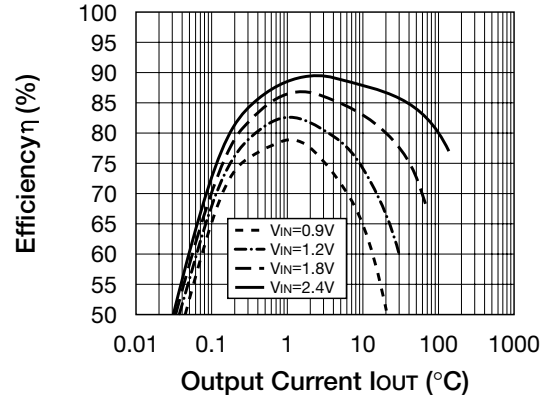


### (2) MM3005EN (C5-K3L : 100µH)
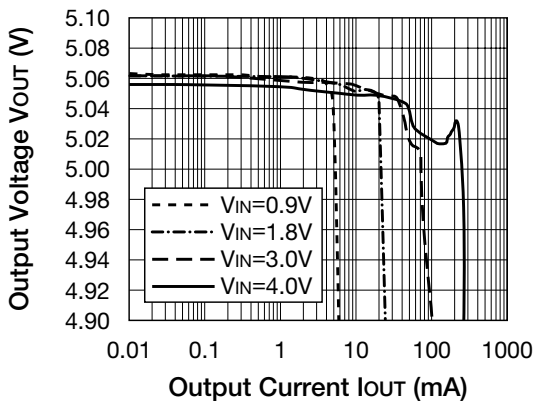
■ Output current vs output voltage
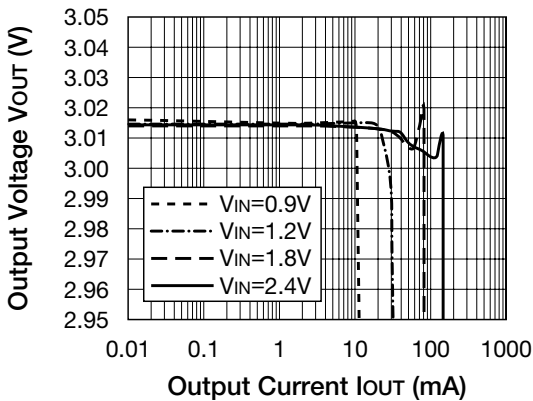
■ Output current vs efficiency
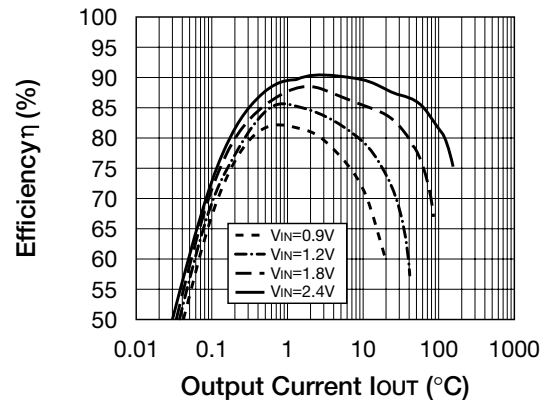


### (3) MM3005EN (C5-K3L : 150µH)

■ Output current vs output voltage
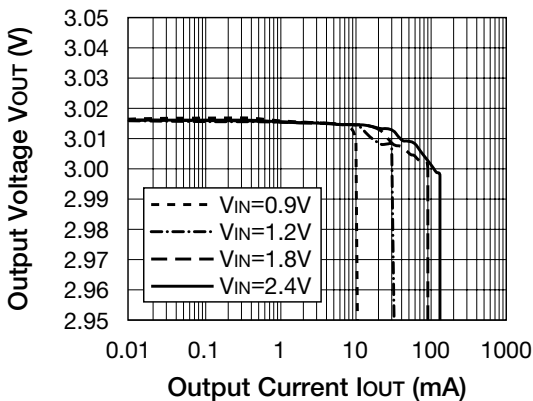
■ Output current vs efficiency
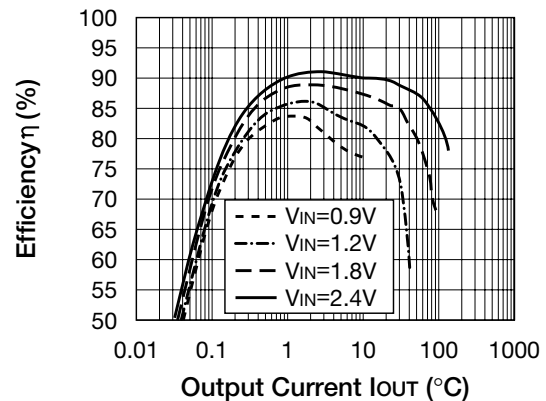


Note: these are typical characteristics.

## (4) MM3005HN (C5-K3L : 47µH)

■ Output current vs output voltage
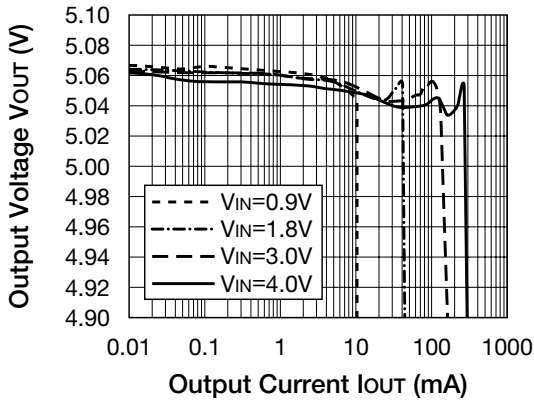


■ Output current vs efficiency
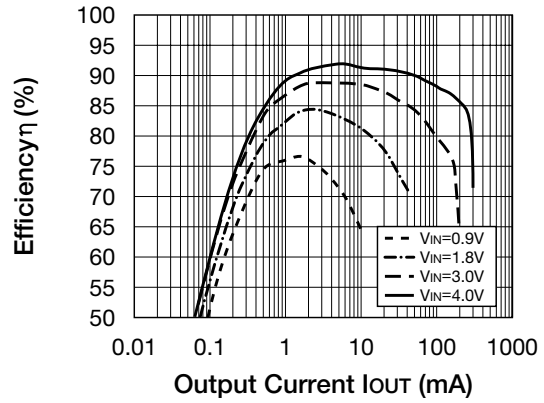


## (5) MM3005HN (C5-K3L : 100µH)

■ Output current vs output voltage
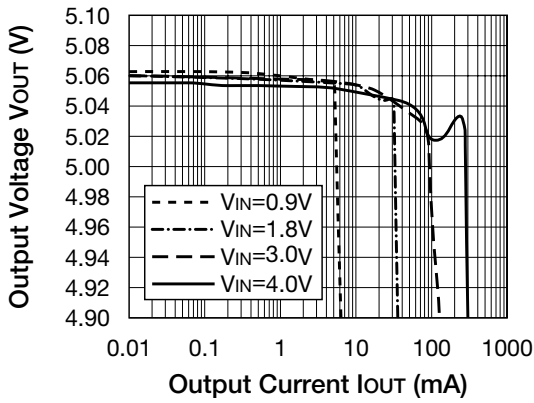


■ Output current vs efficiency
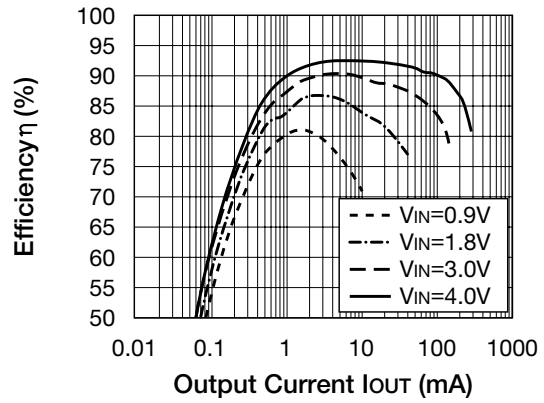


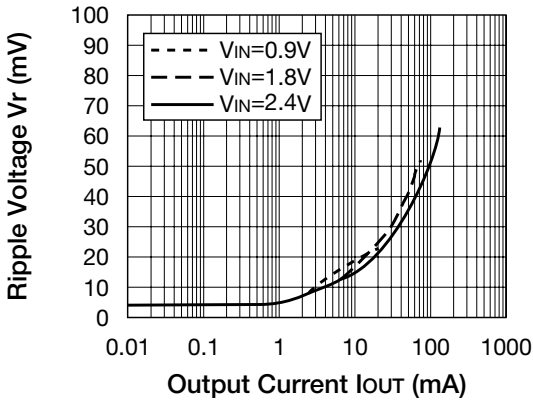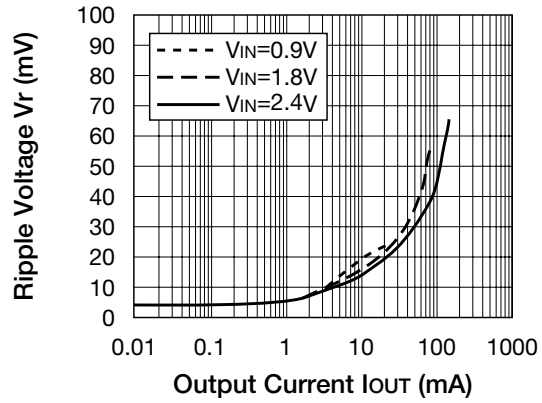## (6) MM3005HN (C5-K3L : 150µH)

■ Output current vs output voltage



■ Output current vs efficiency
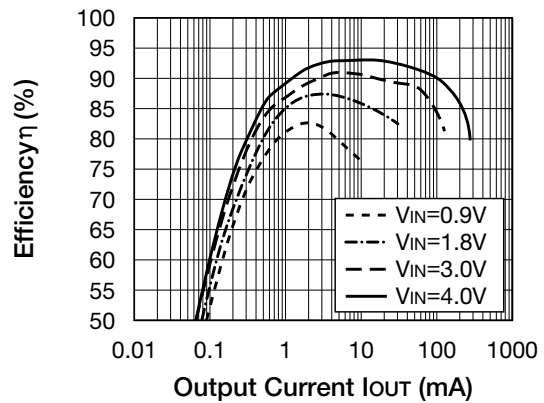


Note: these are typical characteristics.

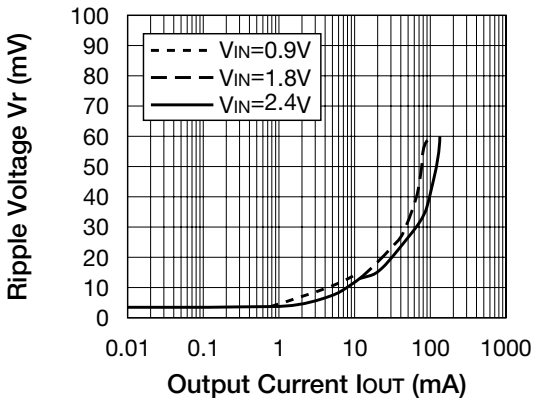### (7) MM3005EN (C5-K3L : 47μH, COUT : 33μF)

■ Output current vs ripple voltage



### (8) MM3005EN (C5-K3L : 100μH, COUT : 33μF)
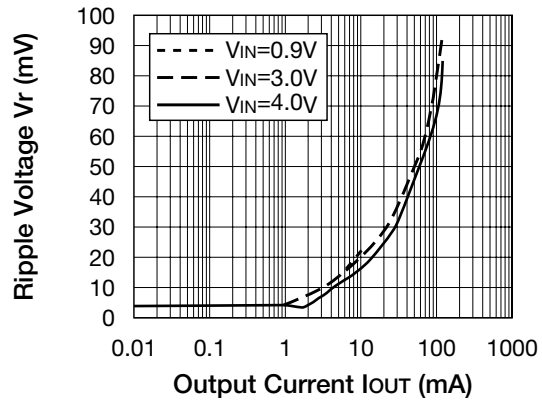
■ Output current vs ripple voltage



### (9) MM3005EN (C5-K3L : 150μH, COUT : 33μF)

■ Output current vs ripple voltage



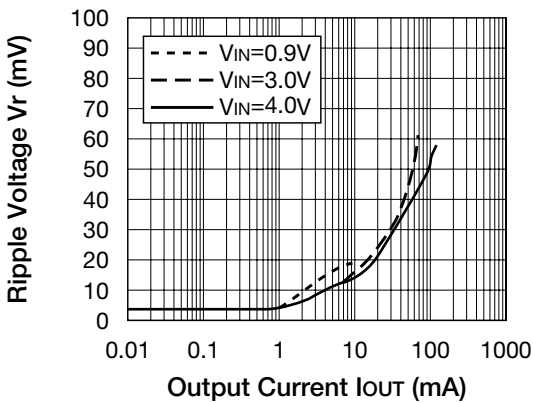### (10) MM3005HN (C5-K3L : 47μH, COUT : 33μF)

■ Output current vs ripple voltage



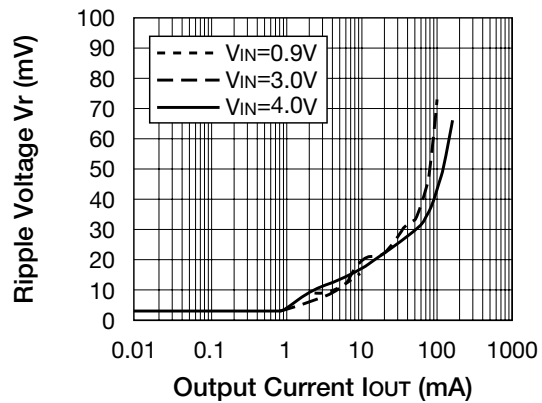### (11) MM3005HN (C5-K3L : 100μH, COUT : 33μF)

■ Output current vs ripple voltage



### (12) MM3005HN (C5-K3L : 150μH, COUT : 33μF)

■ Output current vs ripple voltage



Note: these are typical characteristics.