

3-CHANNEL WHITE LED DRIVER IC**(CHARGE PUMP IC WITH BUILT-IN CONSTANT-CURRENT CIRCUIT)****S-8813 Series**

The S-8813 Series is a PFM control charge pump DC-DC converter with a built-in constant-current circuit, and was developed using CMOS technology. Its constant current output makes this series ideal as a power supply for current drive LEDs.

The S-8813 Series features three output channels and can drive three LEDs.

This series is available in two types: a variable voltage type and a variable current setting resistance type.

Moreover, since small ceramic capacitors can be used as external capacitors (pump capacitors, input capacitors, output capacitors), the S-8813 Series contributes to set miniaturization.

■ Features

- PFM control CMOS charge pump
- Built-in constant-current circuit
- Power supply voltage: 2.7 V to 4.5 V
- Output current value: A current variable is possible between 5.0 mA and 18 mA
(At $V_{IOUT1,2,3} \leq 4.0$ V, $V_{IN} = 3.0$ V)
Variable voltage type and Variable current setting resistance type are available.
- Terminal output current matching: $\pm 1\%$ max.
- Built-in soft start circuit: 1.5 ms typ.
- Constant current output pins: 3 channels, $\pm 5\%$ accuracy
- Oscillation frequency: 600 kHz typ.
- ON/OFF function provided (During standby: 1 μ A max.)
- Ultra-small package: 10-Pin SON(B)
- Lead-free products

■ Applications

- Power supply for white LED display backlights
- Constant-current circuit
- Cellular phones and PDAs using 1-cell lithium batteries
- Power supply for flat panel displays

■ Package

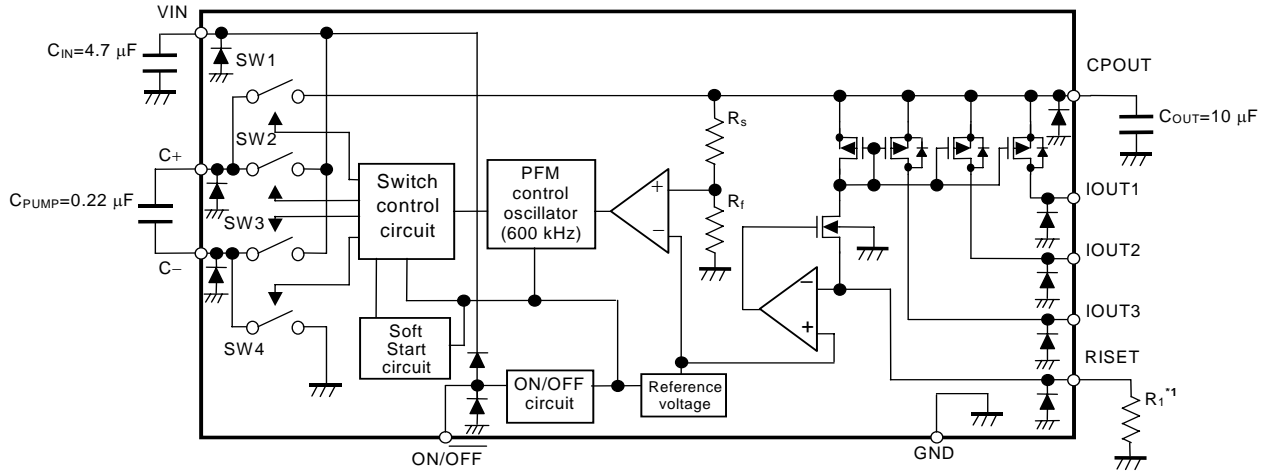
| Package Name | Drawing Code | | |
|---------------|--------------|---------|---------|
| | Package | Tape | Reel |
| 10-Pin SON(B) | PE010-A | PE010-A | PE010-A |

■ Product Name List

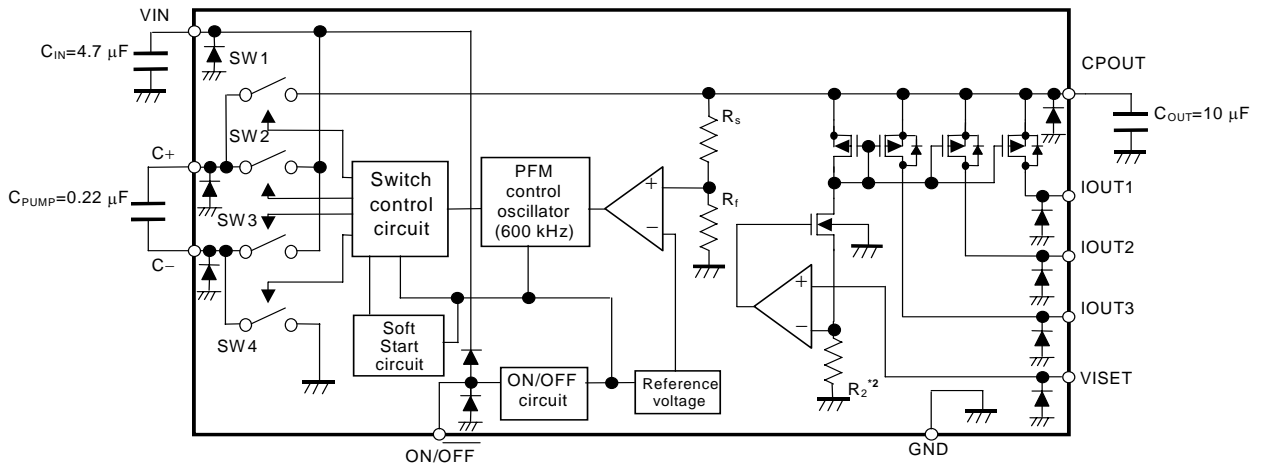
- S-881300CPE-IPATFG (Variable current setting resistance type)
- S-881300BPE-IOQTFG (Variable voltage type)

■ Block Diagrams

1. S-881300CPE



2. S-881300BPE



*1. Current setting resistance

*2. Internal resistance

Figure 1 Block Diagram

■ Pin Configuration

10-Pin SON(B)
Top View

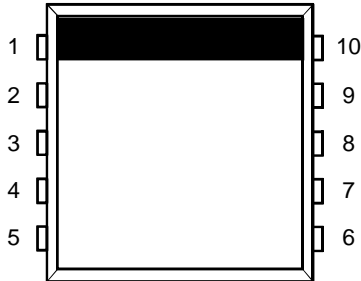


Figure 2 Pin Assignment

Table 1 Pin Descriptions

| Pin No. | Symbol | Description |
|---------|---------------|---|
| 1 | IOUT1 | Output pin (constant-current output) |
| 2 | IOUT2 | Output pin (constant-current output) |
| 3 | IOUT3 | Output pin (constant-current output) |
| 4 | C+ | Pump capacitor connection pin (positive pin) |
| 5 | C- | Pump capacitor connection pin (negative pin) |
| 6 | GND | GND pin |
| 7 | VIN | Voltage input pin |
| 8 | CPOUT | Charge pump output pin (capacitor connection pin) |
| 9 | RISET / VISET | Variable output current pins In the case of RISET, a resistor is connected to this pin and changing the resistance value can vary the output current. In the case of VISET, changing the voltage applied to this pin can vary the output current. |
| 10 | ON/OFF | Power-off pin High level: Normal operation (Step-up operation) Low level: Stepping-up halt (Whole circuit stopped) |

■ **Absolute Maximum Ratings**

Table 2 Absolute Maximum Ratings

(Unless otherwise specified, Ta = 25°C)

| Item | Symbol | Absolute Maximum Rating | Unit |
|-------------------------------|------------------------|---------------------------------|------|
| IOUT 1, 2, 3 pin voltage | $V_{IOUT1,2,3}$ | $V_{SS}-0.3$ to $V_{SS}+7$ | V |
| C+ pin voltage | V_{C+} | $V_{SS}-0.3$ to $V_{SS}+7.5$ | V |
| C- pin voltage | V_{C-} | $V_{SS}-0.3$ to $V_{SS}+7$ | V |
| VIN pin voltage | V_{IN} | $V_{SS}-0.3$ to $V_{SS}+5$ | V |
| CPOUT pin voltage | V_{CPOUT} | $V_{SS}-0.3$ to $V_{SS}+7$ | V |
| RISSET/VISET pin voltage | V_{RISSET}/V_{VISET} | $V_{SS}-0.3$ to $V_{SS}+7$ | V |
| ON/OFF pin voltage | $V_{ON/OFF}$ | $V_{SS}-0.3$ to $V_{IN}+0.3$ | V |
| Power dissipation | P_D | 290 (When not mounted on board) | mW |
| | | 700*1 | mW |
| Operating ambient temperature | T_{opr} | -40 to +85 | °C |
| Storage temperature | T_{stg} | -40 to +125 | °C |

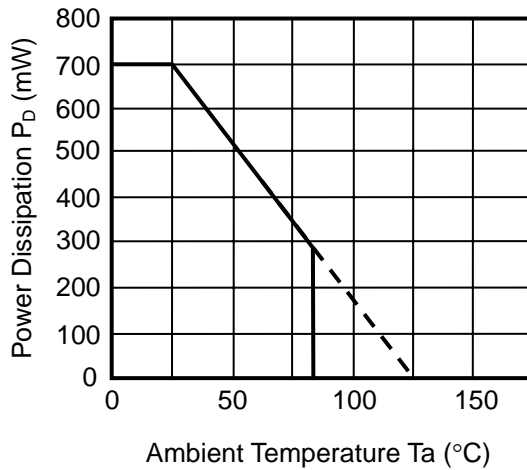
*1. When mounted on board

[Mounted board]

- (1) Board size: 114.3 mm × 76.2 mm × t1.6 mm
- (2) Board name: JEDEC STANDARD51-7

Caution The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

(1) When mounted on board



(2) When not mounted on board

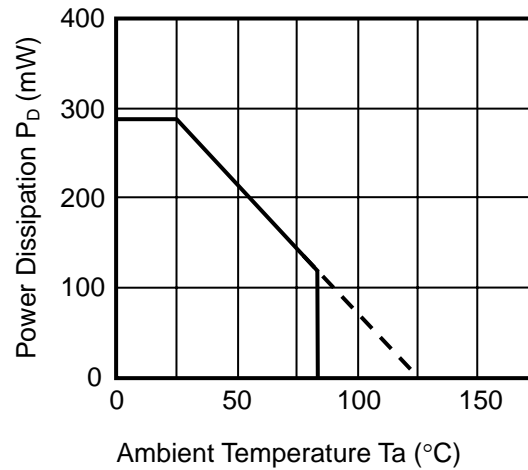


Figure 3 Power Dissipation of Package

■ Electrical Characteristics

1. S-881300CPE

Table 3 Electrical Characteristics

(Unless otherwise specified, $V_{IN} = 3.0\text{ V}$, current setting resistance = 5.6 k Ω , $T_a = 25^\circ\text{C}$)

| Item | Symbol | Conditions | Min. | Typ. | Max. | Unit | Test Circuit |
|---|-----------------------------------|---|------|------|------|-------------------|--------------|
| Operation input voltage | V_{IN} | — | 2.7 | — | 4.5 | V | 2 |
| Stabilized output current | I_{OUT} | $V_{IN} = 3.0\text{ V to }4.5\text{ V}$ $V_{IOUT1,2,3}^{*1} \leq 3.6\text{ V}$ | 23 | — | — | mA | |
| | | $V_{IN} = 3.0\text{ V to }4.5\text{ V}$ $V_{IOUT1,2,3}^{*1} \leq 4.0\text{ V}$ | 18 | — | — | | |
| | | $V_{IN} = 2.7\text{ V to }3.0\text{ V}$ $V_{IOUT1,2,3}^{*1} \leq 3.6\text{ V}$ | 14 | — | — | | |
| Output current V_{IOUT} characteristics | ΔI_{OUT1} | $V_{IN} = 3.0\text{ V}$, $V_{IOUT} = 3.0\text{ V to }4.0\text{ V}$ | — | 0.5 | 1 | | |
| Output current input stability | ΔI_{OUT2} | $V_{IN} = 3.0\text{ V to }4.5\text{ V}$ $V_{IOUT} \leq 3.6\text{ V}$ | — | 0.5 | 1 | | |
| Output current accuracy | $\frac{\Delta I_{OUT1}}{I_{OUT}}$ | $I_{OUT1,2,3} = 17.8\text{ mA}$ | -5.0 | — | +5.0 | % | |
| Inter-pin output current variation | ΔI_M | $V_{IOUT} = 3.6\text{ V}$ | -1.0 | — | +1.0 | | |
| Ripple voltage | V_{RIP} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ $I_{OUT1,2,3} = 18\text{ mA}$ | — | — | 100 | mV _{p-p} | |
| Maximum oscillation frequency | f_{osc} | $V_{CP\text{OUT}} = 4.75\text{ V}$ Measure waveform at C- pin | 540 | 600 | 660 | kHz | 1 |
| Efficiency ^{*2} | η | $V_{IN} = 3.0\text{ V}$, $I_{OUT1,2,3} = 18\text{ mA}$ | — | 82 | — | % | 2 |
| Operation consumption current | I_{SS1} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ $V_{CP\text{OUT}} = 4.75\text{ V}$ | — | 1 | 1.5 | mA | 1 |
| Standby consumption current | I_{SSS} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | — | 0.3 | 1 | μA | |
| Power-off pin input voltage (high level) | V_{SH} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | 2.0 | — | — | V | |
| Power-off pin input voltage (low level) | V_{SL} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | — | — | 0.3 | | |
| Power-off pin input current (high level) | I_{SH} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | -0.1 | — | 0.1 | μA | |
| Power-off pin input current (low level) | I_{SL} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | -0.1 | — | 0.1 | | |
| Soft start time | t_{SS} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | 0.3 | 1.5 | 3 | ms | 2 |
| RISSET pin voltage | V_{RISSET} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | 0.98 | 1 | 1.02 | V | |

*1. $V_{IOUT1,2,3}$ are the voltages of the IOUT pin.

*2. "Efficiency" in the electrical characteristics means the efficiency of the charge pump circuit block. The ideal efficiency is indicated by the following expression.

$$\text{Efficiency} = [V_{CP\text{OUT}} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})] / [2.0 \times V_{IN} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})]$$

The ideal efficiency including the constant current circuit is expressed as following expression.

$$\text{Efficiency} = [(V_{IOUT1} \times I_{OUT1}) + (V_{IOUT2} \times I_{OUT2}) + (V_{IOUT3} \times I_{OUT3})] / [2.0 \times V_{IN} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})]$$

Remark The numbers in the "test circuit" column correspond to the circuit numbers in the "Measurement Circuits" section.

2. S-881300BPE

Table 4 Electrical Characteristics

(Unless otherwise specified, $V_{IN} = 3.0\text{ V}$, current setting voltage = 1.8 V, $T_a = 25^\circ\text{C}$)

| Item | Symbol | Conditions | Min. | Typ. | Max. | Unit | Test Circuit |
|---|-----------------------------------|---|------|------|------|-------------------|--------------|
| Operation input voltage | V_{IN} | — | 2.7 | — | 4.5 | V | 2 |
| Stabilized output current | I_{OUT} | $V_{IN} = 3.0\text{ V to }4.5\text{ V}$ $V_{IOUT1,2,3}^{*1} \leq 3.6\text{ V}$ | 23 | — | — | mA | |
| | | $V_{IN} = 3.0\text{ V to }4.5\text{ V}$ $V_{IOUT1,2,3}^{*1} \leq 4.0\text{ V}$ | 18 | — | — | | |
| | | $V_{IN} = 2.7\text{ V to }3.0\text{ V}$ $V_{IOUT1,2,3}^{*1} \leq 3.6\text{ V}$ | 14 | — | — | | |
| Output current V_{IOUT} characteristics | ΔI_{OUT1} | $V_{IN} = 3.0\text{ V}$, $V_{IOUT} = 3.0\text{ V to }4.0\text{ V}$ | — | 0.5 | 1 | | |
| Output current input stability | ΔI_{OUT2} | $V_{IN} = 3.0\text{ V to }4.5\text{ V}$ $V_{IOUT} \leq 3.6\text{ V}$ | — | 0.5 | 1 | | |
| Output current accuracy | $\frac{\Delta I_{OUT1}}{I_{OUT}}$ | $I_{OUT1,2,3} = 18\text{ mA}$ | -5.0 | — | +5.0 | | |
| Inter-pin output current variation | ΔI_M | $V_{IOUT} = 3.6\text{ V}$ | -1.0 | — | +1.0 | mV _{p-p} | |
| Ripple voltage | V_{RIP} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | — | — | 100 | | |
| Maximum oscillation frequency | f_{osc} | $V_{CP\text{OUT}} = 4.75\text{ V}$ Measure waveform at C- pin | 540 | 600 | 660 | kHz | 1 |
| Efficiency ^{*2} | η | $V_{IN} = 3.0\text{ V}$ | — | 82 | — | % | 2 |
| Operation consumption current | I_{SS1} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ $V_{CP\text{OUT}} = 4.75\text{ V}$ | — | 1 | 1.5 | mA | 1 |
| Standby consumption current | I_{SSS} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | — | 0.3 | 1 | μA | |
| Power-off pin input voltage (high level) | V_{SH} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | 2.0 | — | — | V | |
| Power-off pin input voltage (low level) | V_{SL} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | — | — | 0.3 | | |
| Power-off pin input current (high level) | I_{SH} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | -0.1 | — | 0.1 | μA | |
| Power-off pin input current (low level) | I_{SL} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | -0.1 | — | 0.1 | | |
| Soft start time | t_{SS} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | 0.3 | 1.5 | 3 | ms | 2 |
| VISET pin voltage | V_{VISET} | $V_{IN} = 2.7\text{ V to }4.5\text{ V}$ | 0.5 | — | 1.8 | V | |

*1. $V_{IOUT1, 2, 3}$ are the voltages of the IOUT pin.

*2. "Efficiency" in the electrical characteristics means the efficiency of the charge pump circuit block. The ideal efficiency is indicated by the following expression.

$$\text{Efficiency} = [V_{CP\text{OUT}} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})] / [2.0 \times V_{IN} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})]$$

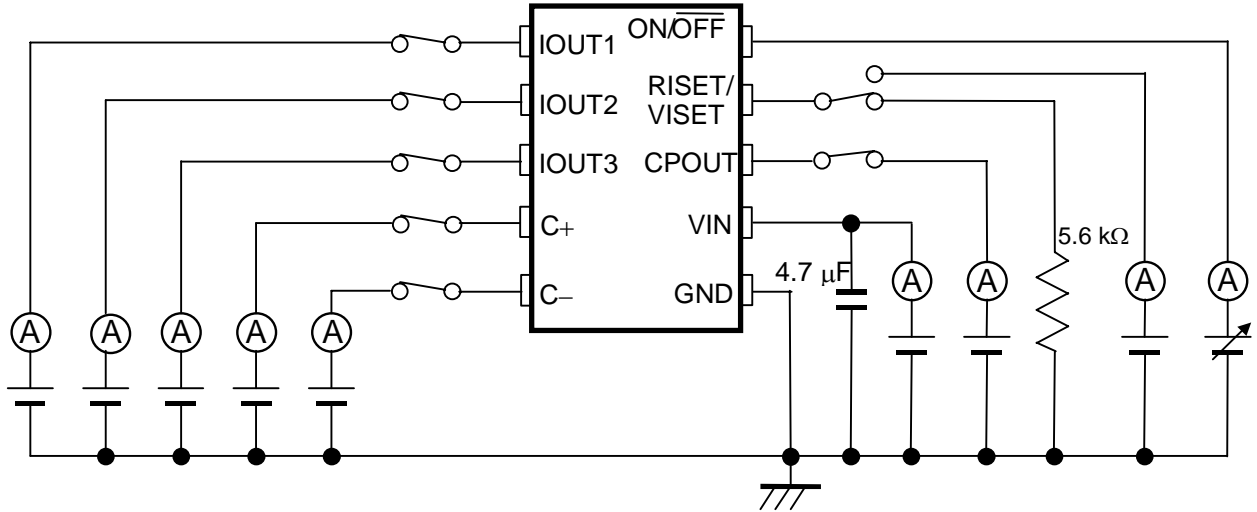
The ideal efficiency including the constant current circuit is expressed as following expression.

$$\text{Efficiency} = [(V_{IOUT1} \times I_{OUT1}) + (V_{IOUT2} \times I_{OUT2}) + (V_{IOUT3} \times I_{OUT3})] / [2.0 \times V_{IN} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})]$$

Remark The numbers in the "test circuit" column correspond to the circuit numbers in the "Measurement Circuits" section.

■ Measurement Circuits

1.



2.

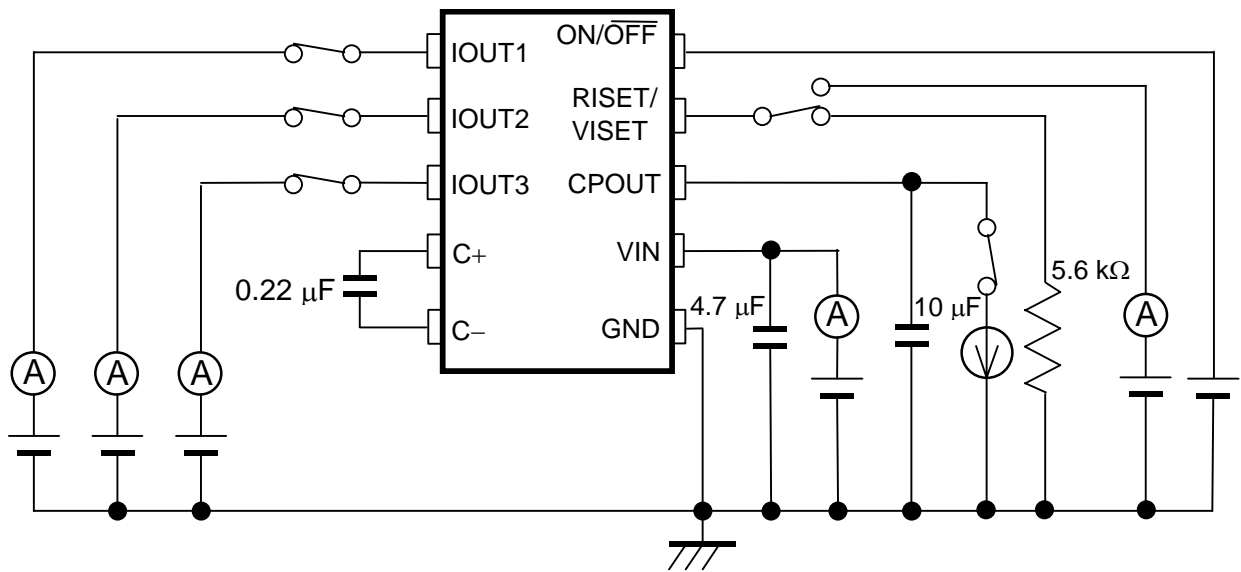


Figure 4 Measurement Circuits

■ Operation

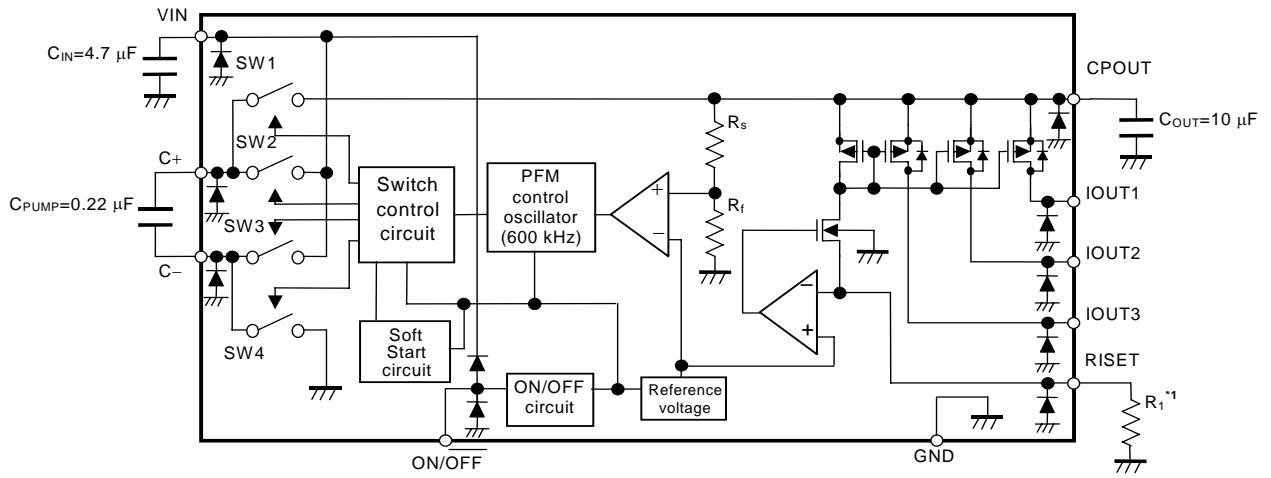
1. Basic Operation

The S-8813 series controls by using the pulse frequency modulation (PFM) method. The SW1 to SW4 switching transistors are switched ON/OFF with the clock generated by the internal oscillator (OSC), and operates the step-up charge pump.

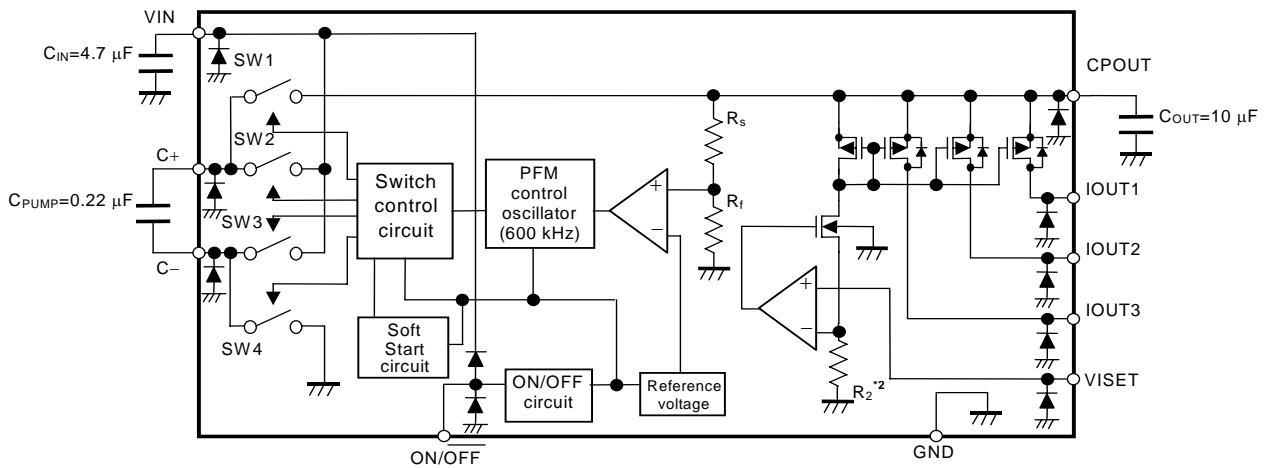
The output voltage is feed back and the voltage split by feedback resistances R_s and R_f and reference voltage (V_{ref}) are compared by a comparator. This comparator signal is used to modulate the oscillation pulse frequency in order to keep the output voltage constant.

Using this constant output voltage as the voltage source, a constant current is created using V_{ref} and the external resistance value applied to the Riset pin, and this constant current is supplied as the current output to the three channels of output pins (IOUT1 to IOUT3). Therefore, even if the white LED V_F (forward voltage) varies between 3 V and 4 V, a constant current can be supplied, making it possible to reduce fluctuations in brightness and keep white LEDs shining at a constant brightness.

S-881300CPE



S-881300BPE



*1. Current setting resistance

*2. Internal resistance

Figure 5 Block Diagram

2. Step-up Charge Pump

The step-up charge pump steps up the voltage by switching ON/OFF the SW1 to SW4 switching transistors.

First, in order to charge the pump capacitance (C_{PUMP}), set SW1 to OFF, SW2 to ON, SW3 to OFF, and SW4 to ON (charge cycle). Following charging the electricity, in order to discharge the charged electricity to the output capacitance (C_{OUT}), SW1 set the switches as to ON, SW2 to OFF, SW3 to ON, and SW4 to OFF (discharge cycle).

The input voltage can be stepped up to a constant voltage value by repeating this charge cycle and discharge cycle.

In the S-8813 Series, the V_{IN} voltage range of 2.7 V to 4.5 V is stepped up to $V_{CPOUT} = 5 V$.

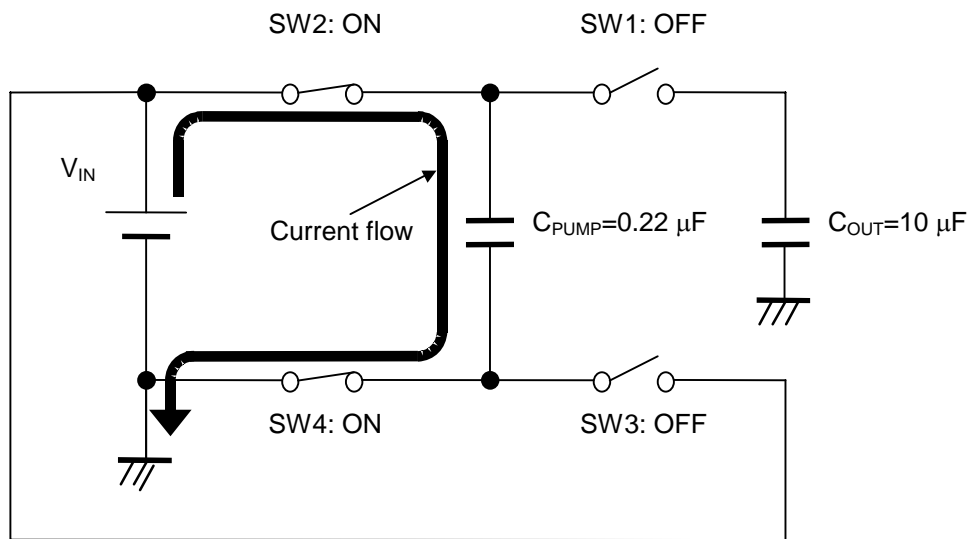


Figure 6 Charge Cycle

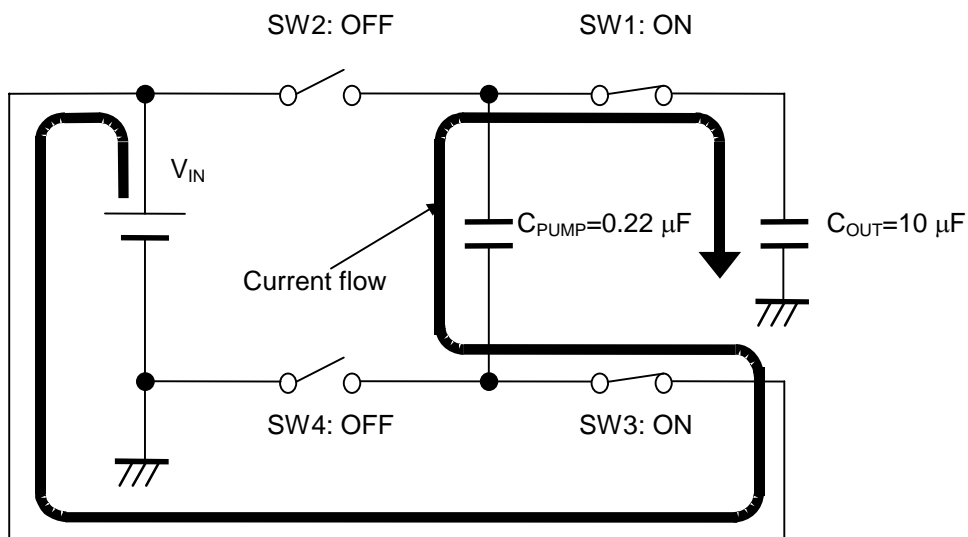


Figure 7 Discharge Cycle

3. Constant current output circuit

The S-8813 Series features a three-channel constant current output circuit and enables driving of white LEDs in the current mode.

In the case of the S-8813 Series, the constant current value can be controlled using one of the two following methods according to the product.

In the case of the S-881300CPE, the desired constant current can be obtained with an external resistance value. Since a reference voltage of $1\text{ V} \pm 2\%$ is output to the RISET pin, application of resistance R_1 of $20\text{ k}\Omega$ to $5.6\text{ k}\Omega$ between the RISET pin and GND results in the flow of a constant current of $50\text{ }\mu\text{A}$ to $178\text{ }\mu\text{A}$ in the current setting resistance (R_1) due to the $I = V/R$ relationship. Amplifying this constant current 100 times and outputting it to I_{OUT1} , I_{OUT2} , and I_{OUT3} can obtain a constant current of between 5 mA to 17.8 mA /channel.

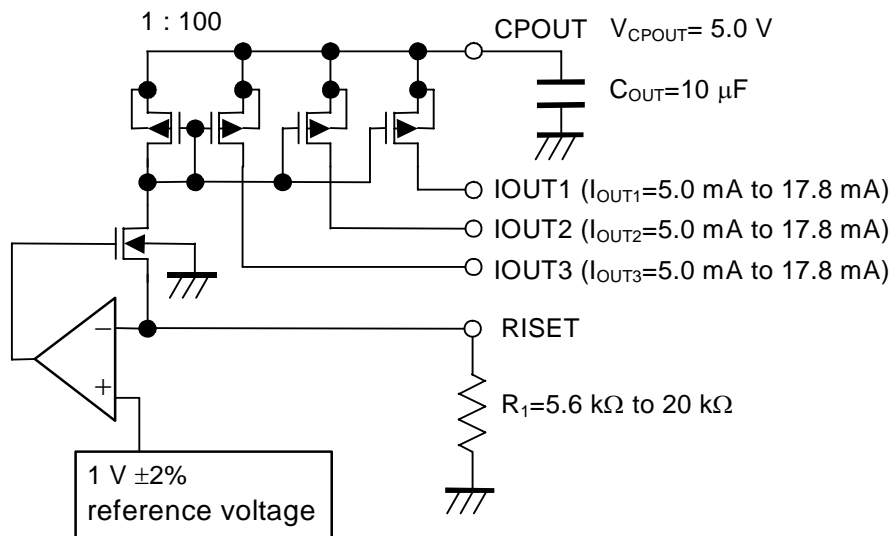


Figure 8 Constant Current Circuit (S-881300CPE)

On the other hand, a constant current of the desired value can also be obtained for the S-881300BPE by supplying the reference voltage to the VISET pin externally. Within the IC, a resistance of $10\text{ k}\Omega$ is applied between the VISET pin and GND. The application of a reference voltage of between 0.5 V and 1.8 V to the VISET pin results in the flow of a current between $50\text{ }\mu\text{A}$ and $180\text{ }\mu\text{A}$ in the internal resistor (R_2) due to the $I = V/R$ relationship. Amplifying this constant current 100 times and outputting it to I_{OUT1} , I_{OUT2} , and I_{OUT3} can obtain a constant current of between 5 mA to 18 mA /channel.

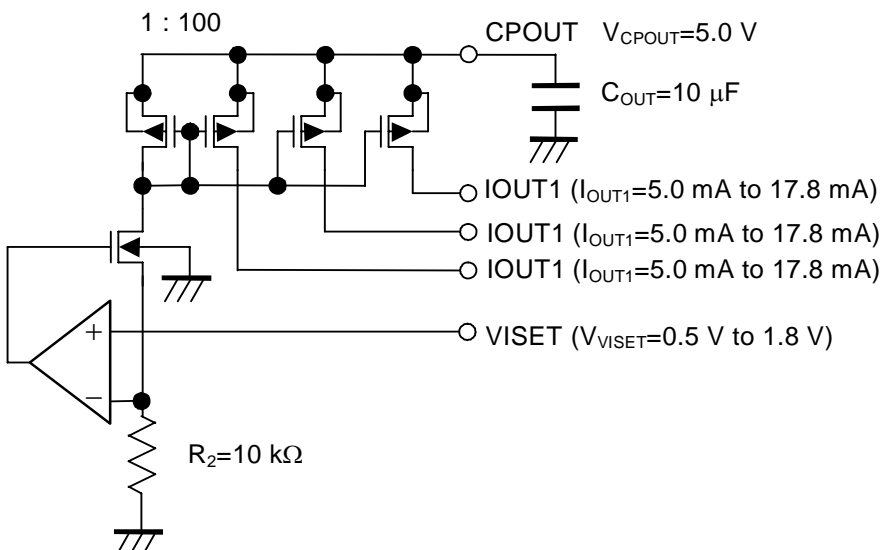


Figure 9 Constant Current Circuit (S-881300BPE)

4. ON/OFF Pin (Power Off Pin)

Setting the ON/OFF pin to the Low level ("L") causes the voltage of the CPOUT pin to change to the GND potential and simultaneously the operation of all the internal circuit to stop. At this time, the consumption current is largely reduced, to a level of approximately 0.3 μA.

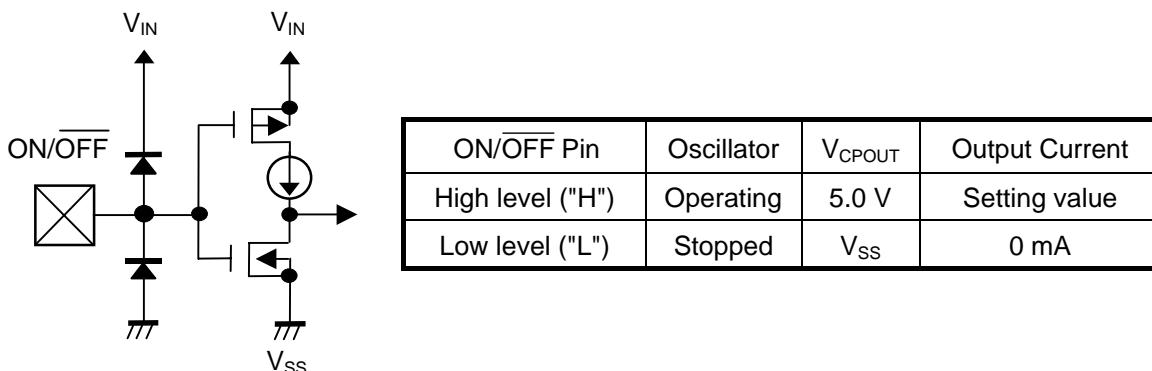


Figure 10 Equivalent Circuit of ON/OFF Pin

5. Soft Start Function

The S-8813 Series features a built-in soft start circuit. Upon power application or when the ON/OFF pin is switched from "L" to "H", the output voltage gradually rises over the soft start time, and the output current is gradually output as a result. This soft start function reduces the input current rush.

6. External Capacitor Selection

6.1 Input and Output Capacitors (C_{IN}, C_{OUT})

The input capacitor (C_{IN}) lowers the power supply impedance and averages the input current, resulting in improved efficiency.

The C_{IN} value is selected according to the impedance of the power supply that is used. Select a ceramic capacitor with a small equivalent series resistance (ESR). Although this figure varies according to the impedance of the power supply that is used as well as the load current value, it is generally in the range of 4.7 μF to 10 μF.

For the output capacitor (C_{OUT}), select a ceramic capacitor with a small ESR for smoothing the ripple voltage. A value of 10 μF is recommended for the capacitance value. Use of a capacitor with a capacitance lower than 10 μF results in a larger ripple voltage as well as a larger ripple current for the output current.

Conversely, use of a capacitor with a capacitance greater than 10 μF results in the output voltage not being able to rise up to 5.0 V and the impossibility to obtain the desired output current.

6.2 Pump Capacitor (C_{PUMP})

The pump capacitor (C_{PUMP}) is required for stepping up the voltage. Select a ceramic capacitor with a small ESR. A capacitance value of 0.22 μF is recommended. Use of a capacitor with a capacitance greater than 0.22 μF results in a larger ripple voltage as well as a larger ripple current for the output current. Conversely, use of a capacitor with a capacitance lower than 0.22 μF results in the output voltage not being able to raise up to 5.0 V and the impossibility to obtain the desired output current.

■ Application Circuit Examples

1. Variable Current Setting Resistance Type

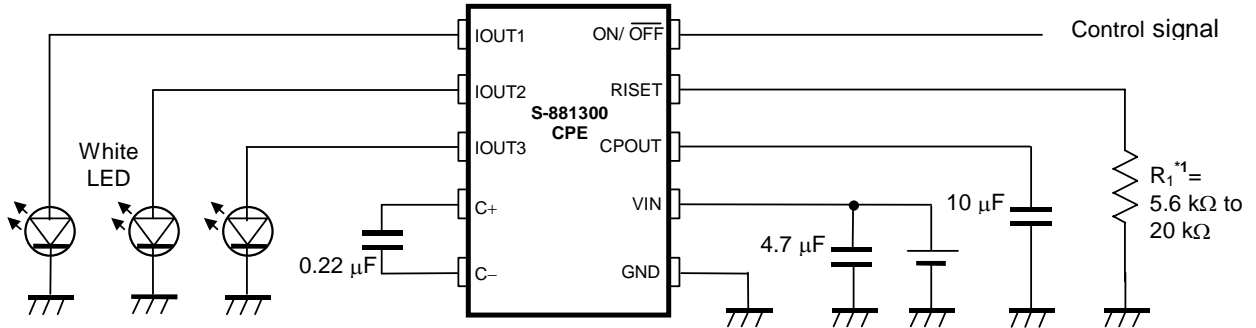


Figure 11 Application Circuit 1 (S-881300CPE)

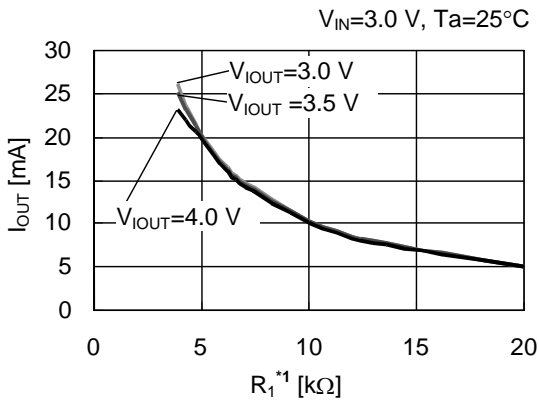


Figure 12 R_1^{*1} Dependence (S-881300CPE)

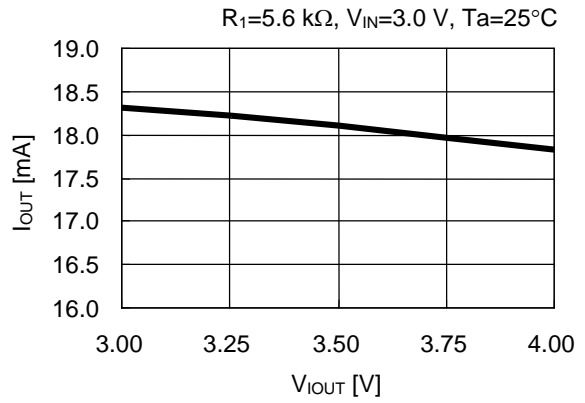


Figure 13 V_{IOUT} Dependence (S-881300CPE)

*1. Current setting resistance

2. Variable Voltage Type

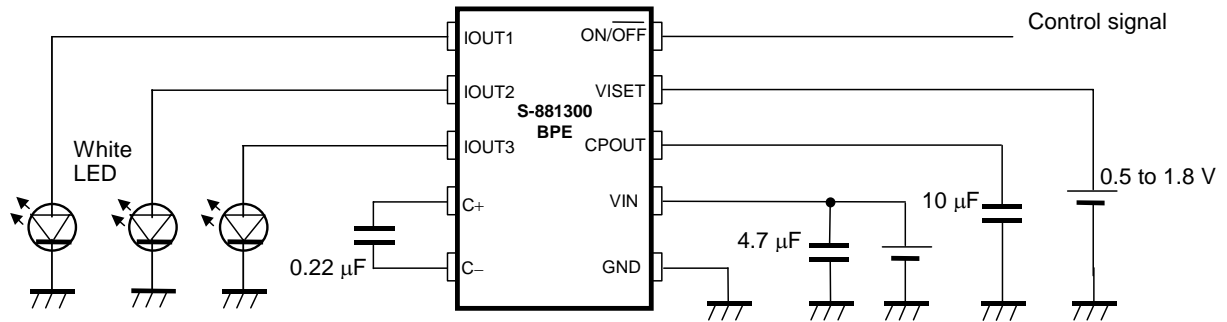


Figure 14 Application Circuit 2 (S-881300BPE)

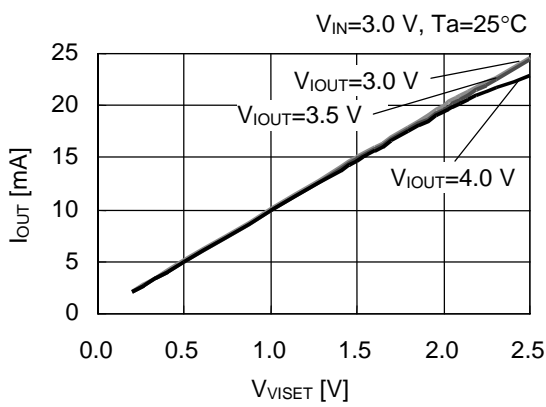


Figure 15 V_{VISET} Dependence (S-881300BPE)

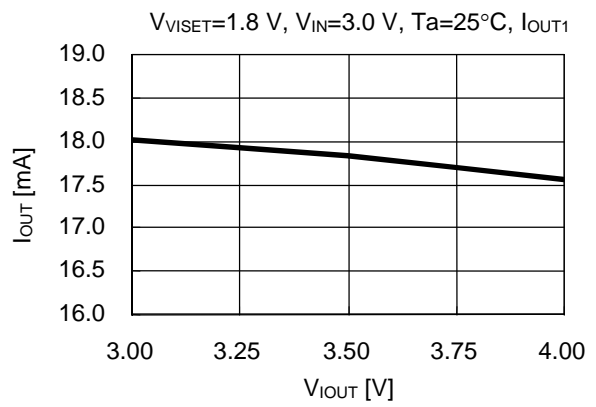


Figure 16 V_{IOUT} Dependence (S-881300BPE)

3. Regulating Luminance Circuit via PWM control signal (It corresponds only to S-881300CPE.)

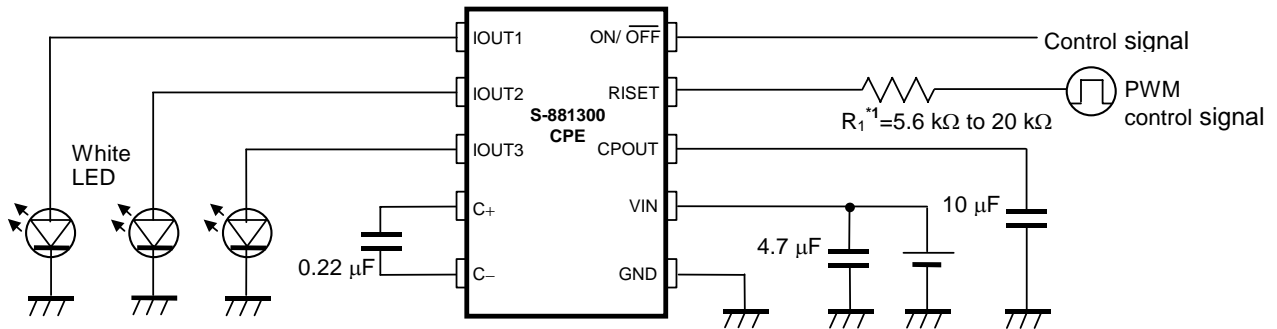


Figure 17 Application Circuit 3 (S-881300CPE)

(1) When $f_{PWM}=1.0$ kHz

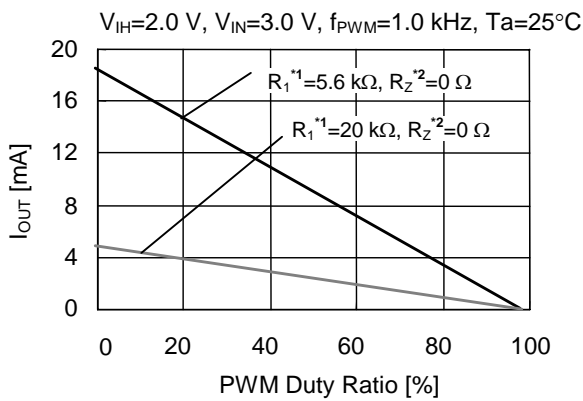


Figure 18 I_{OUT} -PWM Duty Ratio Dependence 1 (R_1^{*1} Dependence)

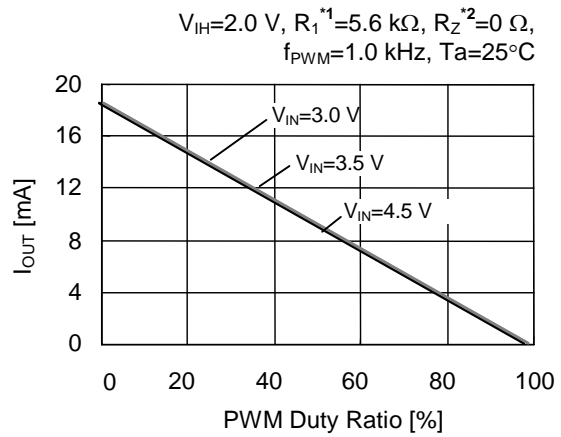


Figure 19 I_{OUT} -PWM Duty Ratio Dependence 1 (V_{IN} Dependence)

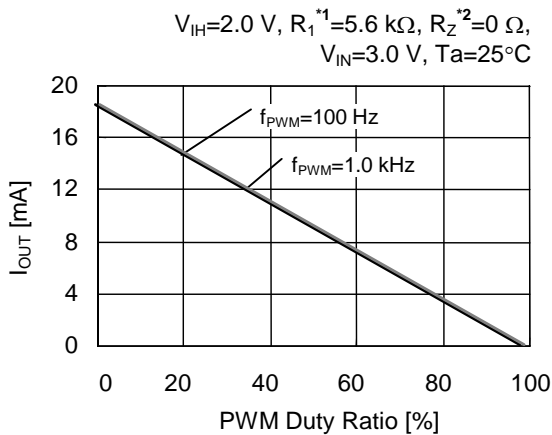


Figure 20 I_{OUT} -PWM Duty Ratio Dependence 1 (f_{PWM} Dependence)

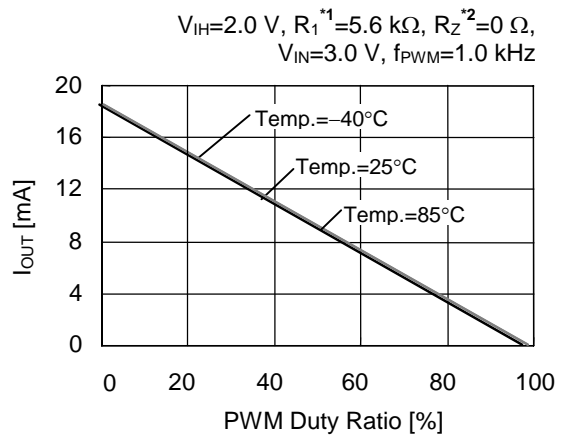


Figure 21 I_{OUT} -PWM Duty Ratio Dependence 1 (Temp. Dependence)

*1. Current setting resistance

*2. The output impedance of the PWM output control signal source when the PWM control signal is "L"

(2) When $f_{PWM}=20$ kHz

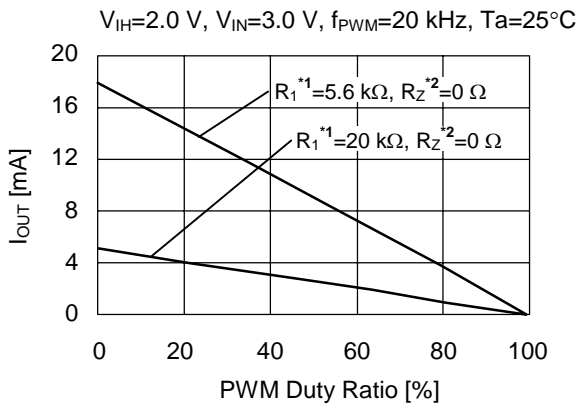


Figure 22 I_{OUT} -PWM Duty Ratio Dependence 2 (R_1^{*1} Dependence)

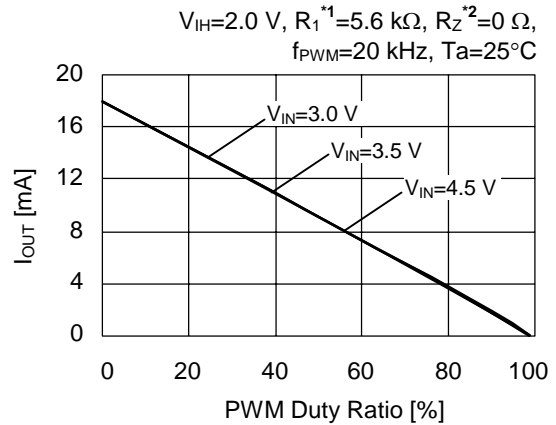


Figure 23 I_{OUT} -PWM Duty Ratio Dependence 2 (V_{IN} Dependence)

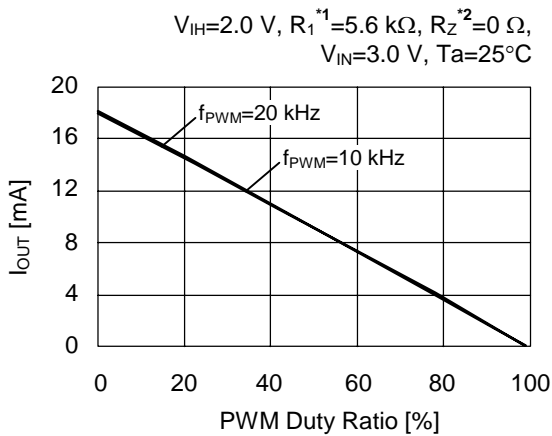


Figure 24 I_{OUT} -PWM Duty Ratio Dependence 2 (f_{PWM} Dependence)

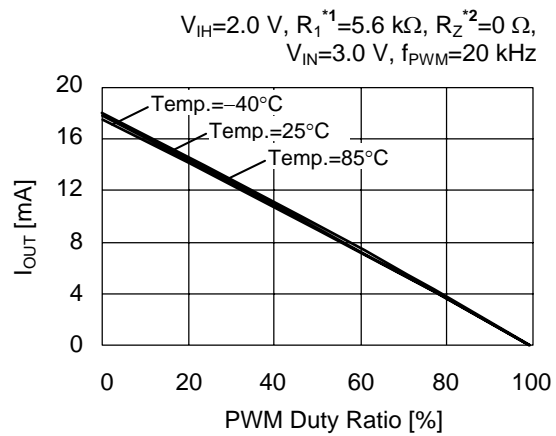
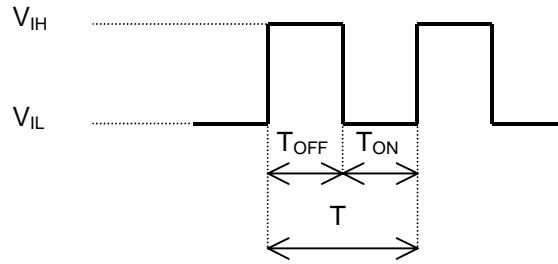


Figure 25 I_{OUT} -PWM Duty Ratio Dependence 2 (Temp. Dependence)

*1. Current setting resistance

*2. The output impedance of the PWM output control signal source when the PWM control signal is "L"



$$\text{PWM Duty Ratio} = \frac{T_{\text{OFF}}}{T}$$

Figure 26 Wave Form Example of PWM Control signal

PWM Control Signal Conditions:

| | Min. | Typ. | Max. |
|------------------|--------|------|--------|
| f_{PWM} | 100 Hz | — | 20 kHz |
| $V_{\text{P-P}}$ | 2.0 V | — | 4.5 V |
| V_{IH} | 2.0 V | — | 4.5 V |
| V_{IL} | 0 V | — | 0 V |

f_{PWM} : Pulse frequency
 $V_{\text{P-P}}$: Pulse amplitude
 V_{IH} : Pulse input voltage (“H”)
 V_{IL} : Pulse input voltage (“L”)

Output Impedance of the PWM Output Control Signal Source (R_z): Max.500 Ω

Calculation of I_{OUT} According to PWM Duty Ratio: $I_{\text{OUT}} = 1 \text{ V} / (R_1 + R_z) \times 100 \times (1 - \text{Duty ratio})$

Ideally, when the duty ratio is 0%, I_{OUT} value is the 100 times value of the Riset pin voltage (1 V) divided by the resistance of R_1 . However, the impedance from the Riset pin to the GND will serve as $R_1 + R_z$ in actual operation. R_z means the output impedance of the PWM control signal source when the PWM control signal is low level. Therefore, the I_{OUT} value varies depend on the R_z value.

- Caution 1.** Fix the PWM output to low level during standby (when the ON/OFF pin is low level). If the PWM Output is set to high level, leak current will flow.
- When the PWM duty is set to 100%, the current to the LED will be switched off. However, the IC will still keep operation. This is not the same as standby mode, and so the current consumption will be the same as in normal operation mode.
 - The duty ratio indicates the percentage of the high-level pulse width to one period.

■ Precautions

- Regarding the wiring to the VIN pin, CPOUT pin, C+ pin, C– pin and GND pin, be careful to perform pattern wiring so as to obtain low impedance.
- Always connect a capacitor to the CPOUT pin, C+ pin, and C– pin.
- Connect C_{IN} and C_{OUT} in the vicinity of the IC and sufficiently strengthen the wiring for GND pin and VIN pin in order to lower the impedance of the wiring resistance, etc. High impedance may cause unstable operation.
Moreover, in selecting C_{IN} and C_{OUT}, perform a full evaluation of the actual usage conditions.
- Connect C_{PUMP} in the vicinity of the IC and sufficiently strengthen the wiring for the C+ pin and C– pin in order to lower the impedance of the wiring resistance, etc. High impedance may cause instable operation.
Moreover, in selecting C_{PUMP}, perform a full evaluation of the actual usage conditions.
- The oscillation pulse width may be small with a light load; however, this causes problems in the IC operation.
- The ON/ $\overline{\text{OFF}}$ pin is configured as shown in Figure 10 and is neither pulled up or down internally, so do not use this pin in a floating state.
When not using the ON/ $\overline{\text{OFF}}$ pin, connect it to the VIN pin.
Moreover, please do not impress voltage higher than V_{IN}+0.3 V to an ON/ $\overline{\text{OFF}}$ pin. Current flows for a VIN pin through the protection diode inside IC.
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.
- Be careful about the usage conditions for the input/output voltages and output current to make sure that dissipation within the IC does not exceed the allowable power dissipation of the package.
For reference, the calculation of the power consumption in this IC is shown below.

$$P_D = (V_{IN} \times 2.0 - V_{I_{OUT1,2,3}}) \times (I_{OUT1} + I_{OUT2} + I_{OUT3})$$

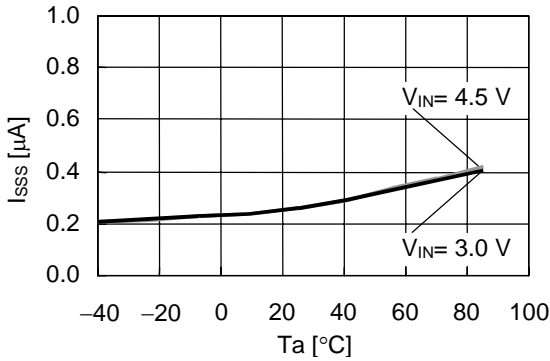
$$\text{Reference: } V_{IN}=4.2 \text{ V, } V_{I_{OUT1,2,3}}=3.6 \text{ V, } I_{OUT1,2,3}=18 \text{ mA}$$

$$P_D=(4.2 \times 2.0 - 3.6) \times 0.054 = 259 \text{ mW}$$

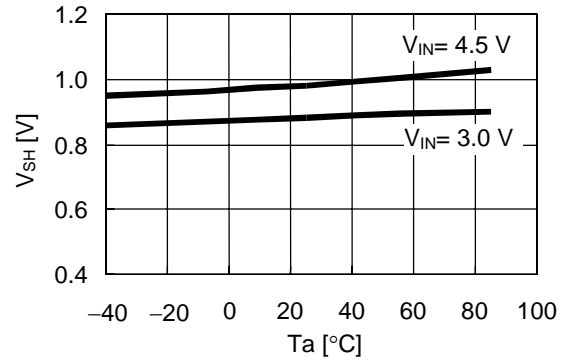
- The contents of this document are subject to change in order to reflect improvements made to the IC therein, so be sure to use the latest version of this document.
- Seiko Instruments Inc. shall not be responsible for any patent infringements caused by products using the S-8813 Series in connection with the method in which the S-8813 Series is used in such products, the product specifications, or the country of destination.

Major Temperature Characteristics Examples

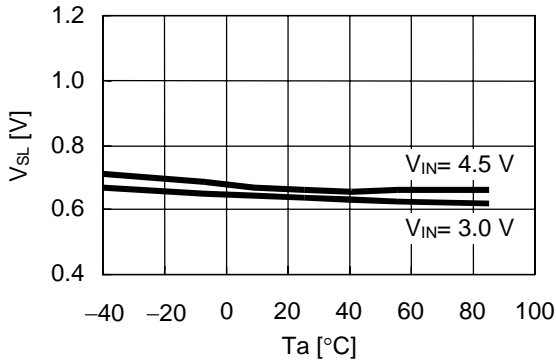
1. Standby Consumption Current (I_{SSS}) vs. Ambient Temperature (T_a) Characteristics



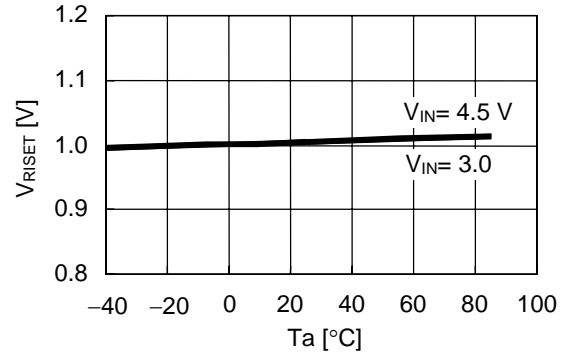
2. Power Off Pin Input Voltage "H" (V_{SH}) vs. Ambient Temperature (T_a) Characteristics



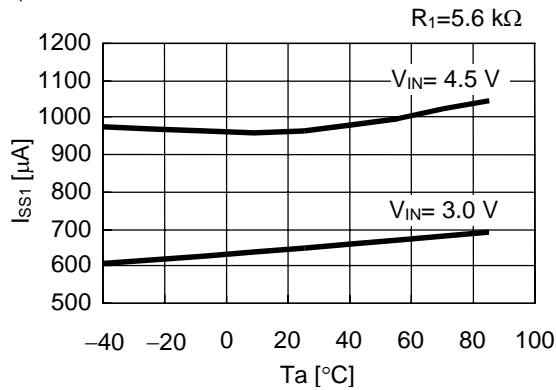
3. Power Off Pin Input Voltage "L" (V_{SL}) vs. Ambient Temperature (T_a) Characteristics



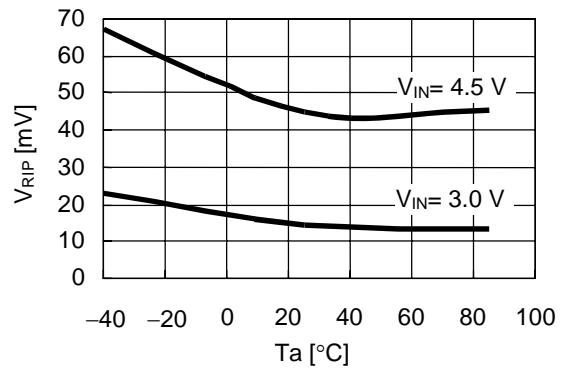
4. RISET Pin Voltage (V_{RISET}) vs. Ambient Temperature (T_a) Characteristics



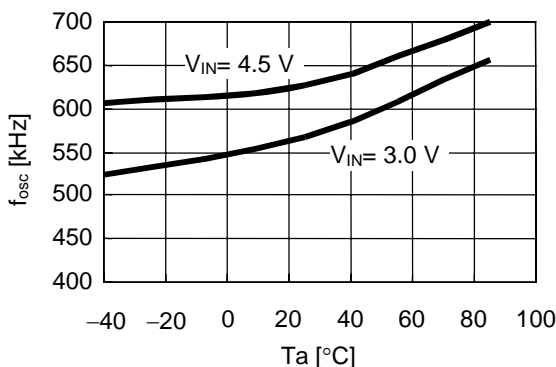
5. Operation Consumption Current (I_{SS1}) vs. Ambient Temperature (T_a) Characteristics



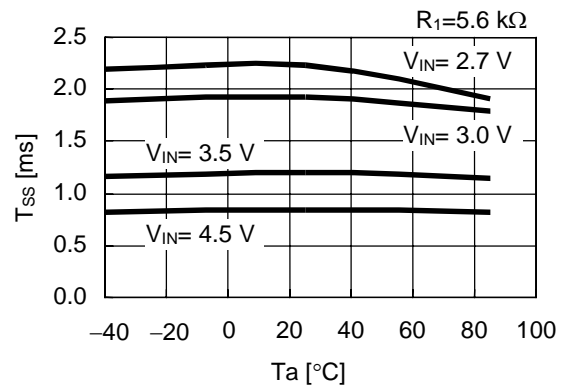
6. Ripple Voltage (V_{RIP}) vs. Ambient Temperature (T_a) Characteristics



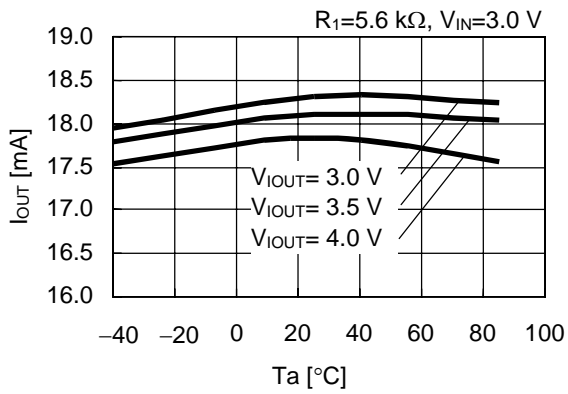
7. Maximum Oscillation Frequency (f_{OSC}) vs. Ambient Temperature (T_a) Characteristics



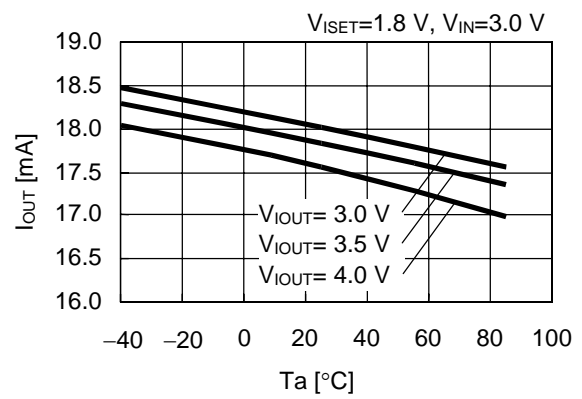
8. Soft Start Time (T_{SS}) vs. Ambient Temperature (T_a) Characteristics



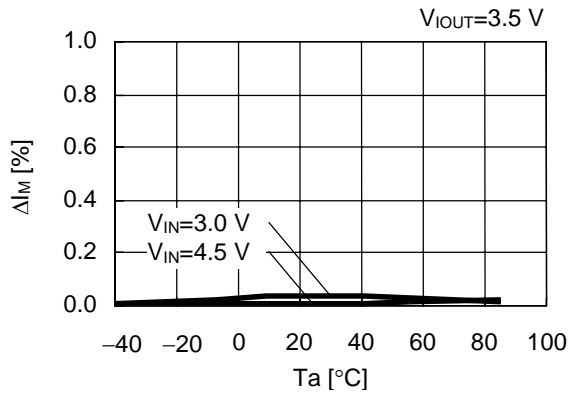
9. Stabilized Output Current (I_{OUT}) vs. Ambient Temperature (T_a) Characteristics



10. Stabilized Output Current (I_{OUT}) vs. Ambient Temperature (T_a) Characteristics

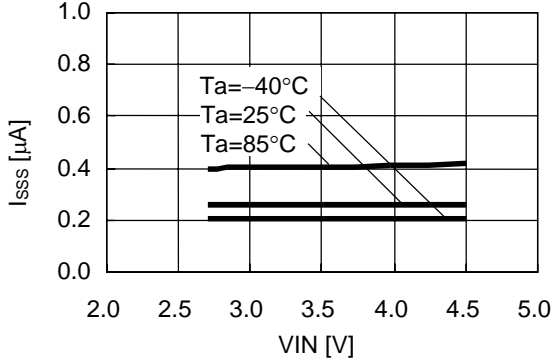


11. Inter-Pin Output Current Variation (ΔI_M) vs. Ambient Temperature (T_a) Characteristics

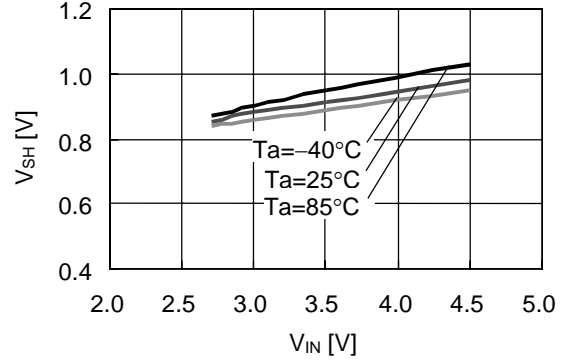


Major Power Supply Dependence Characteristics Examples

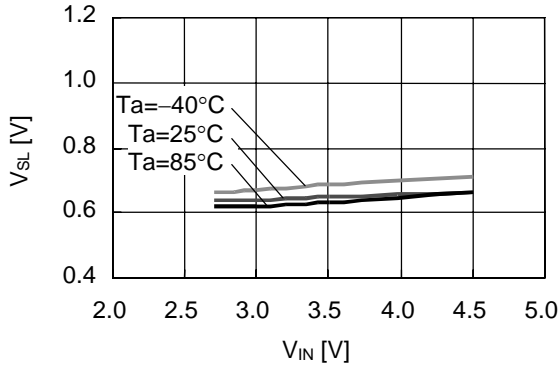
1. Standby Consumption Current (I_{SSS}) vs. Operation Input Voltage (V_{IN}) Characteristics



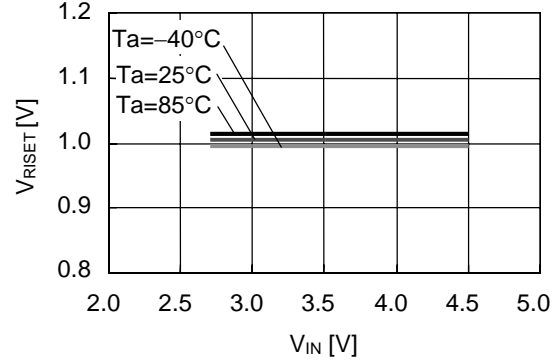
2. Power-Off Pin Input Voltage "H" (V_{SH}) vs. Operation Input Voltage (V_{IN}) Characteristics



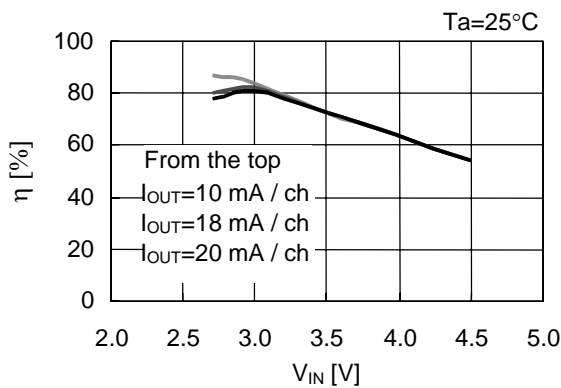
3. Power-Off Pin Input Voltage "L" (V_{SL}) vs. Operation Input Voltage (V_{IN}) Characteristics



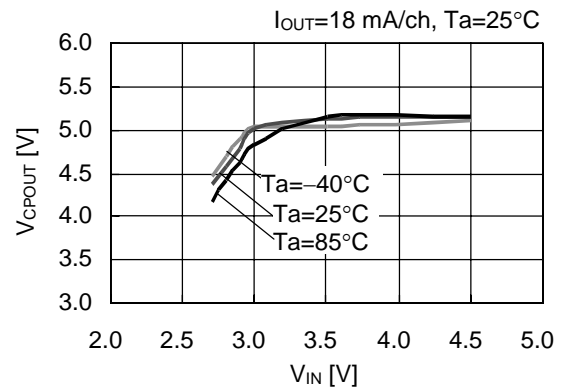
4. R1SET Pin Voltage (V_{R1SET}) vs. Operation Input Voltage (V_{IN}) Characteristics



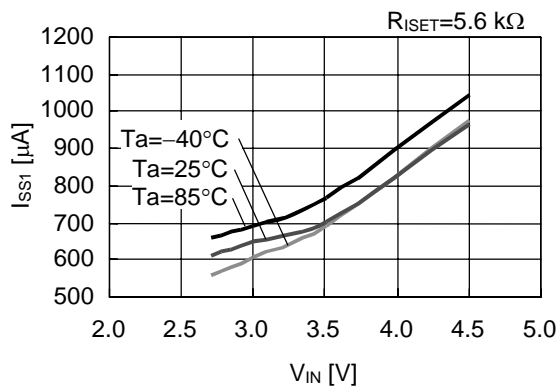
5. Efficiency*1 (η) vs. Operation Input Voltage (V_{IN}) Characteristics



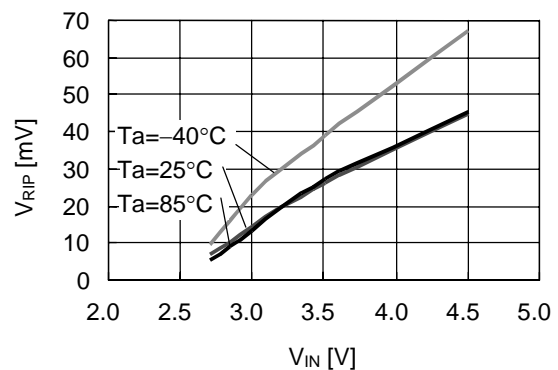
6. CPOUT Pin Voltage (V_{CPOUT}) vs. Operation Input Voltage (V_{IN}) Characteristics



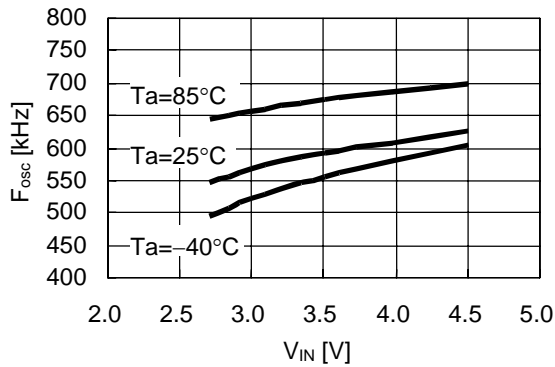
7. Operation Consumption Current (I_{SS1}) vs. Operation Input Voltage (V_{IN}) Characteristics



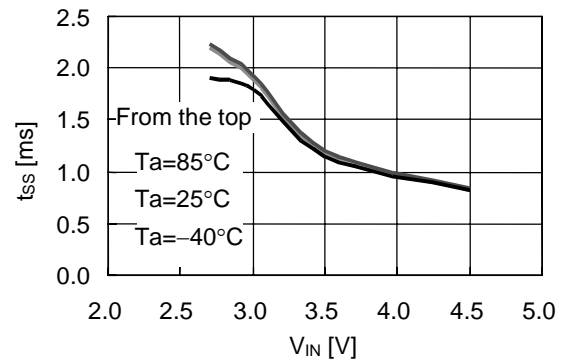
8. Ripple Voltage (V_{RIP}) vs. Operation Input Voltage (V_{IN}) Characteristics



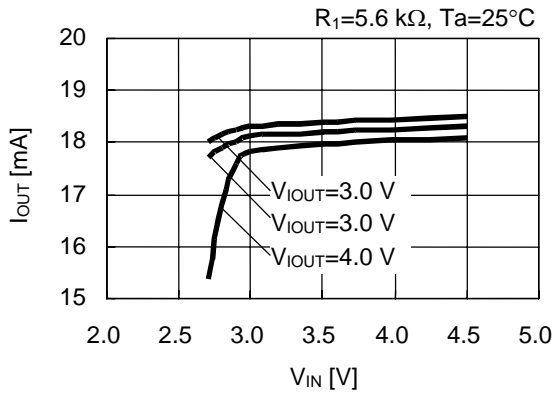
9. Maximum Oscillation Frequency (f_{osc}) vs. Operation Input Voltage (V_{IN}) Characteristics



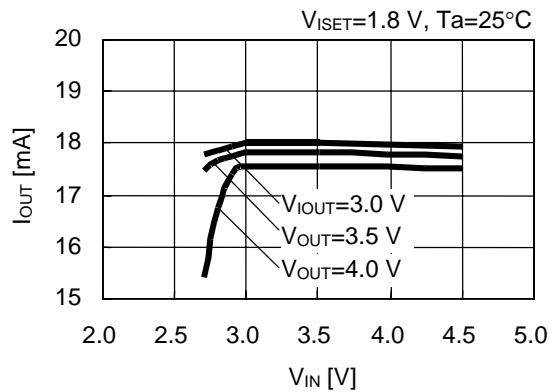
10. Soft Start Time (t_{ss}) vs. Operation Input Voltage (V_{IN}) Characteristics



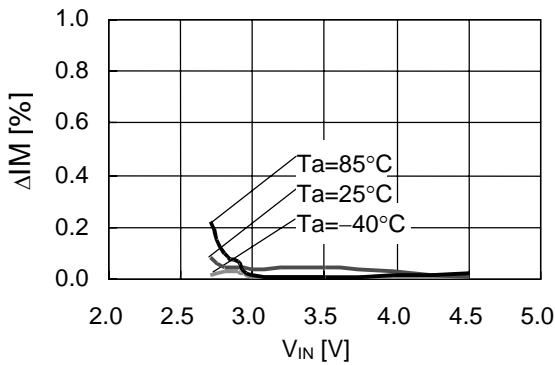
11. Stabilized Output Current (I_{OUT}) vs. Operation Input Voltage (V_{IN}) Characteristics



12. Stabilized Output Current (I_{OUT}) vs. Operation Input Voltage (V_{IN}) Characteristics



13. Inter-Pin Output Current Variation (ΔI_M) vs. Operation Input Voltage (V_{IN}) Characteristics



*1. "Efficiency" in the electrical characteristics means the efficiency of the charge pump circuit block. The ideal efficiency is indicated by the following expression.

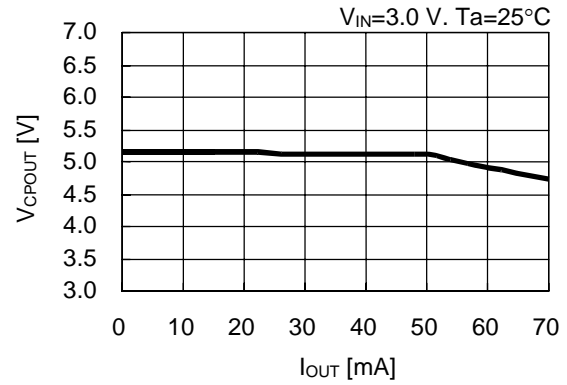
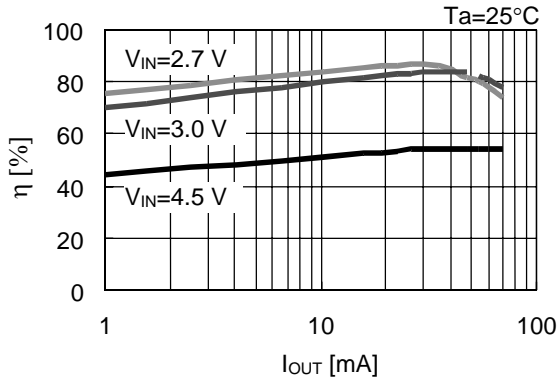
$$\text{Efficiency} = [V_{CP\text{OUT}} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})] / [2.0 \times V_{IN} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})]$$

The ideal efficiency including the constant current circuit is expressed as following expression.

$$\text{Efficiency} = [(V_{I\text{OUT}1} \times I_{OUT1}) + (V_{I\text{OUT}2} \times I_{OUT2}) + (V_{I\text{OUT}3} \times I_{OUT3})] / [2.0 \times V_{IN} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})]$$

■ Major Load Characteristics Examples

1. Efficiency*1 (η) vs. Stabilized Output Current (I_{OUT}) Characteristics 2. CPOUT Pin Voltage (V_{CPOUT}) vs. Stabilized Output Current (I_{OUT}) Characteristics



*1. "Efficiency" in the electrical characteristics means the efficiency of the charge pump circuit block. The ideal efficiency is indicated by the following expression.

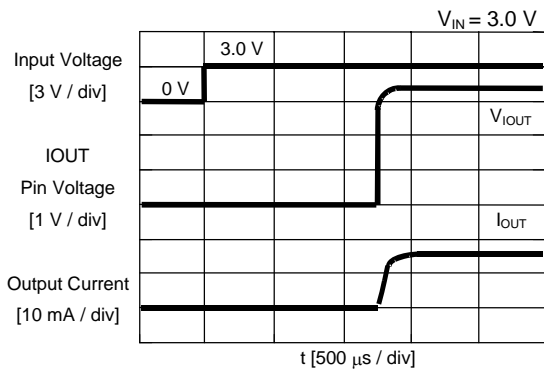
$$\text{Efficiency} = [V_{CPOUT} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})] / [2.0 \times V_{IN} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})]$$

The ideal efficiency including the constant current circuit is expressed as following expression.

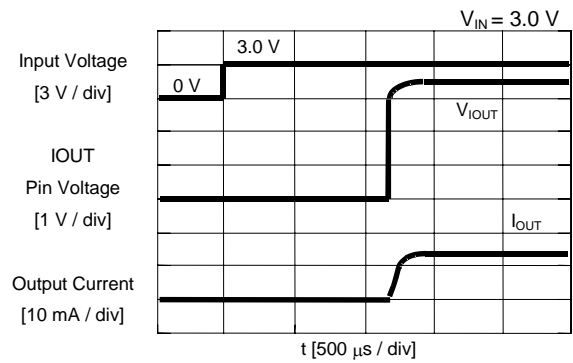
$$\text{Efficiency} = [(V_{IOUT1} \times I_{OUT1}) + (V_{IOUT2} \times I_{OUT2}) + (V_{IOUT3} \times I_{OUT3})] / [2.0 \times V_{IN} \times (I_{OUT1} + I_{OUT2} + I_{OUT3})]$$

■ Transient Response Characteristics Examples

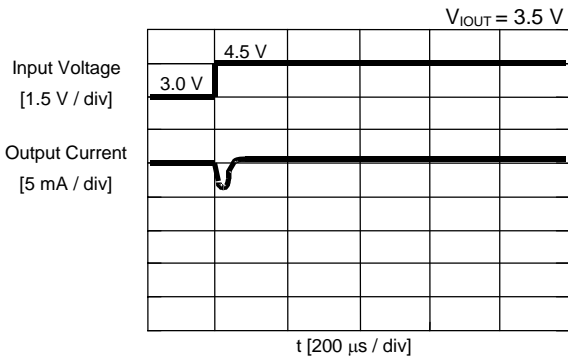
1. Power-Off Pin Response



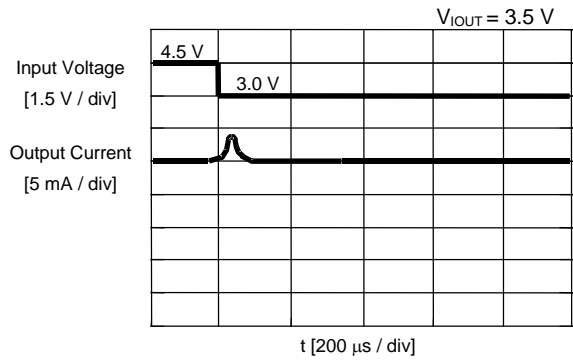
2. Power Supply Application



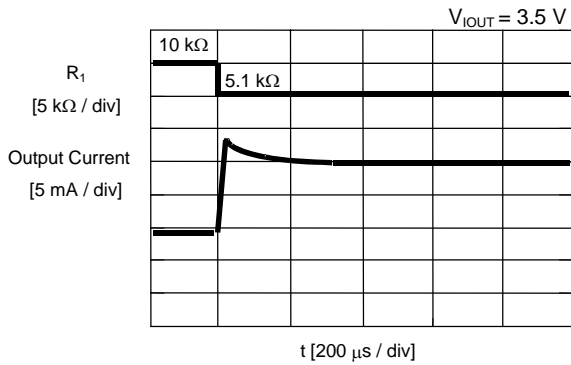
3. Power Supply Voltage Transition



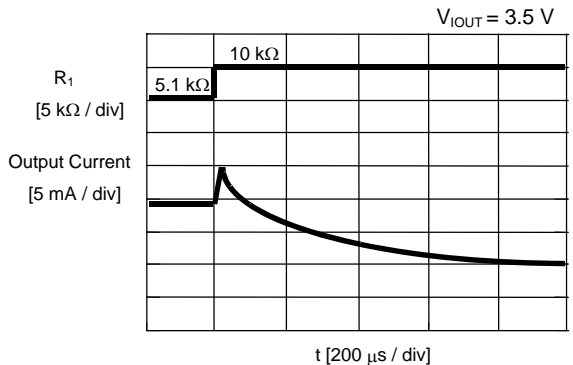
4. Power Supply Voltage Transition



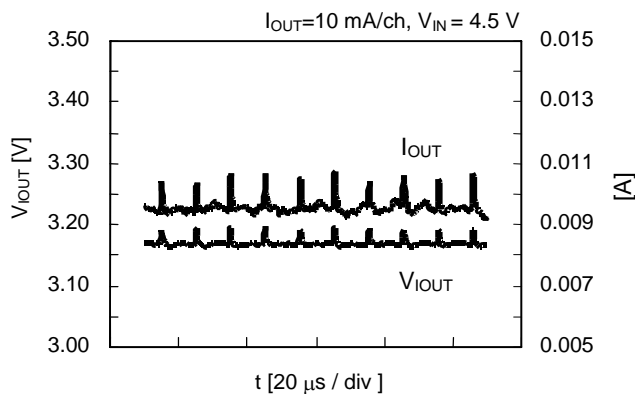
5. Current Setting Switching



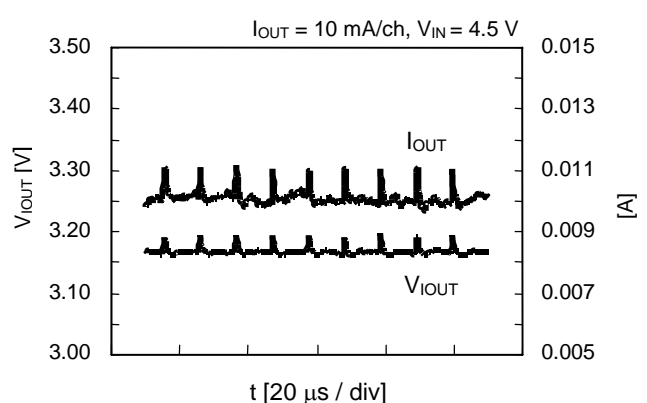
6. Current Setting Switching



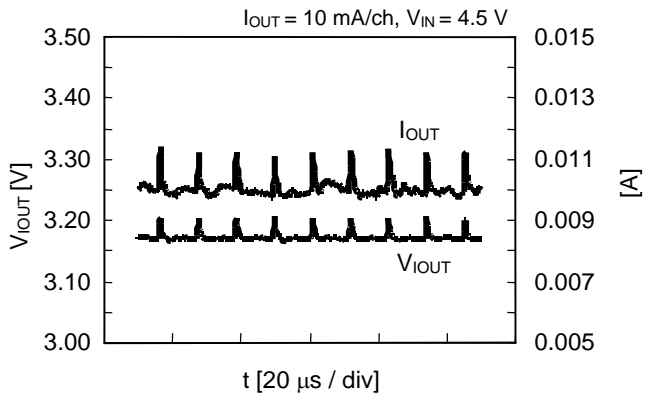
7. Ripple Characteristics (COU_T 10 μF)

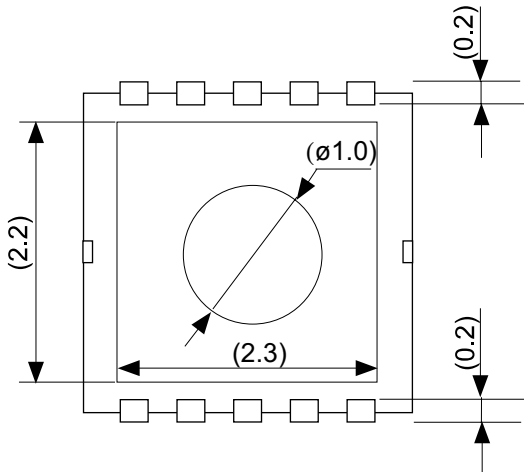
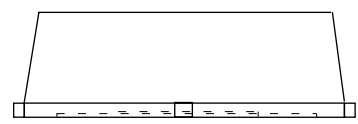
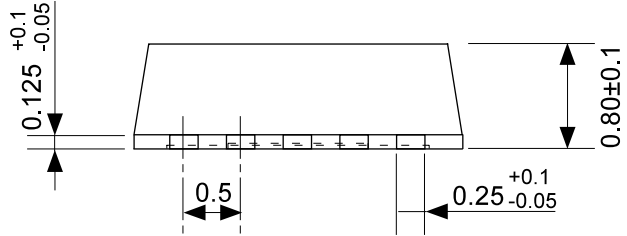
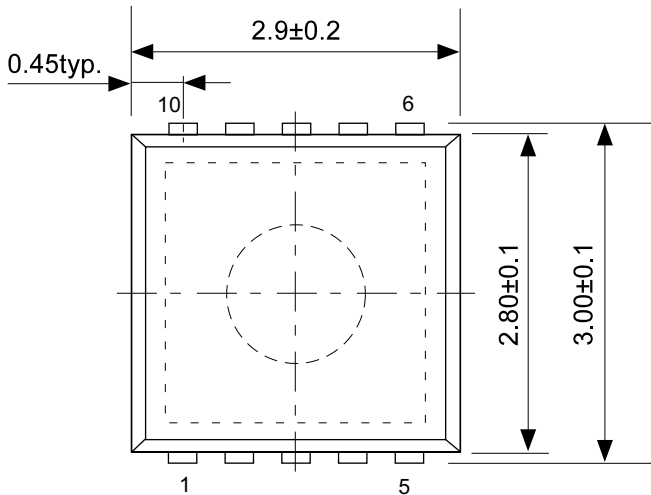


8. Ripple Characteristics (COU_T 4.7 μF)



9. Ripple Characteristics ($C_{OUT} 1.0 \mu F$)

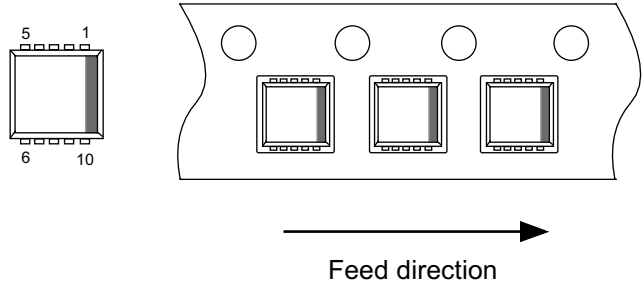
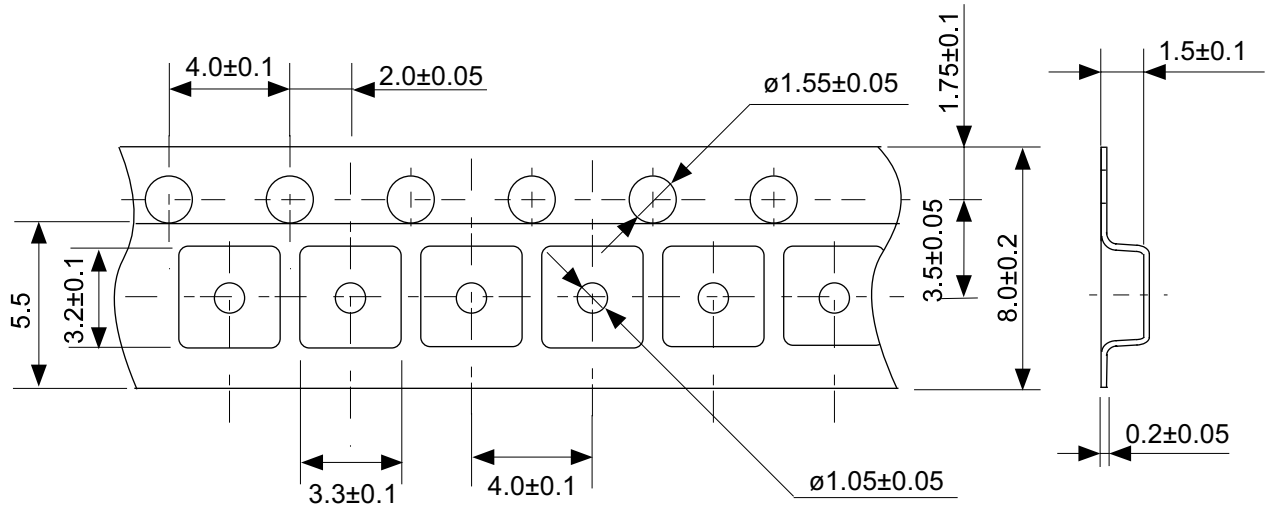




No. PE010-A-P-SD-3.0

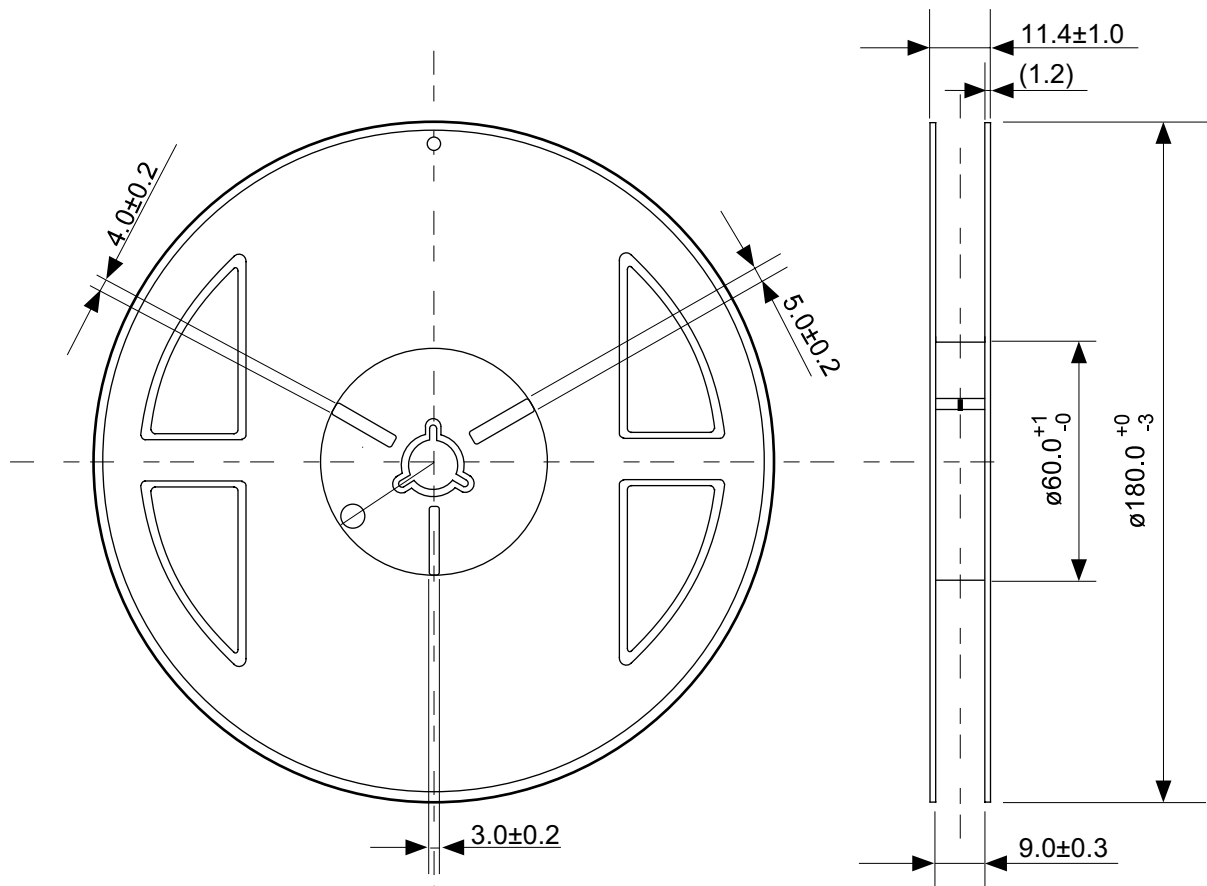
| | |
|-------|-------------------------|
| TITLE | SON10B-A-PKG Dimensions |
| No. | PE010-A-P-SD-3.0 |
| SCALE | |
| UNIT | mm |
| | |

Seiko Instruments Inc.

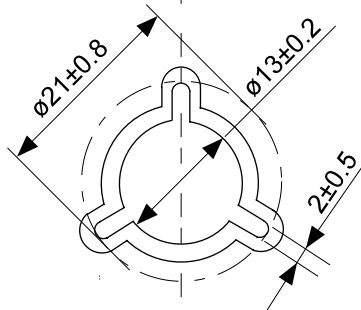


No. PE010-A-C-SD-1.1

| | |
|------------------------|-----------------------|
| TITLE | SON10B-A-Carrier Tape |
| No. | PE010-A-C-SD-1.1 |
| SCALE | |
| UNIT | mm |
| Seiko Instruments Inc. | |



Enlarged drawing in the central part



No. PE010-A-R-SD-1.1

| | | | |
|------------------------|------------------|------|------|
| TITLE | SON10B-A-Reel | | |
| No. | PE010-A-R-SD-1.1 | | |
| SCALE | | QTY. | 3000 |
| UNIT | mm | | |
| | | | |
| Seiko Instruments Inc. | | | |

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