S-85M1A Series (WLP product)

5.6 V INPUT, 200 mA, LOW EMI, SYNCHRONOUS STEP-DOWN SWITCHING REGULATOR WITH 260 nA QUIESCENT CURRENT

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Rev.1.0_00

The S-85M1A Series introduces own distinctive low power consumption control and COT (Constant On-Time) control and features ultra low current consumption and fast transient response. PWM / PFM switching control automatically switches to PFM control when under light load, and the IC operates at ultra low current consumption of 260 nA quiescent current. The S-85M1A Series realizes high efficiency in a wide range of load current consumption and provides strong support for extended period operation of mobile devices and wearable devices which are equipped with compact batteries.
In addition, WLP-6L package suitable for high-density mounting is adopted, it contributes to miniaturization of electronic equipment. By using external parts recommended in this datasheet, the occupancy area can be reduced to 2.0 mm × 3.3 mm = 6.6 mm^2.
Since the S-85M1A Series suppressing EMI emission minimally, allows for high efficiency, it is adequate for applications such as wireless communication, GPS and other noise-affected devices.

■ Features

- Ultra low current consumption: 260 nA quiescent current
- Efficiency (when under 100 μA load): 90.5%
- Fast transient response: COT control
- Input voltage: 2.2 V to 5.6 V
- Output voltage: 0.7 V to 2.5 V, in 0.05 V step
  2.6 V to 3.9 V, in 0.1 V step
- Output voltage accuracy: ±1.5% (1.0 V ≤ V_{OUT} ≤ 3.9 V)
  ±15 mV (0.7 V ≤ V_{OUT} < 1.0 V)
- Switching frequency: 1.0 MHz (at PWM operation)
- High side power MOS FET on-resistance: 360 mΩ
- Low side power MOS FET on-resistance: 250 mΩ
- Soft-start function: 1 ms typ.
- Under voltage lockout function (UVLO): 1.8 V typ. (detection voltage)
- Thermal shutdown function: 135°C typ. (detection temperature)
- Overcurrent protection function: 450 mA (at L = 2.2 μH)
- Automatic recovery type short-circuit protection function: Hiccup control
- Discharge shunt function: Unavailable
  (S-85M1A Series B type)
  Available
  (S-85M1A Series C type)
- Input and output capacitors: Ceramic capacitor compatible
- Operation temperature range: Ta = −40°C to +85°C
- Lead-free, halogen-free

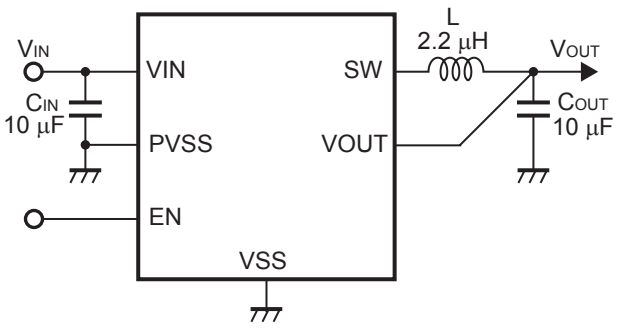
■ Applications

- Wearable device
- Bluetooth device
- Wireless sensor network device
- Healthcare equipment
- Smart meter
- Portable game device
- GPS device

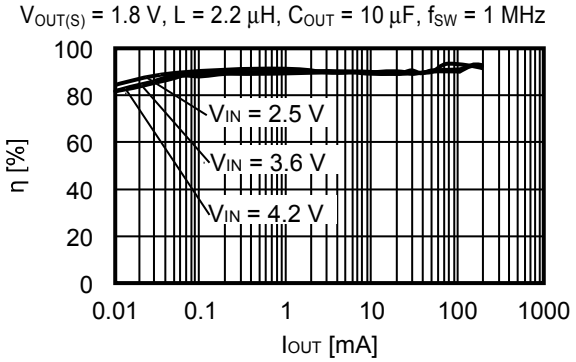
■ Package

- WLP-6L
  (1.25 mm × 0.79 mm × t0.55 mm max.)

■ Typical Application Circuit



■ Efficiency



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■ Block Diagrams

1. S-85M1A Series B type (Product without discharge shunt function)

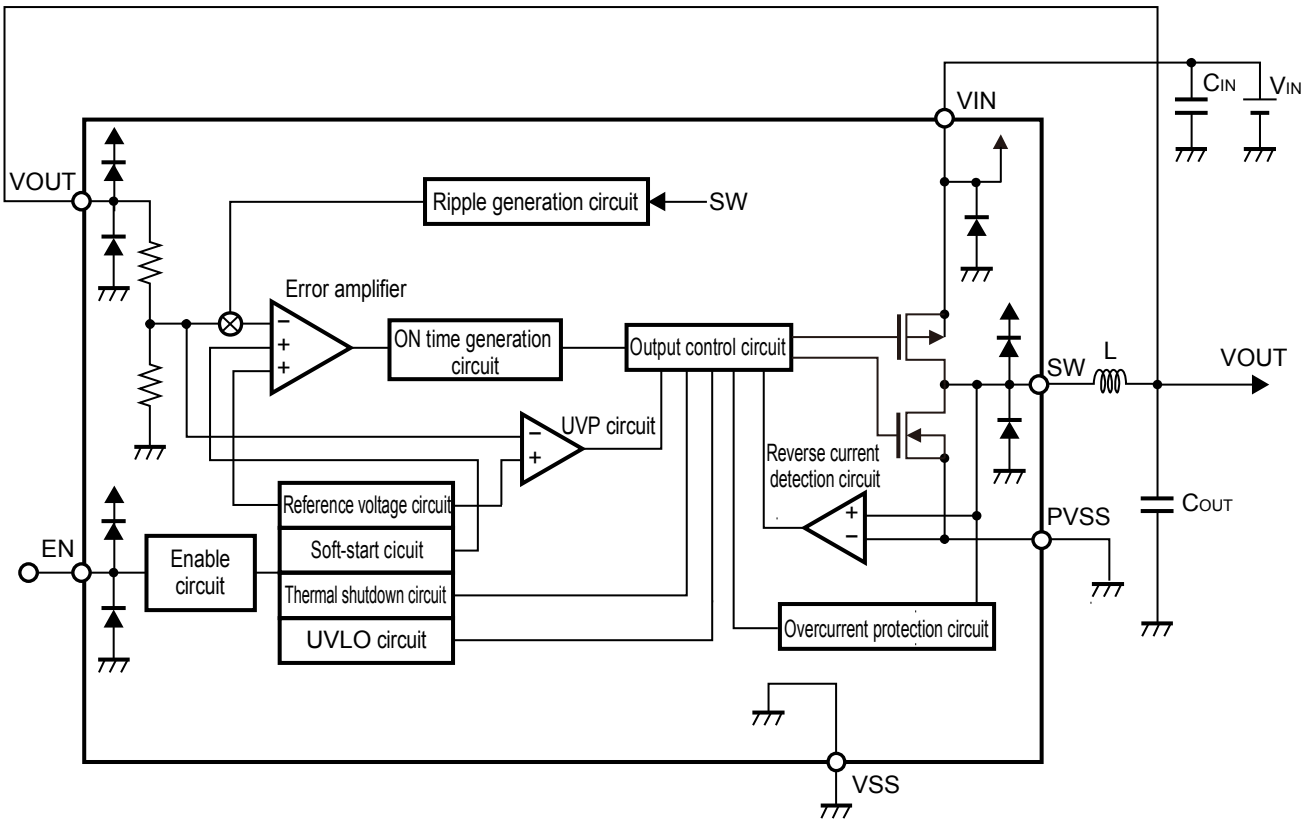


Figure 1

2. S-85M1A Series C type (Product with discharge shunt function)

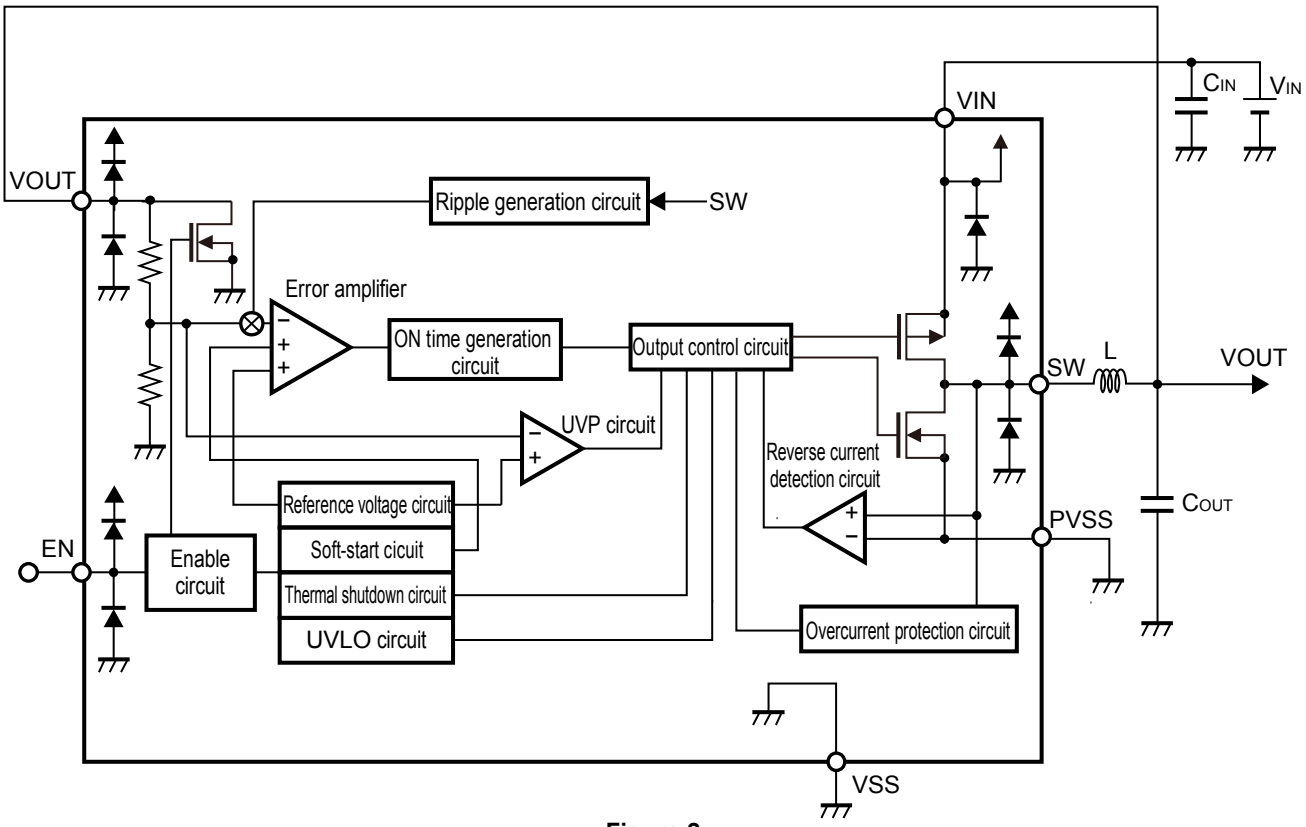


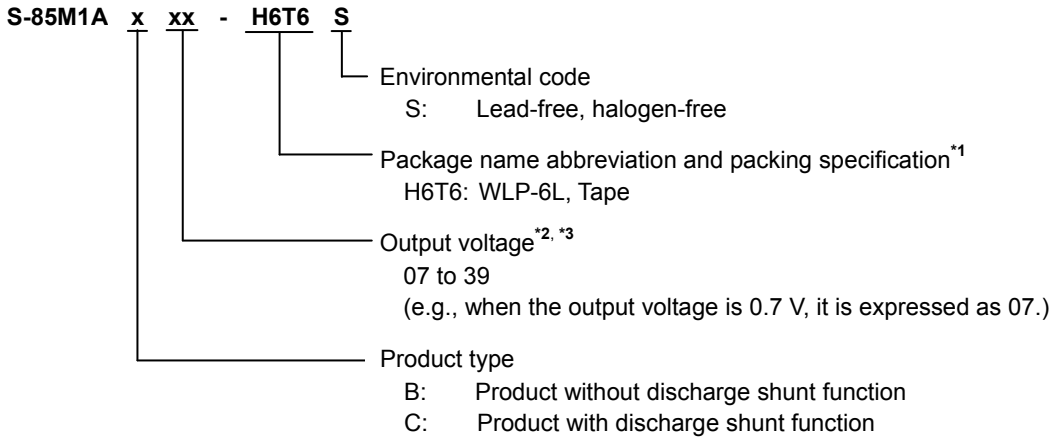
Figure 2

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■ Product Name Structure

Users can select the product type and output voltage for the S-85M1A Series. Refer to "**1. Product name**" regarding the contents of product name, "**2. Package**" regarding the package, "**3. Product name list**" regarding details of the product name.

1. Product name



***1.** Refer to the tape drawing.
***2.** Refer to "**3. Product name list**".
***3.** In the range from 0.7 V to 2.5 V, the products which have 0.05 V step are also available. Contact our sales office when the product is necessary.

2. Package

Table 1 Package Drawing Codes

Package Name	Dimension	Tape	Reel
WLP-6L	HL006-A-P-SD	HL006-A-C-SD	HL006-A-R-SD

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3. Product name list

Table 2

Output Voltage (V_{OUT})	S-85M1A Series B type	S-85M1A Series C type
0.7 V ± 15 mV	S-85M1AB07-H6T6S	S-85M1AC07-H6T6S
0.8 V ± 15 mV	S-85M1AB08-H6T6S	S-85M1AC08-H6T6S
0.9 V ± 15 mV	S-85M1AB09-H6T6S	S-85M1AC09-H6T6S
1.0 V ± 1.5%	S-85M1AB10-H6T6S	S-85M1AC10-H6T6S
1.1 V ± 1.5%	S-85M1AB11-H6T6S	S-85M1AC11-H6T6S
1.2 V ± 1.5%	S-85M1AB12-H6T6S	S-85M1AC12-H6T6S
1.3 V ± 1.5%	S-85M1AB13-H6T6S	S-85M1AC13-H6T6S
1.4 V ± 1.5%	S-85M1AB14-H6T6S	S-85M1AC14-H6T6S
1.5 V ± 1.5%	S-85M1AB15-H6T6S	S-85M1AC15-H6T6S
1.6 V ± 1.5%	S-85M1AB16-H6T6S	S-85M1AC16-H6T6S
1.7 V ± 1.5%	S-85M1AB17-H6T6S	S-85M1AC17-H6T6S
1.8 V ± 1.5%	S-85M1AB18-H6T6S	S-85M1AC18-H6T6S
1.9 V ± 1.5%	S-85M1AB19-H6T6S	S-85M1AC19-H6T6S
2.0 V ± 1.5%	S-85M1AB20-H6T6S	S-85M1AC20-H6T6S
2.1 V ± 1.5%	S-85M1AB21-H6T6S	S-85M1AC21-H6T6S
2.2 V ± 1.5%	S-85M1AB22-H6T6S	S-85M1AC22-H6T6S
2.3 V ± 1.5%	S-85M1AB23-H6T6S	S-85M1AC23-H6T6S
2.4 V ± 1.5%	S-85M1AB24-H6T6S	S-85M1AC24-H6T6S
2.5 V ± 1.5%	S-85M1AB25-H6T6S	S-85M1AC25-H6T6S
2.6 V ± 1.5%	S-85M1AB26-H6T6S	S-85M1AC26-H6T6S
2.7 V ± 1.5%	S-85M1AB27-H6T6S	S-85M1AC27-H6T6S
2.8 V ± 1.5%	S-85M1AB28-H6T6S	S-85M1AC28-H6T6S
2.9 V ± 1.5%	S-85M1AB29-H6T6S	S-85M1AC29-H6T6S
3.0 V ± 1.5%	S-85M1AB30-H6T6S	S-85M1AC30-H6T6S
3.1 V ± 1.5%	S-85M1AB31-H6T6S	S-85M1AC31-H6T6S
3.2 V ± 1.5%	S-85M1AB32-H6T6S	S-85M1AC32-H6T6S
3.3 V ± 1.5%	S-85M1AB33-H6T6S	S-85M1AC33-H6T6S
3.4 V ± 1.5%	S-85M1AB34-H6T6S	S-85M1AC34-H6T6S
3.5 V ± 1.5%	S-85M1AB35-H6T6S	S-85M1AC35-H6T6S
3.6 V ± 1.5%	S-85M1AB36-H6T6S	S-85M1AC36-H6T6S
3.7 V ± 1.5%	S-85M1AB37-H6T6S	S-85M1AC37-H6T6S
3.8 V ± 1.5%	S-85M1AB38-H6T6S	S-85M1AC38-H6T6S
3.9 V ± 1.5%	S-85M1AB39-H6T6S	S-85M1AC39-H6T6S

Remark Please contact our sales office for products with specifications other than the above.

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■ Pin Configuration

1. WLP-6L

Bottom view

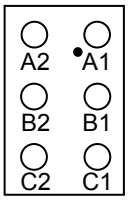


Figure 3

Table 3

Pin No.	Symbol	Description
A1	EN	Enable pin "H" : Enable (normal operation) "L" : Disable (standby)
B1	VIN	Power supply pin
C1	PVSS	Power GND pin
A2	VOUT	Output voltage pin
B2	VSS	GND pin
C2	SW	External inductor connection pin

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■ Absolute Maximum Ratings

Table 4

(Unless otherwise specified: Ta = +25°C, V_{SS} = 0 V)

Item	Symbol	Absolute Maximum Rating	Unit
VIN pin voltage	V_{IN}	V_{SS} – 0.3 to V_{SS} + 6.0	V
EN pin voltage	V_{EN}	V_{SS} – 0.3 to V_{IN} + 0.3 ≤ V_{SS} + 6.0	V
VOUT pin voltage	V_{OUT}	V_{SS} – 0.3 to V_{IN} + 0.3 ≤ V_{SS} + 6.0	V
SW pin voltage	V_{SW}	V_{SS} – 0.3 to V_{IN} + 0.3 ≤ V_{SS} + 6.0	V
PVSS pin voltage	V_{PVSS}	V_{SS} – 0.3 to V_{SS} + 0.3 ≤ V_{SS} + 6.0	V
Operation temperature	T_{opr}	–40 to +85	°C
Storage temperature	T_{stg}	–40 to +125	°C

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.

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■ Electrical Characteristics

Table 5

(V_{IN} = 3.6 V[*1], Ta = +25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating input voltage	V_{IN}	–	2.2	3.6	5.6	V
Output voltage[*2]	V_{OUT}	1.0 V ≤ V_{OUT} ≤ 3.9 V, no external parts	$V_{OUT(S)}$ × 0.985	$V_{OUT(S)}$	$V_{OUT(S)}$ × 1.015	V
		0.7 V ≤ V_{OUT} < 1.0 V, no external parts	$V_{OUT(S)}$ − 0.015	$V_{OUT(S)}$	$V_{OUT(S)}$ + 0.015	V
Current consumption during shutdown	I_{SSS}	V_{EN} = 0 V	–	1	100	nA
Current consumption during switching off	I_{SS1}	V_{OUT} = $V_{OUT(S)}$ + 0.1 V, V_{EN} = V_{IN}, no external parts, no switching operation	–	260	500	nA
High level input voltage	V_{SH}	V_{IN} = 2.2 V to 5.5 V, EN pin	1.1	–	–	V
Low level input voltage	V_{SL}	V_{IN} = 2.2 V to 5.5 V, EN pin	–	–	0.3	V
High level input current	I_{SH}	V_{IN} = 2.2 V to 5.5 V, EN pin, V_{EN} = V_{IN}	−100	–	100	nA
Low level input current	I_{SL}	V_{IN} = 2.2 V to 5.5 V, EN pin, V_{EN} = 0 V	−100	–	100	nA
High side power MOS FET on-resistance	R_{HFET}	I_{SW} = 100 mA	–	360	–	mΩ
Low side power MOS FET on-resistance	R_{LFET}	I_{SW} = −100 mA	–	250	–	mΩ
High side power MOS FET leakage current	I_{HSW}	V_{IN} = 2.2 V to 5.5 V, V_{EN} = 0 V, V_{SW} = 0 V	–	1	100	nA
Low side power MOS FET leakage current	I_{LSW}	V_{IN} = 2.2 V to 5.5V, V_{EN} = 0 V, V_{SW} = V_{IN}	−100	1	–	nA
Current limit[*3]	I_{LIM}	L = 2.2 µH	–	450	–	mA
ON time[*4]	t_{ON}	$t_{ON(S)}$ = 1/f_{SW}[*5] × V_{OUT}/V_{IN}, V_{OUT} = $V_{OUT(S)}$ × 0.9	$t_{ON(S)}$/1.3	$t_{ON(S)}$	$t_{ON(S)}$/0.7	ns
Minimum OFF time	$t_{OFF(MIN)}$	–	–	100	–	ns
UVLO detection voltage	V_{UVLO-}	When V_{IN} falls	1.7	1.8	1.9	V
UVLO release voltage	V_{UVLO+}	When V_{IN} rises	1.9	2.0	2.1	V
UVP detection voltage	V_{UVP}	–	–	$V_{OUT(S)}$ × 0.7	–	V
Soft-start wait time	t_{SSW}	Time until V_{OUT} starts rising	–	1.5	–	ms
Soft-start time	t_{SS}	Time until V_{OUT} reaches 90% after it starts rising	–	1.0	–	ms
Thermal shutdown detection temperature	T_{SD}	Junction temperature	–	135	–	°C
Thermal shutdown release temperature	T_{SR}	Junction temperature	–	115	–	°C
Discharge shunt resistance during power-off	R_{LOW}	V_{OUT} = 0.1 V, V_{EN} = 0 V, C type	–	160	–	Ω

***1.** V_{IN} = $V_{OUT(S)}$ + 1.0 V ($V_{OUT(S)}$ ≥ 2.6 V)

***2.** V_{OUT}: Actual output voltage
$V_{OUT(S)}$: Set output voltage

***3.** The current limit changes according to the L value for the inductor to be used, input voltage, and output voltage. Refer to "■ **Operation**" for details.

***4.** t_{ON}: Actual ON time
$t_{ON(S)}$: Set ON time

***5.** f_{SW}: Switching frequency (1 MHz)

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■ Operation

1. Fast transient response

Distinctive COT (Constant On-Time) control is used for DC-DC converter control.
The S-85M1A Series monitors the output voltage (V_{OUT}) using a comparator and if V_{OUT} falls below the targeted value, the high side power MOS FET will turn on for a certain amount of time. Since the high side power MOS FET turns on and V_{OUT} rises immediately after the load current fluctuates rapidly and V_{OUT} falls, the fast transient response is realized.

The S-85M1A Series outputs ON time in proportion to V_{OUT} and in inverse proportion to power supply voltage. Therefore, when in continuous mode, even if the power supply voltage or V_{OUT} settings would change, it always operates at a quasi-fixed frequency of 1 MHz.

2. PWM / PFM switching control

The S-85M1A Series automatically switches between the pulse width modulation method (PWM) and pulse frequency modulation method (PFM) according to the load current. If the output current (I_{OUT}) is large, the IC will operate at PWM control. If I_{OUT} is small, the IC will operate at PFM control and skip the pulse according to the load current. This reduces switching loss and improves efficiency when under light load.
The S-85M1A Series has a built-in reverse current detection circuit. The reverse current detection circuit monitors the current flowing through the inductor. If the bottom of ripple current in the inductor falls to 0 mA, the high side power MOS FET and low side power MOS FET will turn off and switching operation will stop. Switching frequency will fall from 1.0 MHz by skipping a pulse. This means that the smaller I_{OUT} is, the more the switching frequency (f_{SW}) will drop, and it reduces switching loss.

3. Ultra low current consumption

When in discontinuous mode, the S-85M1A Series reduces current consumption to 260 nA typ. by intermittently operating a control circuit and a protection circuit. When under light load, the high side power MOS FET and low side power MOS FET will turn off. When switching operation stops and a certain amount of time elapses, only the necessary circuits will operate.
Under voltage lockout function (UVLO), thermal shutdown function, current limit function, and automatic recovery type short-circuit protection function are prepared in the S-85M1A Series, and each protection function will carry out detection operation for a certain amount of time from when the high side power MOS FET turns on under light load. It is thus able to realize ultra low current consumption. When under heavy load, the IC changes to continuous mode as a result of the fact that the high side power MOS FET and low side power MOS FET turn on continuously, so all the IC, including the protection circuits, will operate.

4. EN pin

This pin starts and stops switching operation. When the EN pin is set to "L", the operation of all internal circuits, including the high side power MOS FET, is stopped, reducing current consumption. Current consumption increases when a voltage of 0.3 V to V_{IN} – 0.3 V is applied to the EN pin. When not using the EN pin, connect it to the VIN pin. Since the EN pin is neither pulled down nor pulled up internally, do not use it in the floating status. The structure of the EN pin is shown in **Figure 4**.

Table 6

EN Pin	Internal Circuit	VOUT Pin Voltage
"H"	Enable (normal operation)	V_{OUT} *1
"L"	Disable (standby)	"High-Z"

***1.** Refer to ***2** in **Table 5** in "**■ Electrical Characteristics**".

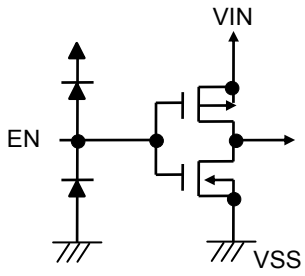


Figure 4

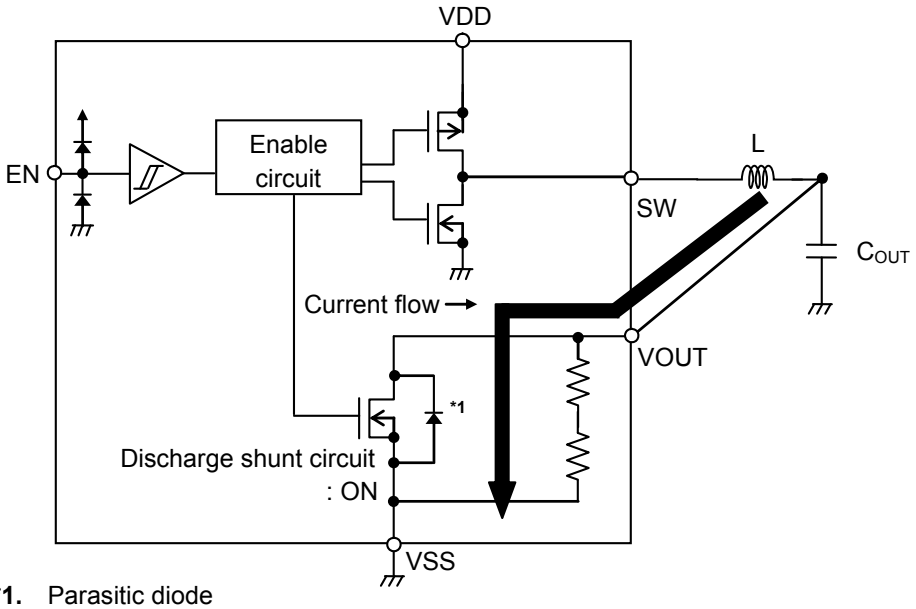
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5. Discharge shunt function (S-85M1A Series C type)

The S-85M1A Series C type has a built-in discharge shunt circuit to discharge the output capacitor (C_{OUT}). C_{OUT} is discharged as follows so that the VOUT pin voltage reaches the V_{SS} level.

<1> The EN pin is set to "L" level.
<2> Switching operation is stopped, and then high side power MOS FET and low side power MOS FET are turned off.
<3> The discharge shunt circuit is turned on.
<4> C_{OUT} discharges.

Since the S-85M1A Series B type does not have a discharge shunt circuit, the VOUT pin voltage is set to V_{SS} level by internal divided resistors between the VOUT pin and the VSS pin. The S-85M1A Series C type allows the VOUT pin voltage to reach the V_{SS} level rapidly due to the discharge shunt circuit.



***1.** Parasitic diode

Figure 5

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6. Under voltage lockout function (UVLO)

The S-85M1A Series has a built-in UVLO circuit to prevent the IC from malfunctioning due to a transient status at power-on or a momentary drop in the supply voltage. When UVLO status is detected, the high side power MOS FET and low side power MOS FET will turn off, and the SW pin will change to "High-Z". For this reason, switching operation will stop. The soft-start function is reset if UVLO status is detected once, and is restarted by releasing the UVLO status.
Note that the other internal circuits operate normally and the status is different from the disabled status.
Also, there is a hysteresis width for avoiding malfunctions due to generation of noise etc. in the input voltage.

7. Thermal shutdown function

The S-85M1A Series has a built-in thermal shutdown circuit to limit overheating. When the junction temperature increases to 135°C typ., the thermal shutdown circuit becomes the detection status, and the switching operation is stopped. When the junction temperature decreases to 115°C typ., the thermal shutdown circuit becomes the release status, and the switching operation is restarted.
If the thermal shutdown circuit becomes the detection status due to self-heating, the switching operation is stopped and output voltage (V_{OUT}) decreases. For this reason, the self-heating is limited and the temperature of the IC decreases. The thermal shutdown circuit becomes release status when the temperature of the IC decreases, and the switching operation is restarted, thus the self-heating is generated again. Repeating this procedure makes the waveform of V_{OUT} into a pulse-like form. Switching operation stopping and starting can be stopped by either setting the EN pin to "L", lowering the output current (I_{OUT}) to reduce internal power consumption, or decreasing the ambient temperature.

Table 7

Thermal Shutdown Circuit	VOUT Pin Voltage
Release: 115°C typ.*1	V_{OUT}
Detection: 135°C typ.*1	"High-Z"

***1.** Junction temperature

8. Overcurrent protection function

The S-85M1A Series has a built-in current limit circuit.
The overcurrent protection circuit monitors the current that flows through the low side power MOS FET and limits current to prevent thermal destruction of the IC due to an overload, magnetic saturation in the inductor, etc.

When a current exceeding the current limit (I_{LIM}) flows through the low side power MOS FET, the current limit circuit operates and prohibits turning on the high side power MOS FET until the current falls below the low side current limit (I_{LIMDET}). If the value of the current that flows through the low side power MOS FET falls to the I_{LIMDET} or lower, the S-85M1A Series returns to normal operation. I_{LIMDET} is fixed at 270 mA typ. in the IC, and I_{LIM} will vary depending on the external parts to be used.
The relation between I_{LIM}, the inductor value (L), the input voltage (V_{IN}), and the output voltage (V_{OUT}) are shown in the following expression.

$$I_{LIM} = I_{LIMDET} + \frac{1}{2 \times L \times f_{SW}} \times \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{V_{IN}}$$

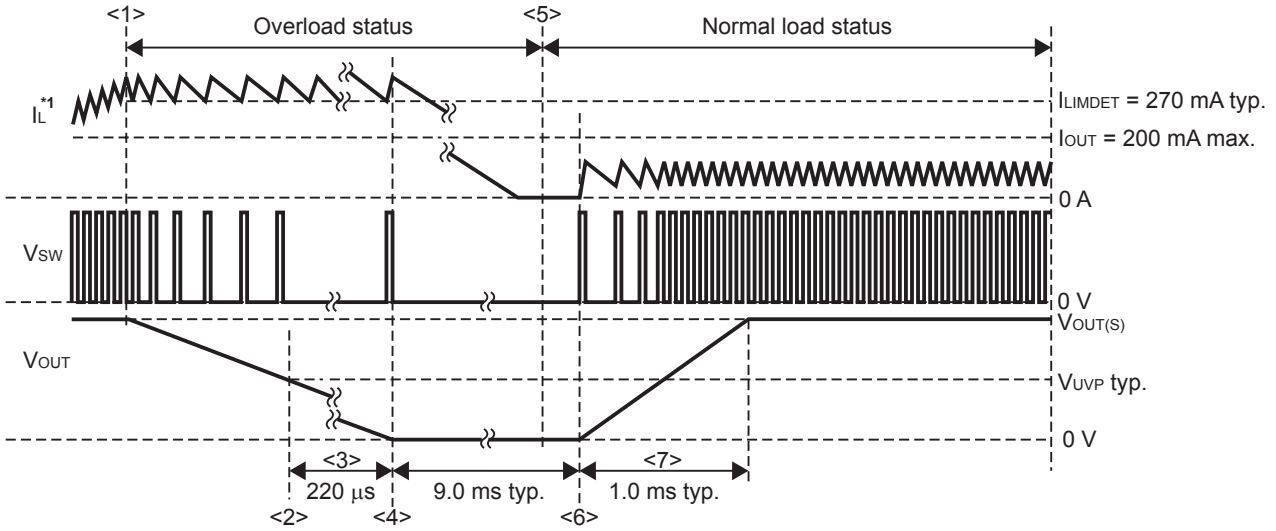
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9. Automatic recovery type short-circuit protection function (Hiccup control)

The S-85M1A Series has a built-in automatic recovery type short-circuit protection function for Hiccup control. Hiccup control is a method for periodically carrying out automatic recovery when the IC detects overcurrent and stops the switching operation.

9. 1 When over load status is released

<1> Overcurrent detection
<2> Under voltage protection circuit (UVP circuit) detects a drop in the output voltage (V_{OUT}).
<3> 220 μs elapse
<4> Switching operation stop (for 9 ms typ.)
<5> Overload status release
<6> The IC restarts, soft-start function starts.
In this case, it is unnecessary to input an external reset signal for restart.
<7> V_{OUT} reaches $V_{OUT(S)}$ after 1.0 ms typ. elapses.

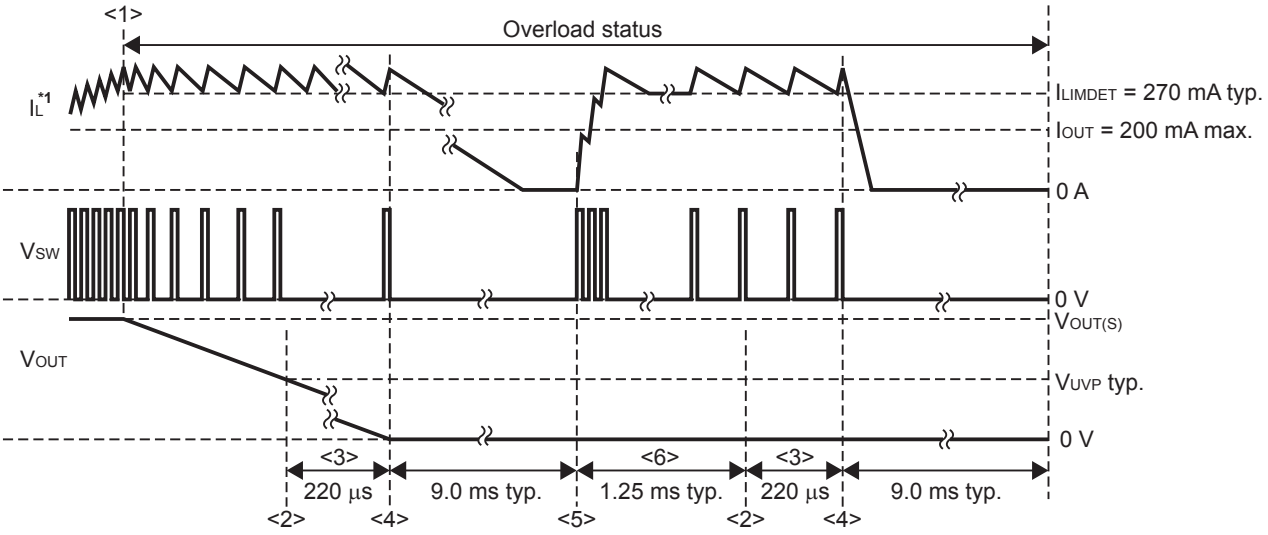


*1. Inductor current

Figure 6

9. 2 When over load status continues

<1> Overcurrent detection
<2> The UVP circuit detects a drop in V_{OUT}.
<3> 220 μs elapse
<4> Switching operation stop (for 9 ms typ.)
<5> The IC restarts, soft-start function starts.
<6> The status returns to <2> when over load status continues after 1.25 ms typ. elapses.



*1. Inductor current

Figure 7

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10. Pre-bias compatible soft-start function

The S-85M1A Series has a built-in pre-bias compatible soft-start circuit.
If the pre-bias compatible soft-start circuit starts when electrical charge remains in the output voltage (V_{OUT}) as a result of power supply restart, etc., or when V_{OUT} is biased beforehand (pre-bias status), switching operation is stopped until the soft-start voltage exceeds the internal feedback voltage, and then V_{OUT} is maintained. If the soft-start voltage exceeds the internal feedback voltage, switching operation will restart and V_{OUT} will rise to the output voltage setting value ($V_{OUT(S)}$). This allows $V_{OUT(S)}$ to be reached without lowering the pre-biased V_{OUT}.
In soft-start circuits which are not pre-bias compatible, a large current flows as a result of the discharge of the residual electric charge through the low side power MOS FET when switching operation starts, which could cause damage, however in a pre-bias compatible soft-start circuit, the IC is protected from the large current when switching operation starts, and it makes power supply design for the application circuit simpler.

In the S-85M1A Series, V_{OUT} reaches $V_{OUT(S)}$ gradually due to the soft-start circuit.
In the following cases, rush current and V_{OUT} overshoot are reduced.

- At power-on
- When the EN pin changes from "L" to "H".
- When UVLO operation is released.
- When thermal shutdown is released.
- At short-circuit recovery

In addition, the soft-start circuit operates under the following conditions.
The soft-start circuit starts operating after "H" is input to the EN pin and the soft-start wait time (t_{SSW}) = 1.5 ms typ. elapses. The soft-start time (t_{SS}) is set to 1.0 ms typ.

- At power supply restart (the IC restart)
- At UVLO detection (after UVLO release)
- At thermal shutdown detection (after thermal shutdown release)
- After Hiccup control

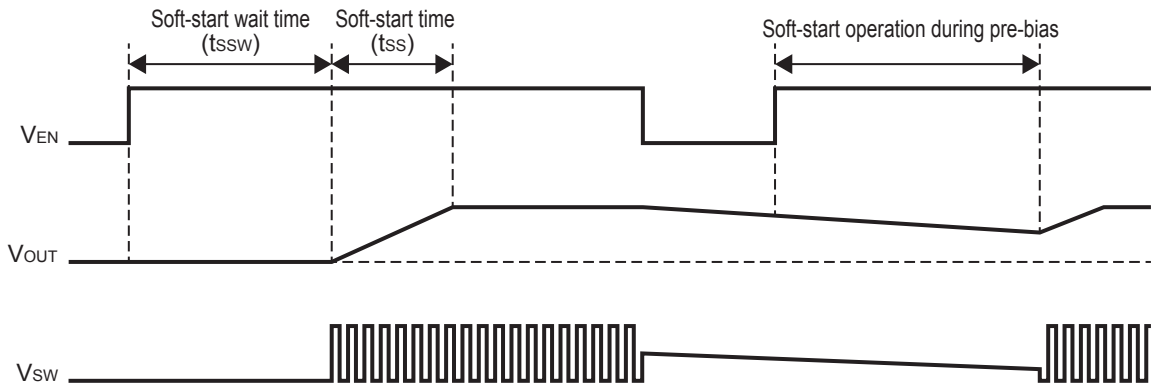


Figure 8

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■ Typical Circuit

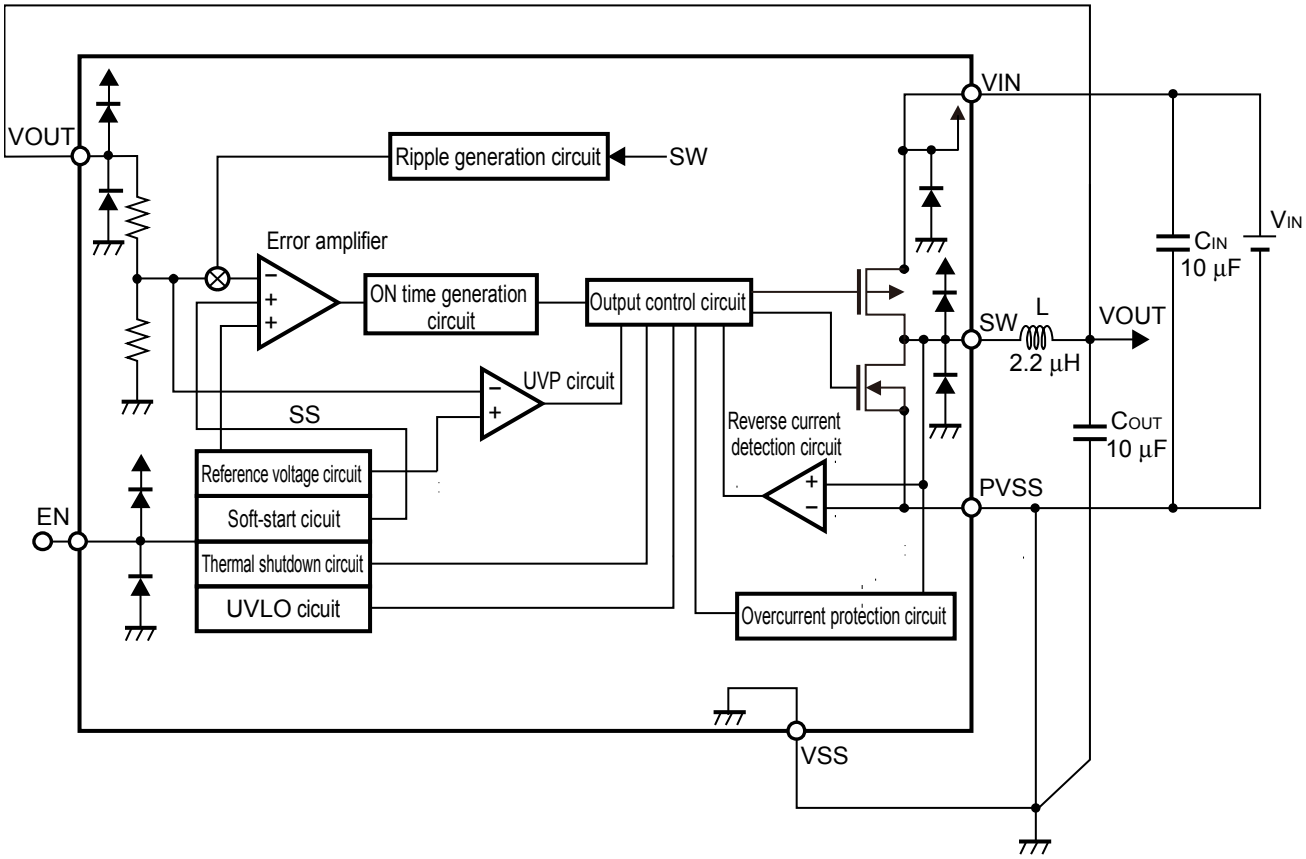


Figure 9

Caution The above connection diagram and constants will not guarantee successful operation. Perform thorough evaluation using an actual application to set the constants.

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■ External Parts Selection

Selectable values and recommended values for external parts are shown in **Table 8**.
Use ceramic capacitors for C_{IN} and C_{OUT}.

Table 8

Item	Input Capacitor (C_{IN})	Output Capacitor (C_{OUT})	Inductor (L)
Selectable value	2.2 µF or larger	4.7 µF to 100 µF	1.5 µH to 10 µH
Recommended value	10 µF	10 µF	2.2 µH

1. Input capacitor (C_{IN})

C_{IN} can lower the power supply impedance, average the input current, improve the efficiency and noise tolerance. Select a capacitor according to the impedance of the power supply to be used. Also take into consideration the DC bias characteristics of the capacitor to be used.

2. Output capacitor (C_{OUT})

C_{OUT} is used to smooth output voltage. If the capacitance is large, the overshoot and undershoot during load transient and output ripple voltage can be improved even more. Select a proper capacitor after the sufficient evaluation under actual conditions.

Table 9 Recommended Capacitors (C_{IN}, C_{OUT}) List (at $V_{OUT(S)} \leq 3.3$ V)

Manufacturer	Part Number	Capacitance	Withstanding Voltage	Dimensions (L × W × H)
Murata Manufacturing Co., Ltd.	GRM155R60J106ME15	10 µF	6.3 V	1.0 mm × 0.5 mm × 0.5 mm
TDK Corporation	C1608X5R0J106K080AB	10 µF	6.3 V	1.6 mm × 0.8 mm × 0.8 mm
Murata Manufacturing Co., Ltd.	GRM185R60J106ME15	10 µF	6.3 V	1.6 mm × 0.8 mm × 0.5 mm

Table 10 Recommended Capacitors (C_{IN}, C_{OUT}) List (at $V_{OUT(S)} > 3.3$ V)

Manufacturer	Part Number	Capacitance	Withstanding Voltage	Dimensions (L × W × H)
TDK Corporation	C1608X5R0J106K080AB	10 µF	6.3 V	1.6 mm × 0.8 mm × 0.8 mm
Murata Manufacturing Co., Ltd.	GRM185R60J106ME15	10 µF	6.3 V	1.6 mm × 0.8 mm × 0.5 mm

3. Inductor (L)

When selecting L, note the allowable current. If a current exceeding this allowable current flows through the inductor, magnetic saturation may occur, and there may be risks which substantially lower efficiency and damage the IC as a result of large current.
Therefore, select an inductor so that peak current value (I_{PK}), even during overcurrent detection, does not exceed the allowable current.
When prioritizing the load response, select an inductor with a small L value such as 2.2 µH. When prioritizing the efficiency, select an inductor with a large L value such as 4.7 µH. I_{PK} is calculated using the following expression.

$$I_{PK} = I_{OUT} + \frac{1}{2 \times L \times f_{SW}} \times \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{V_{IN}}$$

Table 11 Recommended Inductors (L) List

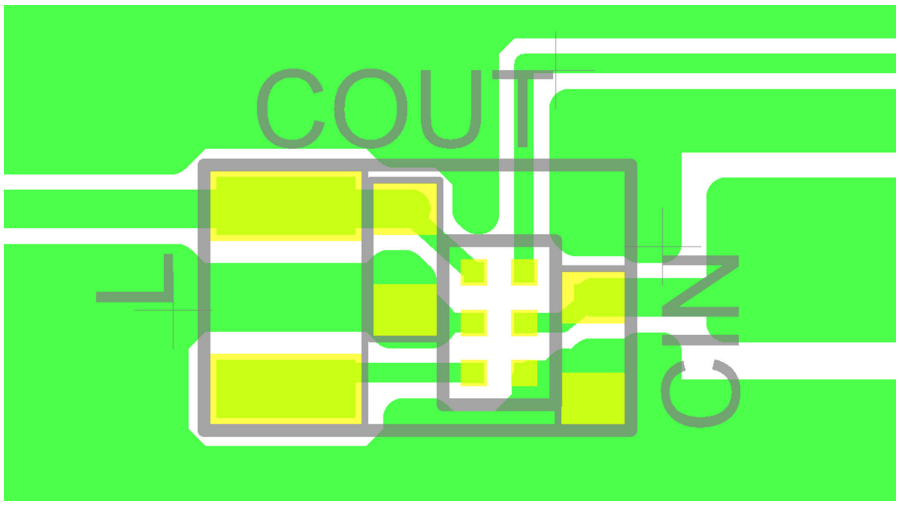
Manufacturer	Part Number	Inductance	Rated Current	Dimensions (L × W × H)
ALPS ELECTRIC CO., LTD.	GLUHK2R201A	2.2 µH	1700 mA	2.0 mm × 1.6 mm × 1.0 mm
Murata Manufacturing Co., Ltd.	DFE201210S-2R2M=P2	2.2 µH	2000 mA	2.0 mm × 1.2 mm × 1.0 mm
Würth Elektronik GmbH & Co. KG	74438313022	2.2 µH	850 mA	1.6 mm × 1.6 mm × 1.0 mm
Würth Elektronik GmbH & Co. KG	74438343022	2.2 µH	1100 mA	2.0 mm × 1.6 mm × 1.0 mm
Murata Manufacturing Co., Ltd.	LQM2MPN2R2MGH	2.2 µH	1300 mA	2.0 mm × 1.6 mm × 0.9 mm
TDK Corporation	MLP2016G2R2M	2.2 µH	850 mA	2.0 mm × 1.6 mm × 1.0 mm
Coilcraft, Inc.	PFL2015-222ME	2.2 µH	1050 mA	2.2 mm × 1.45 mm × 1.5 mm

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■ Board Layout Guidelines

Note the following cautions when determining the board layout for the S-85M1A Series.

- Place C_{IN} as close to the VIN pin and the PVSS pin as possible.
- Make the VIN pattern and GND pattern as wide as possible.
- Place thermal vias in the GND pattern to ensure sufficient heat dissipation.
- Keep thermal vias near C_{IN} and C_{OUT} approximately 3 mm to 4 mm away from capacitor pins.
- Large current flows through the SW pin. Make the wiring area of the pattern to be connected to the SW pin small to minimize parasitic capacitance and emission noise.
- Do not wire the SW pin pattern under the IC.



Total size 2.0 mm × 3.3 mm = 6.6 mm^2

Figure 10 Reference Board Pattern

Caution The above pattern diagram does not guarantee successful operation. Perform thorough evaluation using the actual application to determine the pattern.

Remark Refer to the land drawing of WLP-6L and "**WLP Package User's Guide**".

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■ Precautions

- Mount external capacitors and inductors as close as possible to the IC, and make single GND.
- Characteristic ripple voltage and spike noise occur in the IC containing switching regulators. Moreover rush current flows at the time of a power supply injection. Because these largely depend on the inductor, the capacitor and impedance of power supply to be used, fully check them using an actually mounted model.
- The 10 μF capacitor connected between the VIN pin and the VSS pin is a bypass capacitor. It stabilizes the power supply in the IC when application is used with a heavy load, and thus effectively works for stable switching regulator operation. Allocate the bypass capacitor as close to the IC as possible, prioritized over other parts.
- Although the IC contains a static electricity protection circuit, static electricity or voltage that exceeds the limit of the protection circuit should not be applied.
- The power dissipation of the IC greatly varies depending on the size and material of the board to be connected. Perform sufficient evaluation using an actual application before designing.
- ABLIC Inc. assumes no responsibility for the way in which this IC is used on products created using this IC or for the specifications of that product, nor does ABLIC Inc. assume any responsibility for any infringement of patents or copyrights by products that include this IC either in Japan or in other countries.

■ Precautions for WLP package

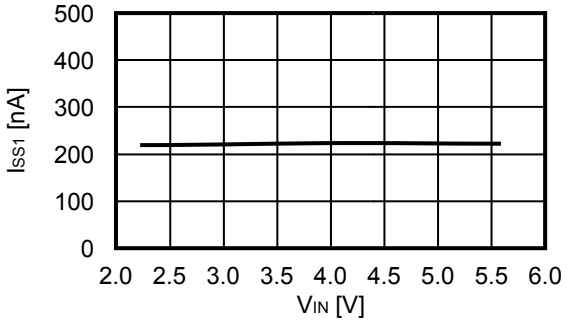
- The side of device silicon substrate is exposed to the marking side of device package. Since this portion has lower strength against the mechanical stress than the standard plastic package, chip, crack, etc. should be careful of the handing of a package enough. Moreover, the exposed side of silicon has electrical potential of device substrate, and needs to be kept out of contact with the external potential.
- In this package, the overcoat of the resin of translucence is carried out on the side of device area. Keep it mind that it may affect the characteristic of a device when exposed a device in the bottom of a high light source.

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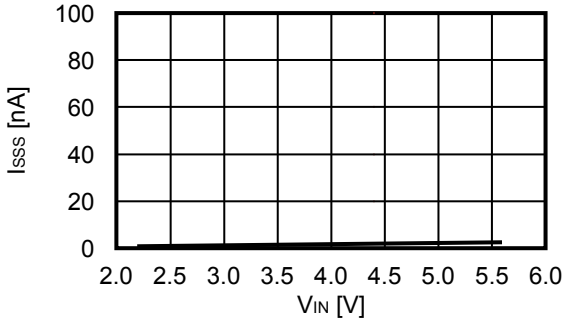
■ Characteristics (Typical Data)

1. Example of major power supply dependence characteristics (Ta = +25°C)

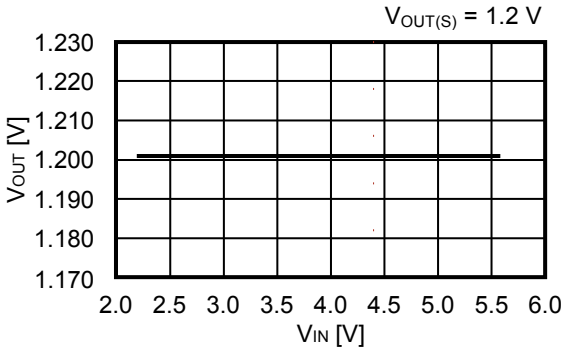
1. 1 Current consumption during switching off (I_{SS1}) vs. Input voltage (V_{IN})



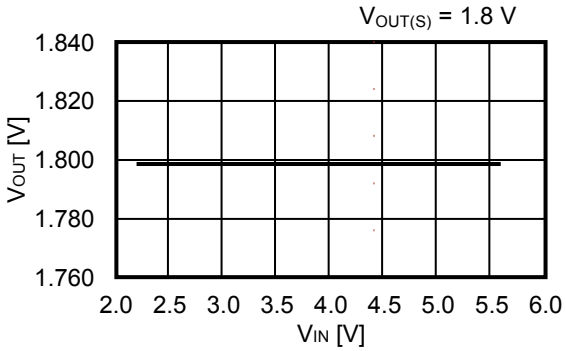
1. 2 Current consumption during shutdown (I_{SSS}) vs. Input voltage (V_{IN})



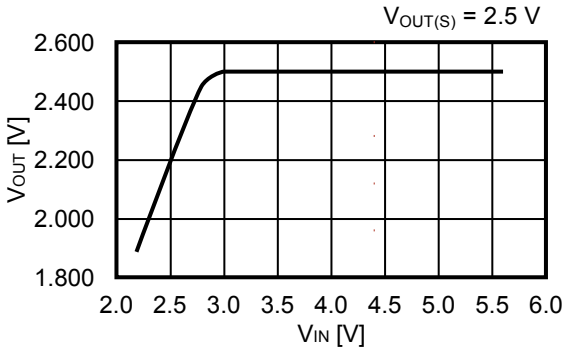
1. 3 Output voltage (V_{OUT}) vs. Input voltage (V_{IN})



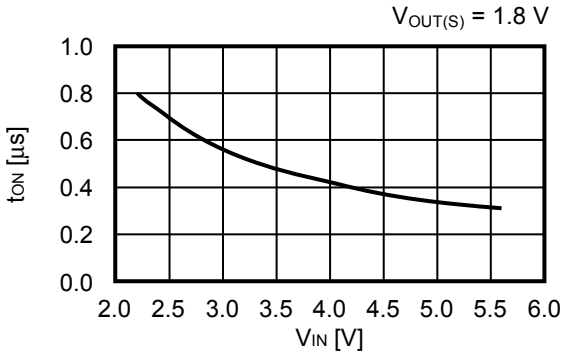
1. 4 Output voltage (V_{OUT}) vs. Input voltage (V_{IN})



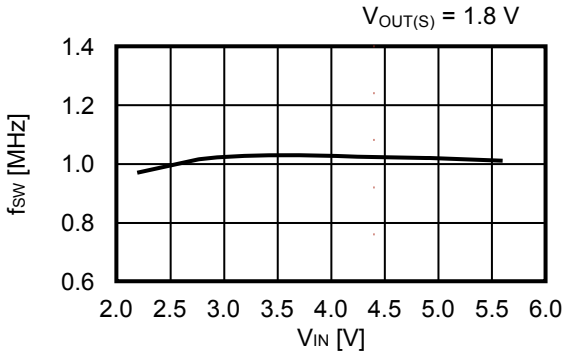
1. 5 Output voltage (V_{OUT}) vs. Input voltage (V_{IN})



1. 6 ON time (t_{ON}) vs. Input voltage (V_{IN})

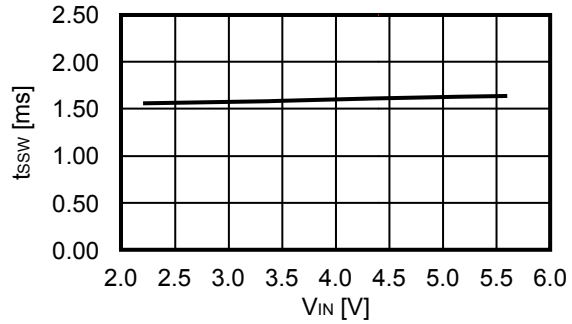


1. 7 Switching frequency (f_{SW}) vs. Input voltage (V_{IN})

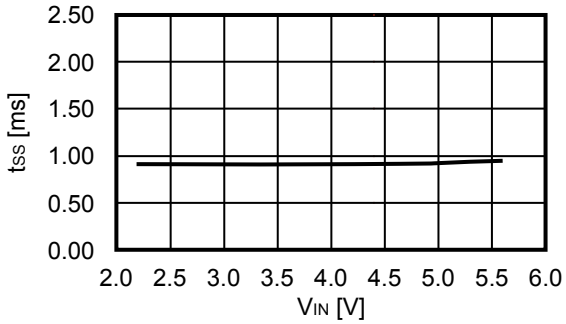


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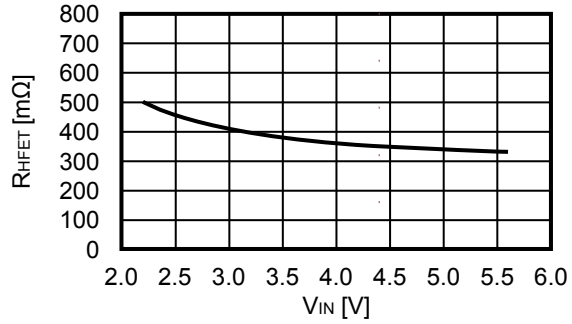
1. 8 Soft-start wait time (t_{SSW}) vs. Input voltage (V_{IN})



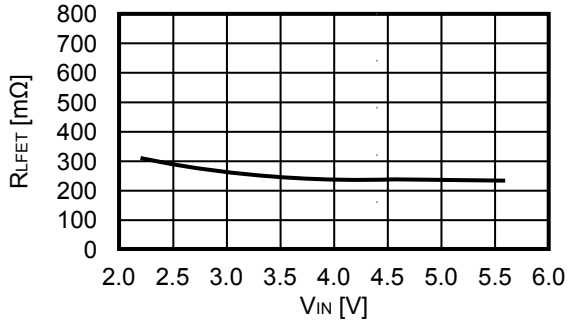
1. 9 Soft-start time (t_{SS}) vs. Input voltage (V_{IN})



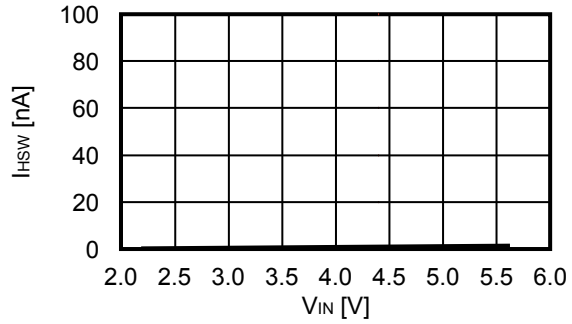
1. 10 High side power MOS FET on-resistance (R_{HFET}) vs. Input voltage (V_{IN})



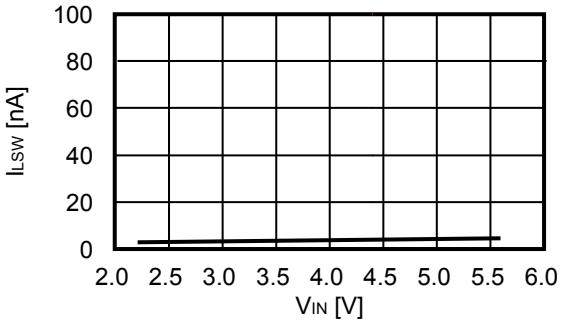
1. 11 Low side power MOS FET on-resistance (R_{LFET}) vs. Input voltage (V_{IN})



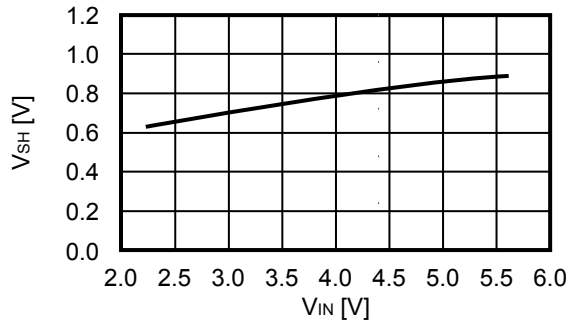
1. 12 High side power MOS FET leakage current (I_{HSW}) vs. Input voltage (V_{IN})



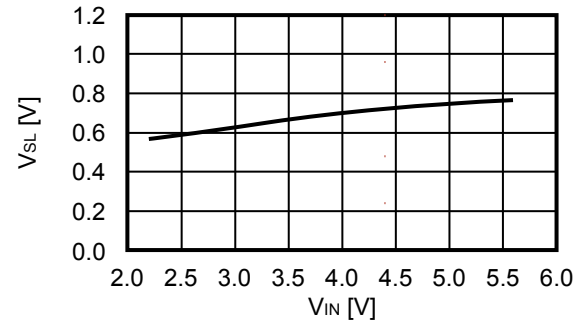
1. 13 Low side power MOS FET leakage current (I_{LSW}) vs. Input voltage (V_{IN})



1. 14 High level input voltage (V_{SH}) vs. Input voltage (V_{IN})



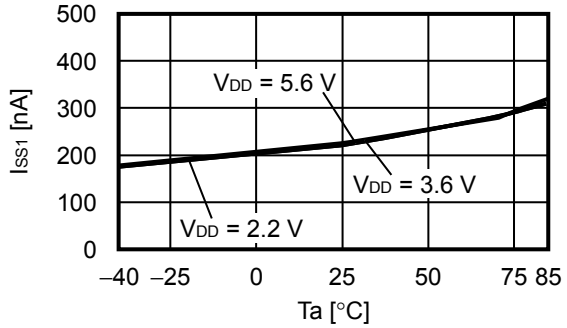
1. 15 Low level input voltage (V_{SL}) vs. Input voltage (V_{IN})



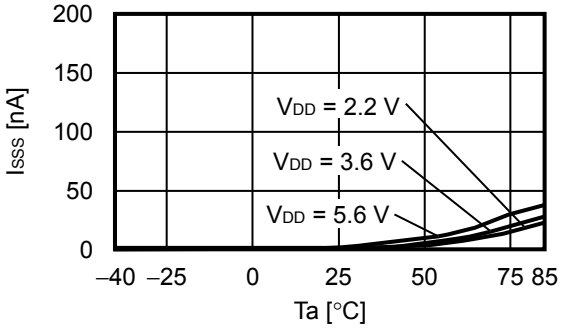
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2. Example of major temperature characteristics (Ta = –40°C to +85°C)

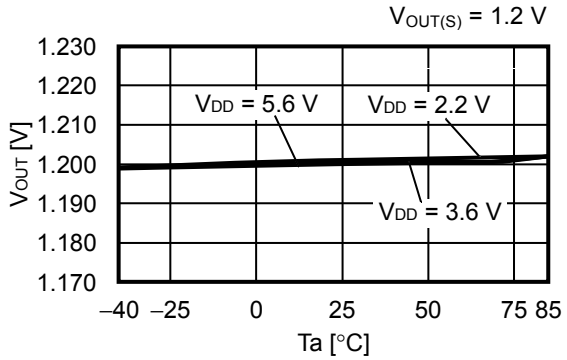
2. 1 Current consumption during switching off (I_{SS1}) vs. Temperature (Ta)



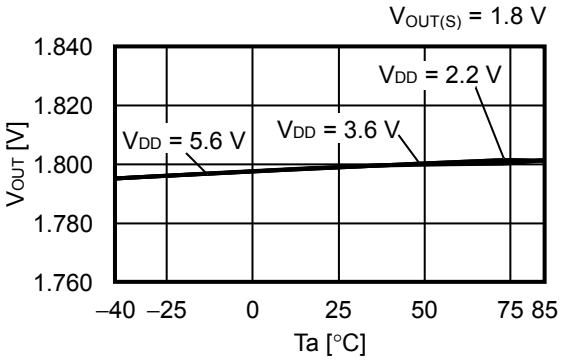
2. 2 Current consumption during shutdown (I_{SSS}) vs. Temperature (Ta)



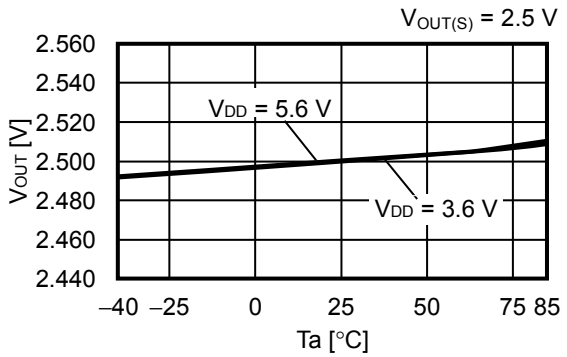
2. 3 Output voltage (V_{OUT}) vs. Temperature (Ta)



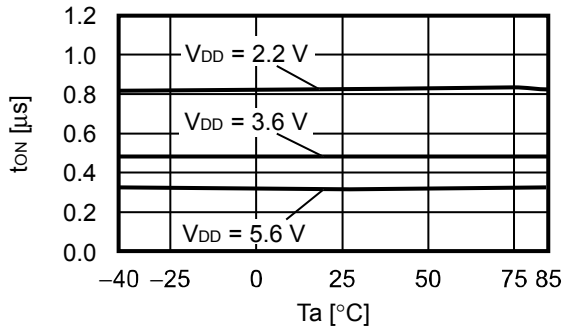
2. 4 Output voltage (V_{OUT}) vs. Temperature (Ta)



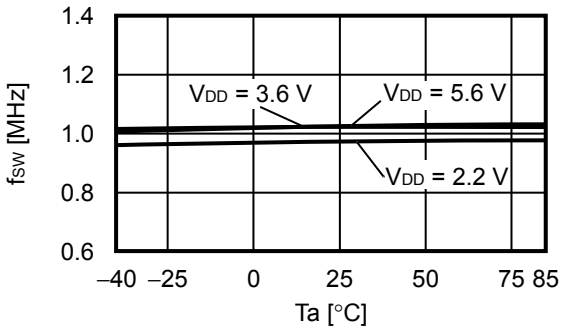
2. 5 Output voltage (V_{OUT}) vs. Temperature (Ta)



2. 6 ON time (t_{ON}) vs. Temperature (Ta)

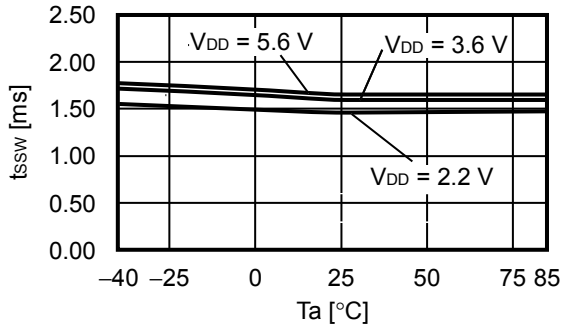


2. 7 Switching frequency (f_{SW}) vs. Temperature (Ta)

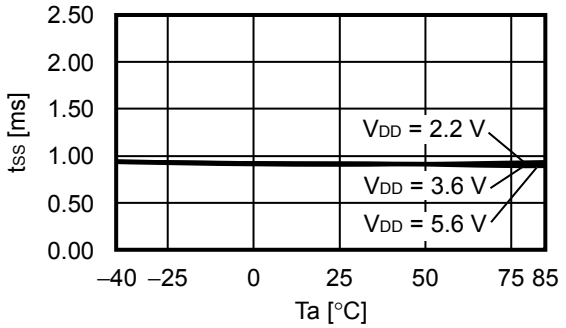


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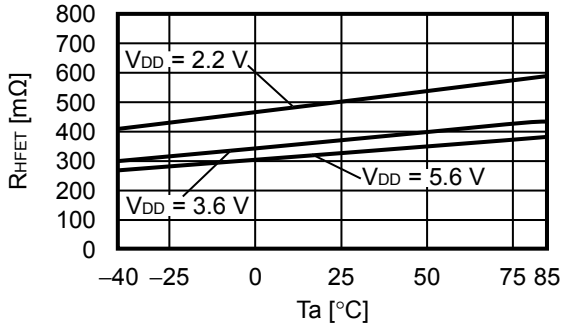
2. 8 Soft-start wait time (t_{SSW}) vs. Temperature (Ta)



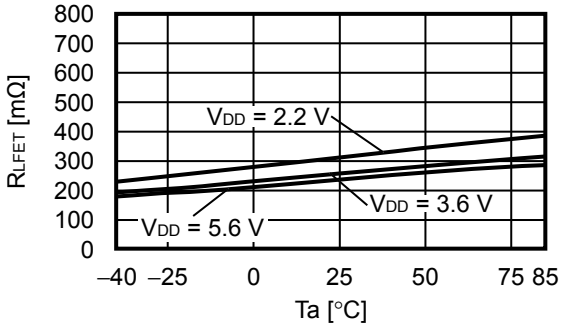
2. 9 Soft-start time (t_{SS}) vs. Temperature (Ta)



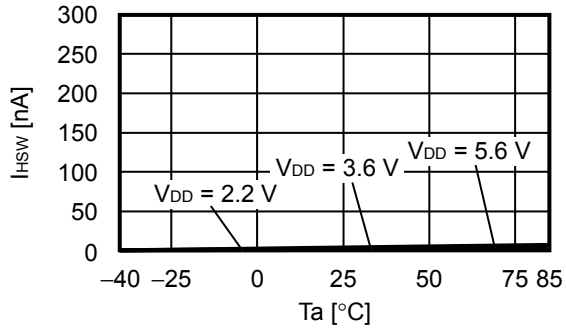
2. 10 High side power MOS FET on-resistance (R_{HFET}) vs. Temperature (Ta)



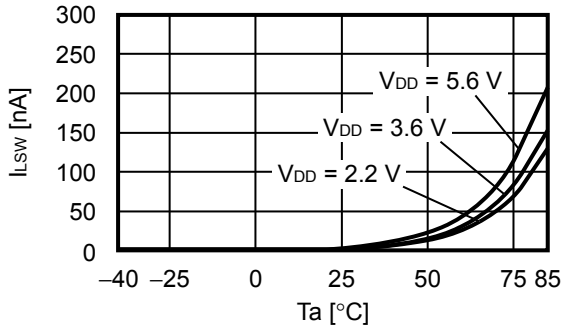
2. 11 Low side power MOS FET on-resistance (R_{LFET}) vs. Temperature (Ta)



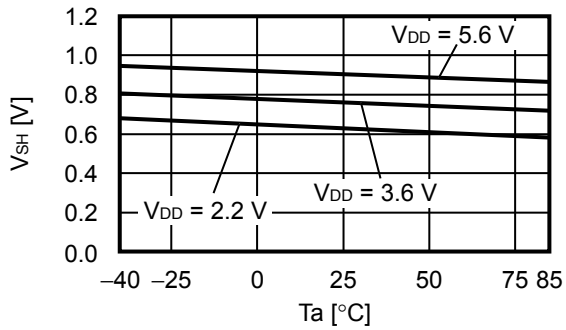
2. 12 High side power MOS FET leakage current (I_{HSW}) vs. Temperature (Ta)



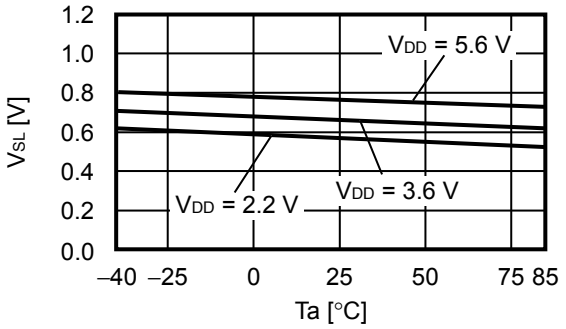
2. 13 Low side power MOS FET leakage current (I_{LSW}) vs. Temperature (Ta)



2. 14 High level input voltage (V_{SH}) vs. Temperature (Ta)

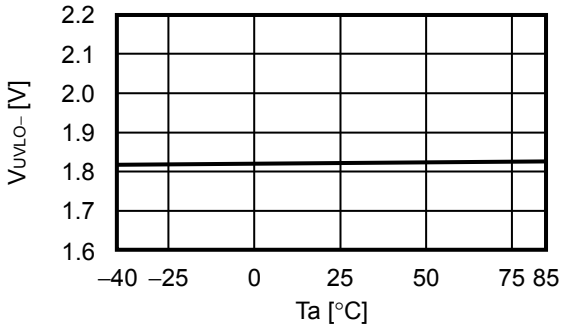


2. 15 Low level input voltage (V_{SL}) vs. Temperature (Ta)

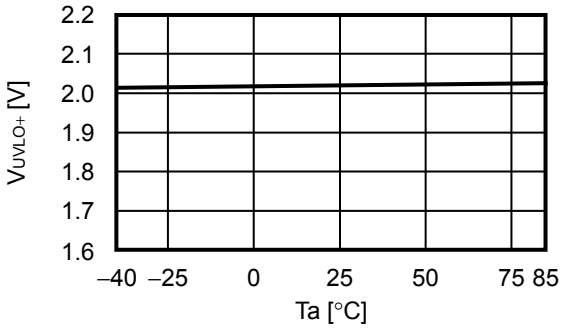


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2. 16 UVLO detection voltage (V_{UVLO-}) vs. Temperature (Ta)



2. 17 UVLO release voltage (V_{UVLO+}) vs. Temperature (Ta)



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3. Transient response characteristics

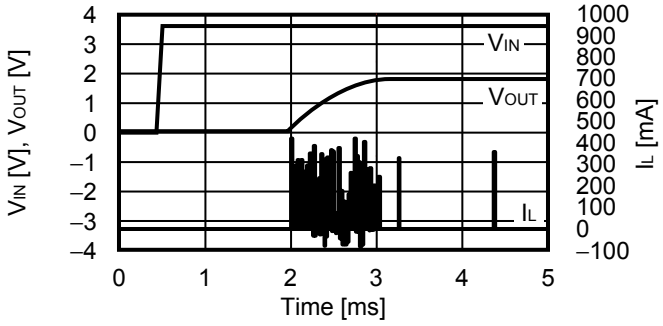
The external parts shown in **Table 12** are used in "**3. Transient response characteristics**".

Table 12

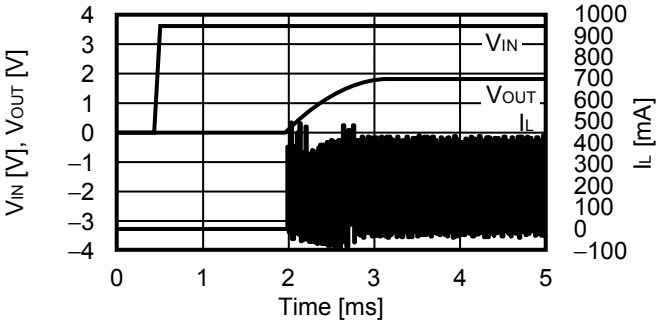
Element Name	Constant	Manufacturer	Part Number
Inductor	2.2 µH	ALPS ELECTRIC CO., LTD.	GLUHK2R201A
Input capacitor	10 µF	Murata Manufacturing Co., Ltd.	C1608X5R0J106K080AB
Output capacitor	10 µF	Murata Manufacturing Co., Ltd.	C1608X5R0J106K080AB

3. 1 Power-on (V_{OUT} = 1.8 V, V_{IN} = 0 V → 3.6 V, Ta = +25°C)

3. 1. 1 I_{OUT} = 0.1 mA



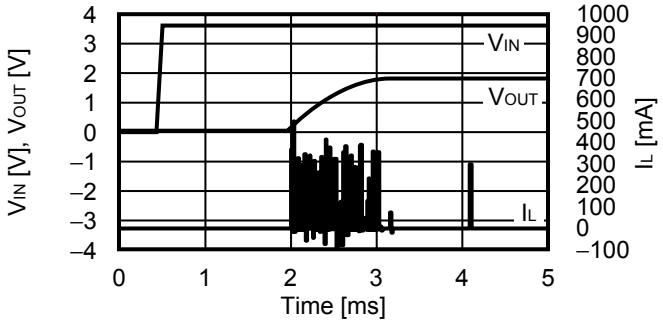
3. 1. 2 I_{OUT} = 200 mA



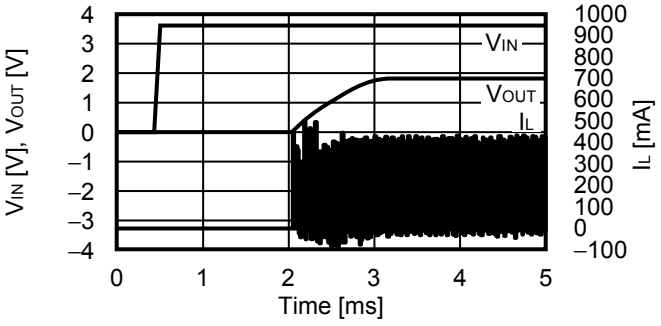
3. 2 Transient response characteristics of EN pin

(V_{OUT} = 1.8 V, V_{IN} = 3.6 V, V_{EN} = 0 V → 3.6 V, Ta = +25°C)

3. 2. 1 I_{OUT} = 0.1 mA

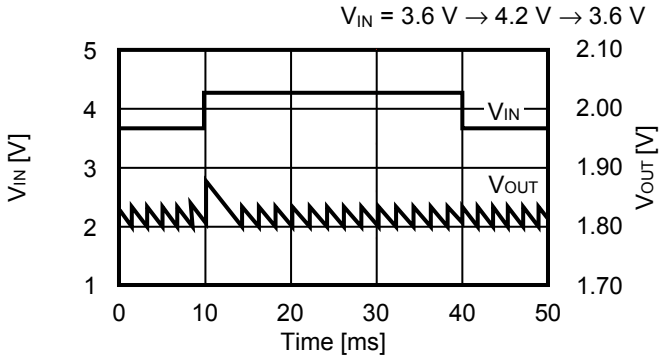


3. 2. 2 I_{OUT} = 200 mA

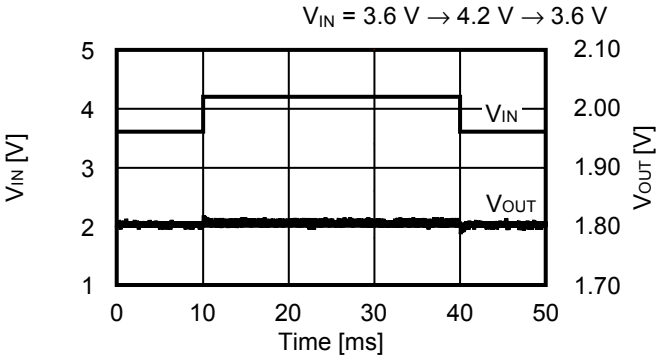


3. 3 Power supply fluctuation (V_{OUT} = 1.8 V, Ta = +25°C)

3. 3. 1 I_{OUT} = 0.1 mA



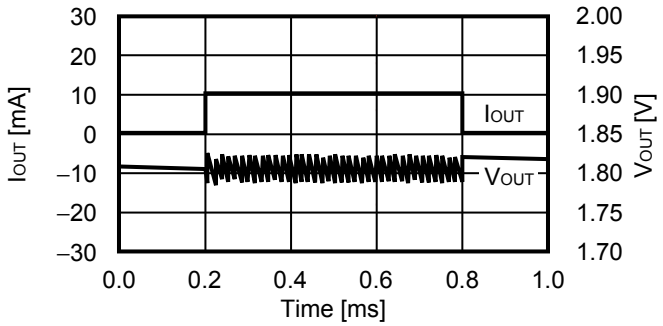
3. 3. 2 I_{OUT} = 200 mA



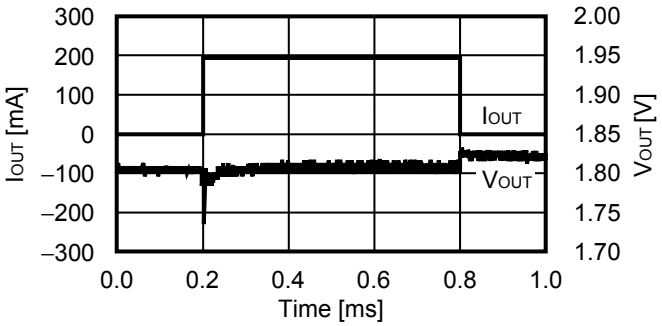
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3. 4 Load fluctuation (V_{OUT} = 1.8 V, V_{IN} = 3.6 V, Ta = +25°C)

3. 4. 1 I_{OUT} = 0.1 mA → 10 mA → 0.1 mA



3. 4. 2 I_{OUT} = 0.1 mA → 200 mA → 0.1 mA



■ Reference Data

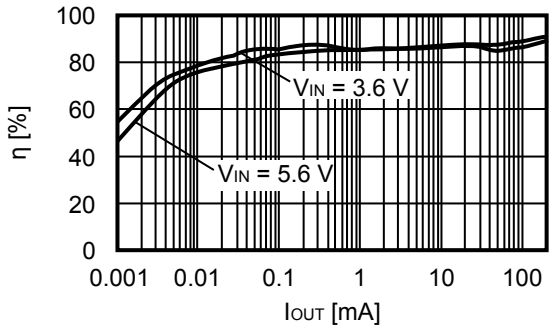
The external parts shown in **Table 13** are used in "■ **Reference Data**".

Table 13

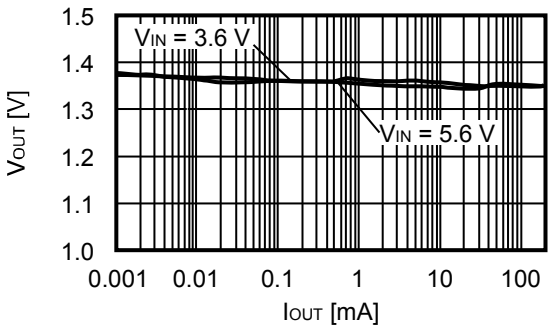
Condition	Inductor (L)	Input Capacitor (C_{IN})	Output Capacitor (C_{OUT})
<1>	GLUHK2R201A (2.2 µH) ALPS ELECTRIC CO., LTD.	GRM155R60J106ME15D (10 µF) Murata Manufacturing Co., Ltd.	GRM155R60J106ME15D (10 µF) Murata Manufacturing Co., Ltd.
<2>	DFE201210S-2R2M=P2 (2.2 µH) Murata Manufacturing Co., Ltd.	GRM155R60J106ME15D (10 µF) Murata Manufacturing Co., Ltd.	GRM155R60J106ME15D (10 µF) Murata Manufacturing Co., Ltd.

1. V_{OUT} = 1.35 V (External parts: Condition<1>)

1. 1 Efficiency (η) vs. Output current (I_{OUT})

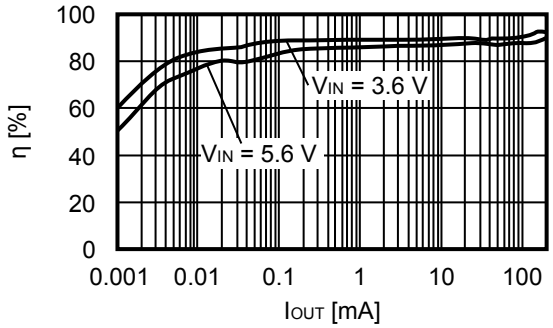


1. 2 Output voltage (V_{OUT}) vs. Output current (I_{OUT})

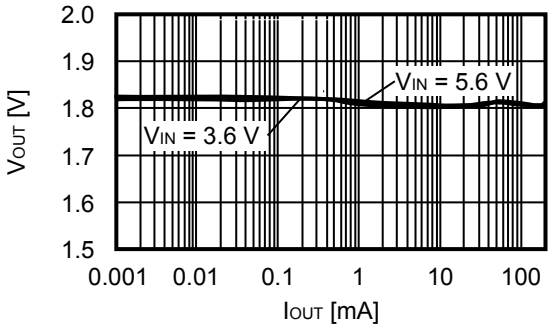


2. V_{OUT} = 1.8 V (External parts: Condition<1>)

2. 1 Efficiency (η) vs. Output current (I_{OUT})



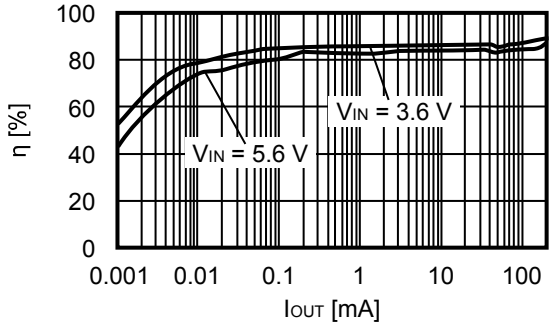
2. 2 Output voltage (V_{OUT}) vs. Output current (I_{OUT})



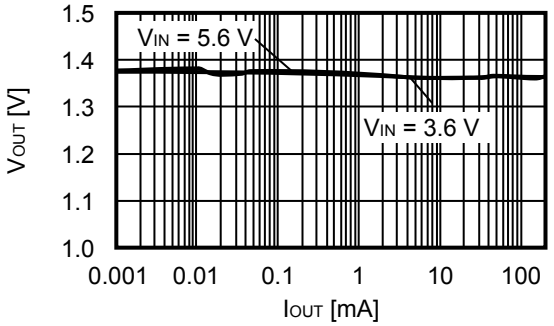
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3. V_{OUT} = 1.35 V (External parts: Condition<2>)

3. 1 Efficiency (η) vs. Output current (I_{OUT})

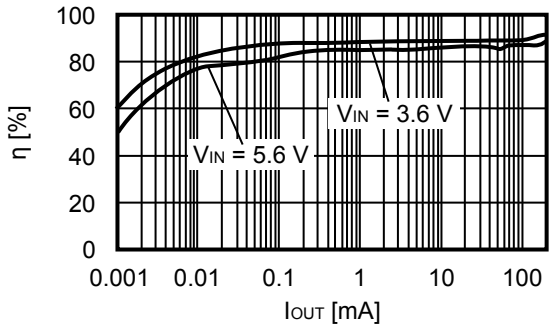


3. 2 Output voltage (V_{OUT}) vs. Output current (I_{OUT})

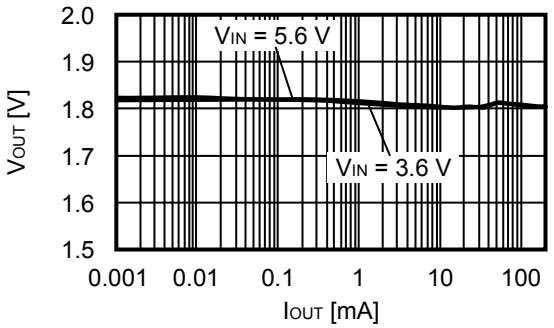


4. V_{OUT} = 1.8 V (External parts: Condition<2>)

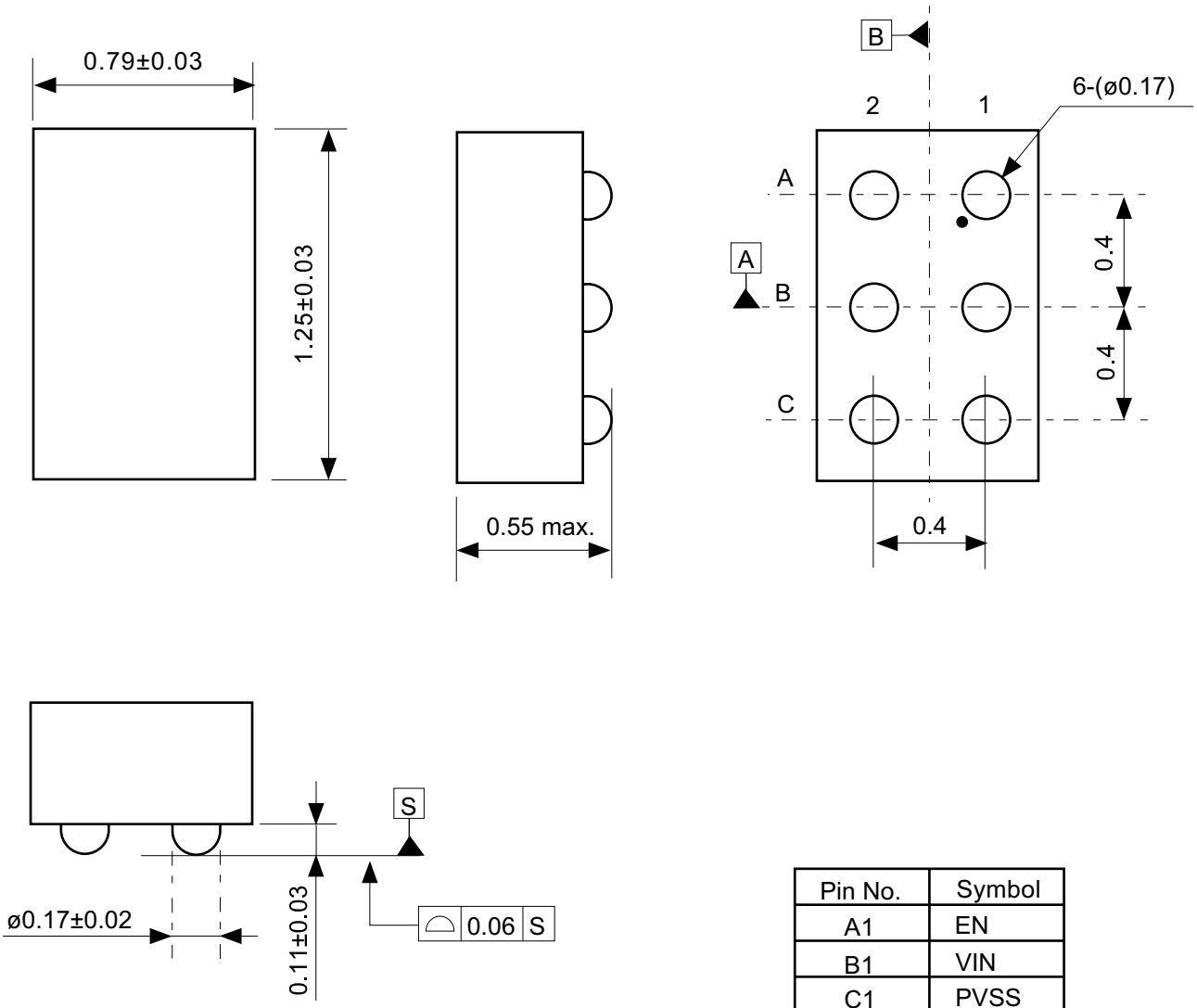
4. 1 Efficiency (η) vs. Output current (I_{OUT})



4. 2 Output voltage (V_{OUT}) vs. Output current (I_{OUT})



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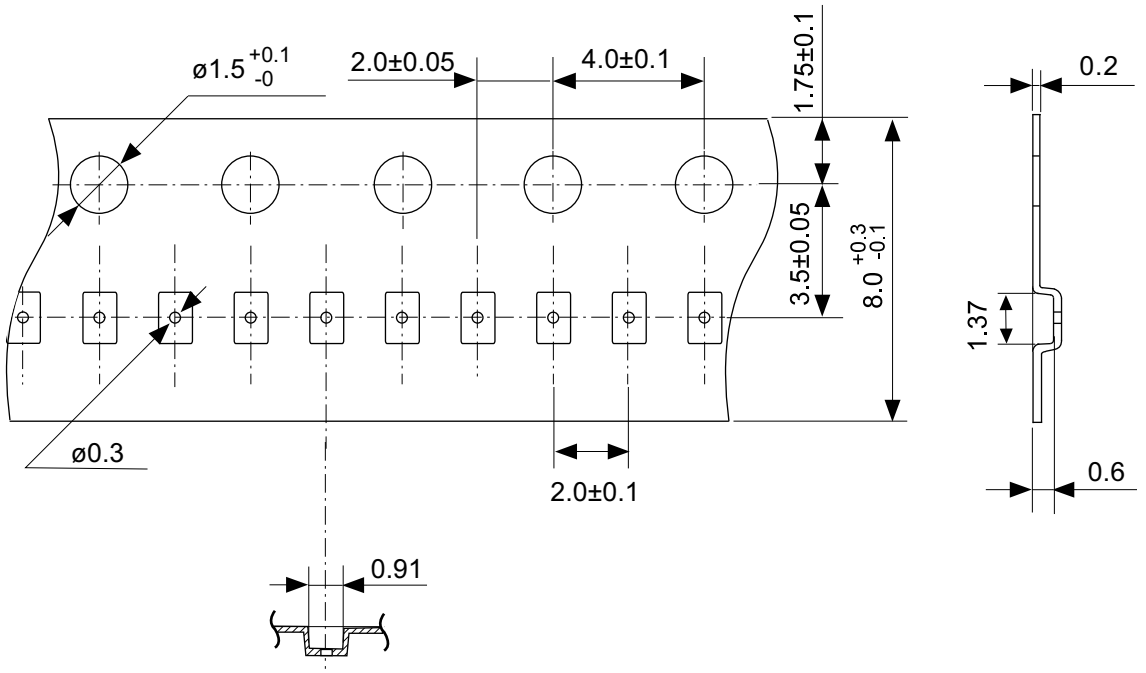


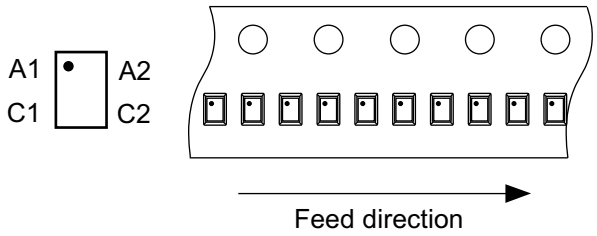
Pin No.	Symbol
A1	EN
B1	VIN
C1	PVSS
A2	VOUT
B2	VSS
C2	SW

No. HL006-A-P-SD-1.0

TITLE	WLP-6L-A-PKG Dimensions (S-85M0A/S-85M1A)
No.	HL006-A-P-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	

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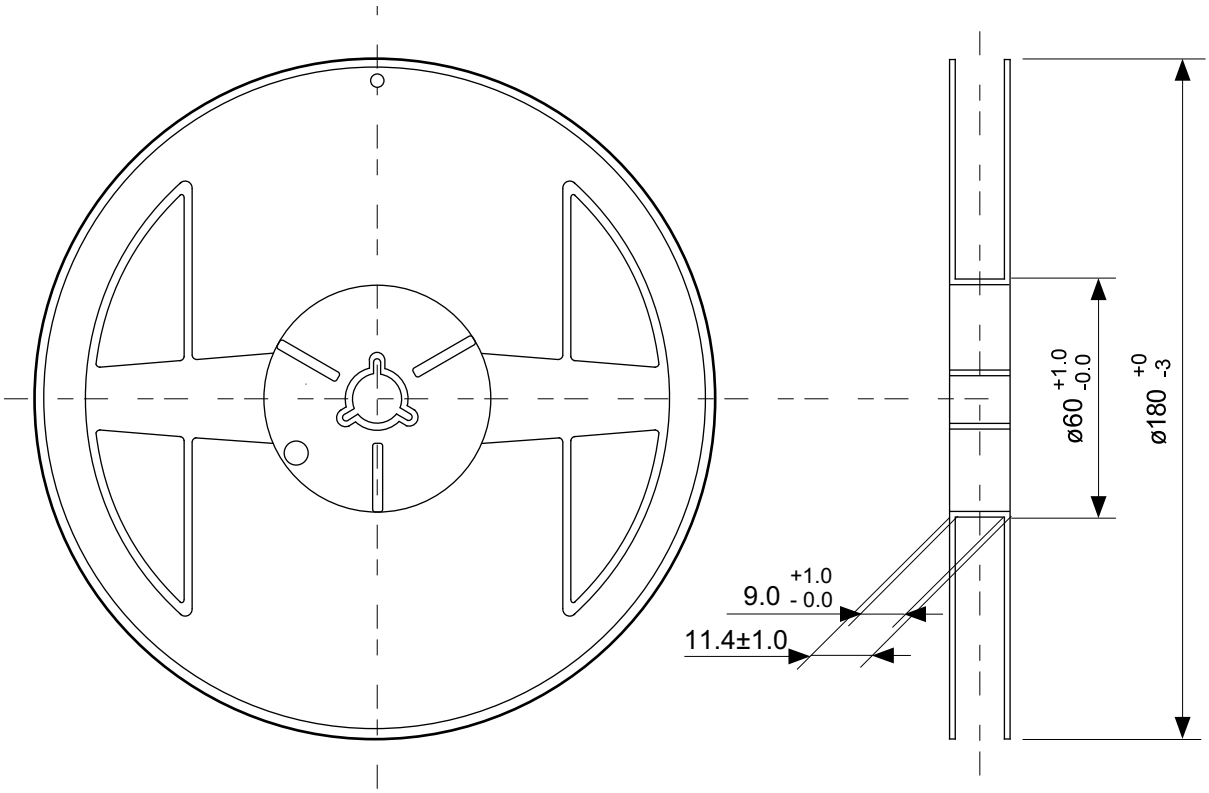




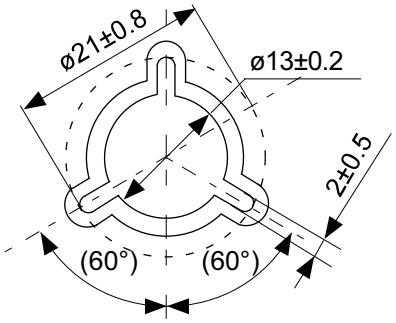
No. HL006-A-C-SD-2.0

TITLE	WLP-6L-A-Carrier Tape (S-85M0A/S-85M1A)
No.	HL006-A-C-SD-2.0
ANGLE	
UNIT	mm
ABLIC Inc.	

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Enlarged drawing in the central part



No. HL006-A-R-SD-1.0

TITLE	WLP-6L-A-Reel (S-85M0A/S-85M1A)		
No.	HL006-A-R-SD-1.0		
ANGLE		QTY.	6,000
UNIT	mm		
	ABLIC Inc.		

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