# 1. OVERVIEW

The SM8150A is a charge pump type white LED driver, with 2-system programmable LDOs (Low Dropout Regulator), and step-down DC/DC converter power management IC. The white LED driver provides constant-current drive for 1 to 6 backlight white LED connected in parallel and 1 torch/strobe white LED. The charge pump automatically selects between ×1 mode, ×1.5 boost mode, and ×2 boost mode in response to battery voltage, LED drive current, and VF_{LED} (LED forward bias voltage drop) conditions in order to extend battery drive life. The SM8150A operating mode settings are accessed using an I^2C^{*1} interface, allowing LED drive current, LDO voltage, output ON/OFF, and other settings to be controlled from a microcontroller.

*1. I^2C-BUS is a registered trademark of NXP B. V.

2. FEATURES

- Optimum specifications for clamshell cellular phone with camera
  - LCD backlight: Main-4ch/Sub-2ch (max 25mA/ch)
  - Camera flash: 1ch (max 300mA)
- Power saving design by automatic mode selection of charge pump
  - Power at ×1.5 mode is reduced by 25% from ×2 mode
  - Power at ×1 mode is reduced by 50% from ×2 mode, 33% from ×1.5 mode
- I^2C interface best match for cellular phone chipset
- Selecting current value (torch/strobe) of flash LED by SBN pin
- Shutdown synchronized to microcontroller supply by VEN pin
- 1 system of step-down DC/DC converter built-in
  - Output: 1.2 to 3.0V@ max 500mA
- 2 systems of programmable LDO built-in
  - Output: 1.5/1.8/2.5/2.6/2.8/3.0/3.1/3.3V@ max 300mA
- Various protection circuits built-in
  - Startup soft start circuit built-in
  - Overtemperature thermal shutdown (TSD) circuit built-in
  - Supply undervoltage lockout (UVLO) circuit built-in
- Supply voltage range (VIN1 to VIN3): 2.7 to 4.6V
  Logic operating voltage range (VEN): 1.8 to 4.6V
- White LED Driver
  - Charge-pump frequency: 1.0MHz (typ)
  - Charge-pump maximum output current: 450mA
  - Backlight LED current: 25 ± 1.5mA/ch (max)
  - Backlight LED relative accuracy: ± 3%
  - Flash LED current: 300 ± 20mA (max)
- DC/DC converter
  - DC/DC converter output voltage: 1.2 to 3.0V (typ)
  - DC/DC converter output current: 500mA (max)
  - DC/DC converter operating frequency: 2.0MHz (typ)
  - DC/DC converter voltage accuracy: ± 2%
- LDO
  - LDO output voltage: 1.5 to 3.3V (VIN = 3.6V)
  - LDO output current: 300mA (max)
  - LDO dropout voltage: 0.1V (typ)
  - LDO voltage accuracy: ± 2%
- Package: 28-pin QFN
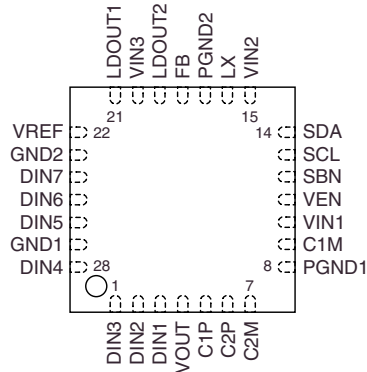
3. TYPICAL APPLICATION CIRCUIT
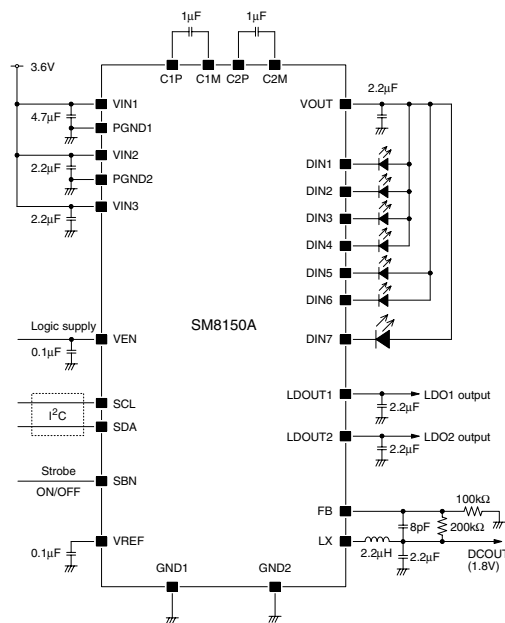
4. APPLICATIONS

- Cellular phone
- Mobile equipment

5. ORDERING INFORMATION

Device	Package
SM8150AB	28-pin QFN

6. PINOUT

(Top view)

7. PIN DESCRIPTION

| Number	Name	I/O	Description
1	DIN3	O	LED drive current control output 3 (group A)[*1]
2	DIN2	O	LED drive current control output 2 (group A)[*1]
3	DIN1	O	LED drive current control output 1 (group A)[*1]
4	VOUT	O	LED drive voltage output
5	C1P	–	Charge pump boost capacitor connection
6	C2P	–	Charge pump boost capacitor connection
7	C2M	–	Charge pump boost capacitor connection
8	PGND1	–	Ground (charge pump)
9	C1M	–	Charge pump boost capacitor connection
10	VIN1	–	Supply input (charge pump)
11	VEN	–	Supply input (logic)[*2]
12	SBN	I	Torch/strobe selecting voltage input (strobe when LOW)[*3]
13	SCL	I	I²C interface clock input[*3]
14	SDA	I/O	I²C interface data input[*3]
15	VIN2	–	Supply input (DC/DC converter)
16	LX	O	DC/DC converter coil switching output[*4]
17	PGND2	–	Ground (DC/DC converter)
18	FB	I	DC/DC converter feedback input
19	LDOUT2	O	LDO output 2[*4]
20	VIN3	–	Supply input (logic and LDOs)
21	LDOUT1	O	LDO output 1[*4]
22	VREF	O	Bypass capacitor connection
23	GND2	–	Ground
24	DIN7	O	LED drive current control output 7 (high-current LED)[*1]
25	DIN6	O	LED drive current control output 6 (group B)[*1]
26	DIN5	O	LED drive current control output 5 (group B)[*1]
27	GND1	–	Ground
28	DIN4	O	LED drive current control output 4 (group A)[*1]

*1. Connect to ground when no LED is connected.
*2. Connect to a supply with ≥ 1.8mA drive current capability. If pull-up resistors Rup are connected to SCL, SDA, and SBN, the current consumption increases by the amount flowing through the pull-up resistances only. The current component for each of the 3 pins is given by Iup [mA] = VEN [V] / Rup [kΩ].
*3. Pull-up or pull-down resistances are not built-in.
*4. Leave open circuit when not used (do not connect to ground).

8. BLOCK DIAGRAM
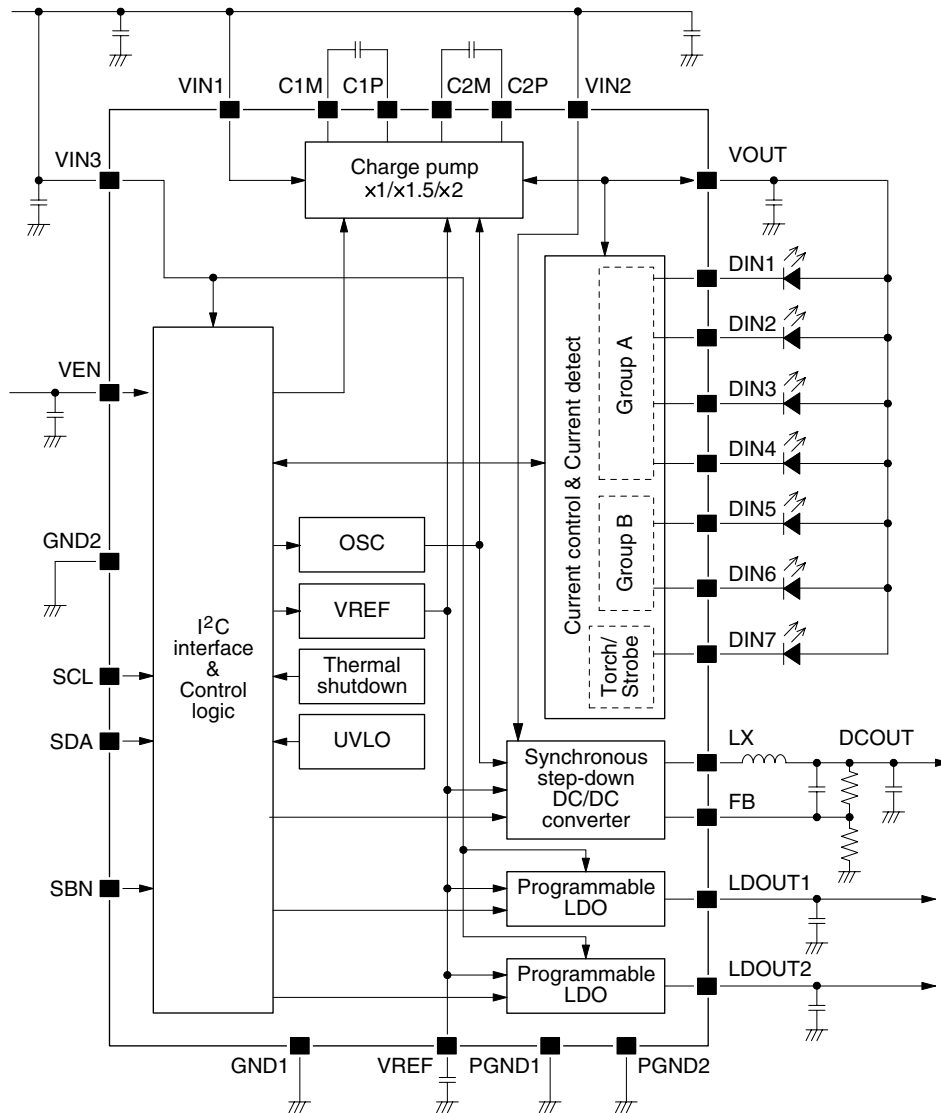
9. ABSOLUTE MAXIMUM RATINGS

GND = PGND = 0V

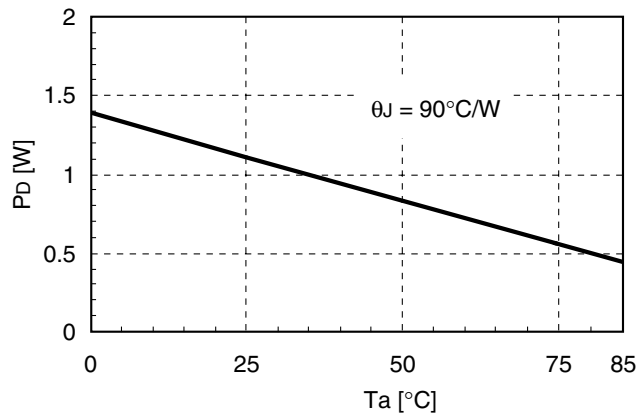| Parameter	Pins	Symbol	Rating	Unit
Supply voltage	VIN1 to 3	V_{IN}	−0.3 to 5.5	V
Logic operating voltage	VEN	V_{EN}	−0.3 to 5.5	V
Input voltage	SBN, SCL, SDA	V_{DATA}	−0.3 to V_{EN} + 0.3	V
	All other input pins	V_{INPUT}	−0.3 to V_{IN} + 0.3	V
Output voltage	SDA	V_{OUT_ACK}	−0.3 to V_{EN} + 0.3	V
	VOUT	V_{OUT_CP}	5.5	V
	All other output pins	V_{OUTPUT}	−0.3 to V_{IN} + 0.3	V
Output current	VOUT	I_{OUT_CP}	600	mA
	LX	I_{OUT_LX}	1.2	A
	LDOUT1 to 2	I_{OUT_LDO}	1	A
Power dissipation		P_D	1.1 (θ_J = 90°C /W)[*1]	W
Junction temperature	−	T_{JMAX}	+125	°C
Storage temperature		T_{STG}	−55 to +125	°C

*1. When the SM8150A is mounted on a $40 \times 60 \times 1.6$mm 2-layer board whose wiring pattern ratio is 130%.

Note. The device may suffer breakdown if any one of these parameter ratings is exceeded.

The thermal resistance θ_J required for the operating environment is determined by the relationship with power dissipation and operating temperature given below.

■ Maximum junction temperature: T_{JMAX} = 125 [°C]
■ Operating temperature: Ta [°C]
■ Thermal resistance: θ_J [°C/W]

$$P_D = \frac{(T_{JMAX} - Ta)}{\theta_J}$$

SM8150A power dissipation

10. RECOMMENDED OPERATING CONDITIONS

VIN1 = VIN2 = VIN3, GND = PGND = 0V

Parameter	Pin	Symbol	Conditions	Rating			Unit
				min	typ	max	
Supply voltage[*1]	VIN1 to 3	$V_{IN\_\times1}$	×1 mode, I_{OUT} = 0mA	2.7	3.6	4.6	V
		$V_{IN\_\times1.5}$	×1.5 mode, I_{OUT} = 150mA	3.0	3.6	4.6	V
		$V_{IN\_\times2}$	×2 mode, I_{OUT} = 450mA	3.3	3.6	4.6	V
Logic operating voltage	VEN	V_{EN}		1.8	2.8	4.6	V
Input voltage	SBN, SCL, SDA	V_{DATA}		0	–	V_{EN}	V
Strobe time[*2]	DIN7	t_{STROBE}	$I_{LED7} \geq$ 150mA	–	–	250	ms
Torch LED current[*2]		I_{LED7}	t_{TORCH} > 250ms	–	–	150	mA
Operating temperature	–	Ta		−30	25	+85	°C

*1. Supply voltage and I_{OUT} (LED)
When the white LED drive current is increased, the required supply voltage also increases. The supply is automatically switched in charge pump boost mode, and cannot be manually selected. The forward-bias voltage drop VF of the LED is assumed to be ≤ 3.5V.
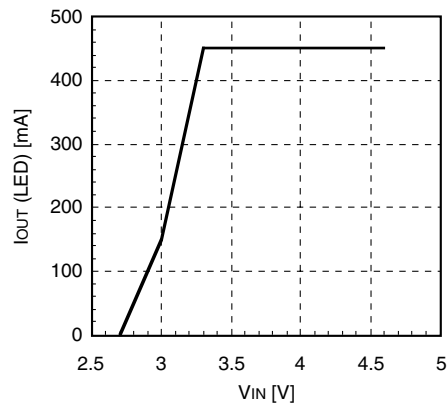
I_{OUT} (LED) vs. V_{IN}

*2. Torch and Strobe
Pin DIN7 is provided for connection to a high-current white LED. Two types of light modulation (dimming) data are available, switched by the SBN input voltage. When SBN is HIGH, torch mode is selected. When SBN is LOW, strobe mode is selected. The recommended operating condition is high current with short ON times in strobe mode, and low current with longer ON times in torch mode. In strobe mode (SBN = LOW), high-current supply is the main priority and, therefore, the current consumption is not optimized (see "Torch/Strobe Selecting").

| I²C data settings								SBN	Torch	Strobe	Dimming	Recommended operating conditions
DIN7 − Enable	1	1	1	*	*	1	*	*	H	ON	OFF	Torch	I_{LED7} < 150mA
									L	OFF	ON	Strobe	Operating time < 250ms
DIN7 − Disable	1	1	1	*	*	0	*	*	H	OFF	OFF	–	–
									L	OFF	OFF	–	–

11. ELECTRICAL CHARACTERISTICS

11-1. Common Blocks

V_{IN} = 3.6V, V_{EN} = 2.8V, GND = PGND = 0V, Ta = 25°C unless otherwise noted.

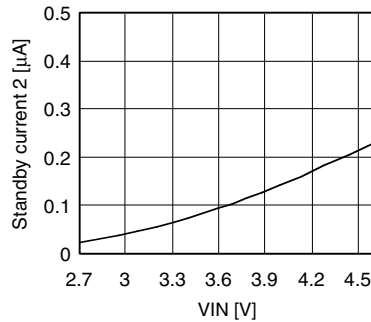| Parameter	Pin	Symbol	Condition	Rating			Unit
				min	typ	max	
Standby current 1	VIN	I_{STB1}	VEN = 0V, input/outputs no load	–	0.01	1	µA
Standby current 2		I_{STB2}	VEN ≥ 1.8V, input/outputs no load	–	0.1	1	µA
Current consumption[*1]	VEN	I_{EN1}	SCL = SDA = SBN = VEN	–	0.1	1	µA
		I_{EN2}	SBN = VEN = 2.8V SCL, SDA: f = 400kHz t_r = t_f = 300ns signal amplitude = VEN × 90%	–	0.1	0.5	mA
		I_{EN3}	SBN = VEN = 4.6V SCL, SDA: f = 400kHz t_r = t_f = 300ns signal amplitude = VEN × 90%	–	0.6	1.8	mA
Power-ON reset time[*2]	VIN	t_{POR}	Design value	–	–	1	ms
UVLO operating voltage		V_{UVLO}	VIN falling	2.0	2.45	2.65	V
TSD operating temperature	–	T_{SD}	Design value	–	170	–	°C
TSD hysteresis		T_{SDHYS}	Design value	–	20	–	°C
H-level input voltage 1	SBN, SCL, SDA	V_{IH1}	VEN ≥ 2.3V	1.8	–	–	V
L-level input voltage 1		V_{IL1}	VEN ≥ 2.3V	–	–	0.6	V
H-level input voltage 2		V_{IH2}	VEN < 2.3V	1.5	–	–	V
L-level input voltage 2		V_{IL2}	VEN < 2.3V	–	–	0.3	V
H-level input current		I_{IH}	V_{IH} = VEN	–	–	1.0	µA
L-level input current		I_{IL}	V_{IL} = GND	–1.0	–	–	µA

*1. Excluding the current that flows to external circuit such as pull-up resistors.
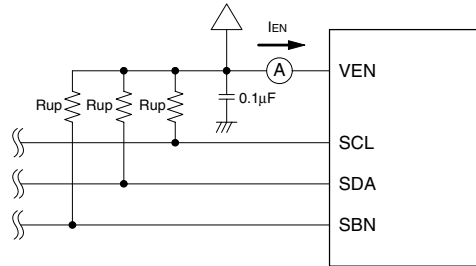
*2. The time between when power is applied and the device enters standby mode.

Reference Data

Standby current (VEN = 1.8V)

11-2. White LED Driver

V_{IN} = 3.6V, V_{EN} = 2.8V, GND = PGND = 0V, Ta = 25°C unless otherwise noted.

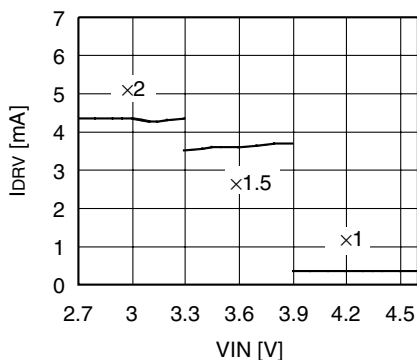| Parameter	Pin	Symbol	Condition	Rating			Unit
				min	typ	max	
Current consumption[1]	VIN	$I_{DRV\_\times1}$	×1 mode, no load	–	0.3	1	mA
		$I_{DRV\_\times1.5}$	×1.5 mode, no load	–	4	8	mA
		$I_{DRV\_\times2}$	×2 mode, no load	–	5	10	mA
Output voltage[2]	VOUT	V_{OUT_CP}	Boost ON, no load	4.6	4.9	5.2	V
Output current		I_{OUT_CP}	Boost ON	–	–	450	mA
Charge pump frequency	C1M	f_{OSC}		0.85	1.0	1.15	MHz
Soft start time[3]	DIN1 to 7	t_{SS}		–	1	3	ms
LED drive pin leakage current		$I_{LEAK1\ to\ 7}$	Standby mode, DIN1 to 7 = VIN	–	0.01	1.0	μA
LED current (max) 1	DIN1 to 6	$I_{LED1\ to\ 6}$	×1 mode, $I_{LED1\ to\ 6}$ max setting	23.5	25.0	26.5	mA
LED current relative accuracy		ΔI_{LED}	×1 mode, $I_{LED1\ to\ 6}$ max setting	–3.0	–	+3.0	%
LED current (max) 2	DIN7	I_{LED7}	×2 mode, I_{LED7} max setting	280	300	320	mA

*1. LDOUT1 to 2 and the DC/DC converter is disabled.
*2. Over voltage protection threshold.
*3. The time from when one of the DIN1 to 7 outputs is enabled until the LED turns ON.

Charge Pump Operating Mode Switching

The SM8150A switches between 3 charge pump operating modes; ×1 mode (VIN through mode), ×1.5 mode (×1.5 charge pump boost), and ×2 mode (×2 charge pump boost), reducing the total power dissipation. These selecting occurs automatically in internal circuits, and cannot be controlled by external signals. If the LED current drops below the setting value while operating in ×1 or ×1.5 mode, each LED drive circuit detects the undercurrent and the operating mode is automatically selected ×1 → ×1.5, ×1.5 → ×2. This occurs even if only one LED undercurrent condition is detected among the 7-channel LED drive circuits, thus it is recommended that LED has small VF variation to optimize the total efficiency. In ×1.5 or ×2 mode operating, the SM8150A generates "a mode reset signal" internally once every 1 second. This signal forces to select the mode ×1.5 → ×1, ×2 → ×1.5.

Reference Data

Current consumption (No load)
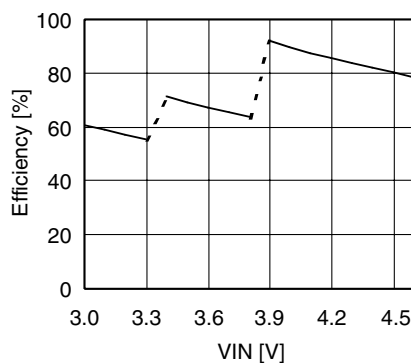
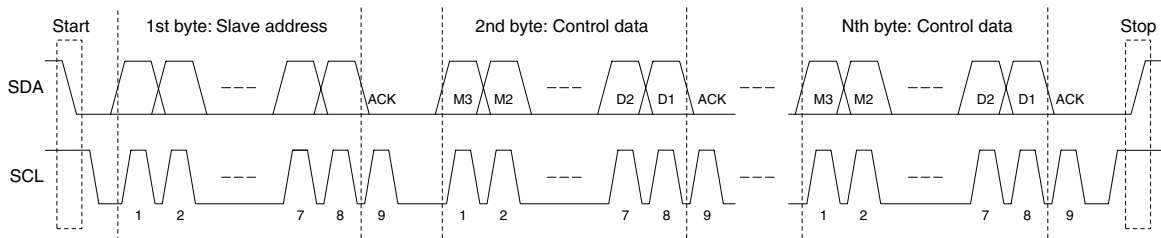Efficiency (DIN1 to 6: 25mA, DIN7: 155mA)

11-3. I^{2}C Interface

V_{IN} = 3.6V, V_{EN} = 2.8V, GND = PGND = 0V, Ta = 25°C unless otherwise noted.

Parameter	Pin	Symbol	Condition	Rating			Unit
				min	typ	max	
SCL clock frequency	SCL	f_{SCL}		–	–	400	kHz
SCL hold time	SCL, SDA	$t_{HD;STA}$	I^{2}C start condition	0.6	–	–	μs
SCL L-level pulsewidth	SCL	t_{LOW}		1.3	–	–	μs
SCL H-level pulsewidth		t_{HIGH}		0.6	–	–	μs
SCL setup time	SCL, SDA	$t_{SU;STA}$	I^{2}C start condition	0.6	–	–	μs
SDA data hold time		$t_{HD;DAT}$		0.05	–	0.9	μs
SDA data setup time		$t_{SU;DAT}$		100	–	–	ns
Rise time		t_r		–	–	300	ns
Fall time		t_f		–	–	300	ns
SCL setup time		$t_{SU;STO}$	I^{2}C stop condition	0.6	–	–	μs
Bus free time		t_{BUF}		1.3	–	–	μs
Capacitive load for each bus line		C_b		–	–	400	pF
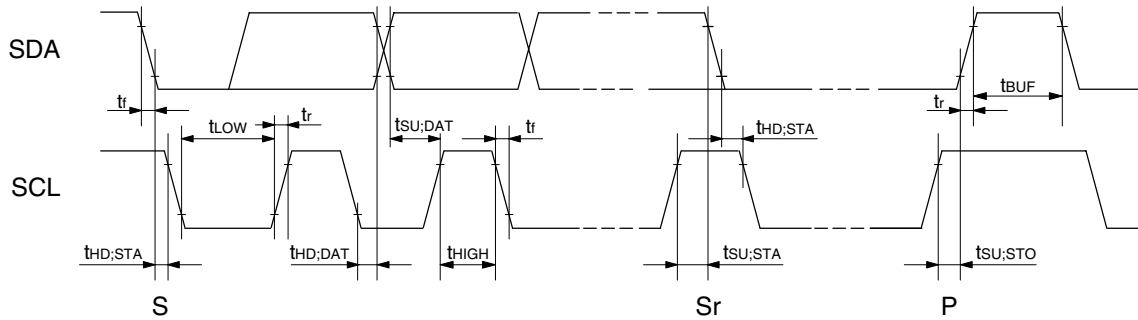
Note. S: START condition, Sr: repeated START condition, P: STOP condition

After a START condition, the slave address should be sent, and a data transfer should be terminated by a STOP condition.

11-4. DC/DC Converter

V_{IN} = 3.6V, V_{EN} = 2.8V, GND = PGND = 0V, Ta = 25°C unless otherwise noted.

Parameter	Pin	Symbol	Condition	Rating			Unit
				min	typ	max	
Current consumption[*1]	VIN	I_{DD}	No load, switching stopped	–	0.5	1.2	mA
Soft start time[*2]	LX	t_{SS}	DCOUT = 1.8V	–	1	–	ms
Output voltage range[*3]	DCOUT	V_{DCO}		1.2	–	3.0	V
FB pin voltage	FB	V_{FB}	I_{DCO} = 1mA	0.588	0.6	0.612	V
LX pin output current	DCOUT	I_{DCO}		–	–	500	mA
Switching frequency	LX	f_{OSC}		1.7	2.0	2.3	MHz
Supply-side switch ON resistance		R_{ONP}	I_{LX} = 50mA	–	0.5	1.0	Ω
GND-side switch ON resistance		R_{ONN}	I_{LX} = 50mA	–	0.4	0.8	Ω
LX pin leakage current		I_{LEAKLX}	Standby mode, LX = 1/2VIN	−1.0	–	1.0	μA
Line regulation	DCOUT	ΔV_{OUT1}	2.7 ≤ VIN ≤ 4.6V, I_{DCO} = 1mA	–	10	–	mV
Load regulation		ΔV_{OUT2}	1mA ≤ I_{DCO} ≤ 300mA	–	60	–	mV
Overcurrent protection circuit operating current	LX	$I_{LIMITLX}$	Supply-side switch	0.8	1.2	1.7	A

*1. DIN1 to 7 and LDOUT1 to 2 outputs are disabled.
*2. The time from when the DC/DC converter is enabled until the output is stabilized.
*3. The DCOUT output voltage is determined by the external resistors R1 and R2, as given by the following equation. The SM8150A DC/DC converter controls the output such that the FB pin voltage remains at 0.6V. The DCOUT voltage is given for values of R1 and R2 in the table on the right, where R1 is a fixed 200kΩ resistance.
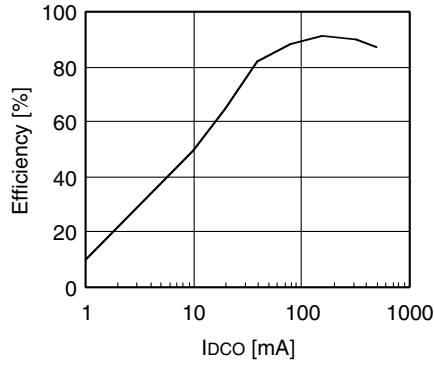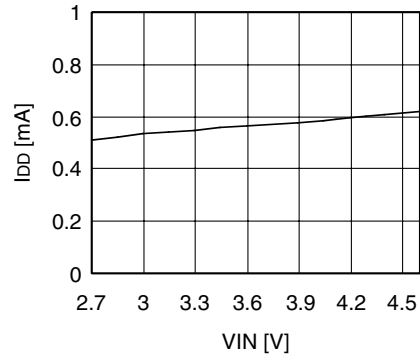
$$DCOUT = \frac{0.6 \times (R1 + R2)}{R2}$$
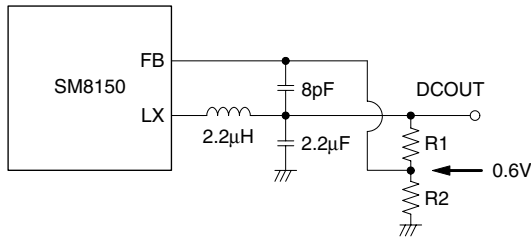
Example

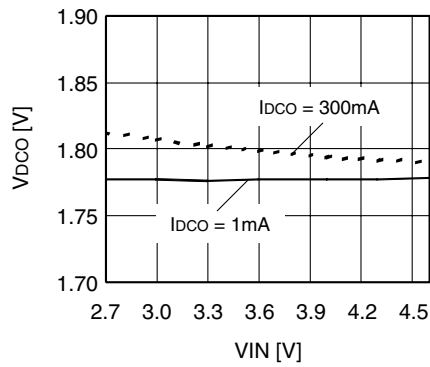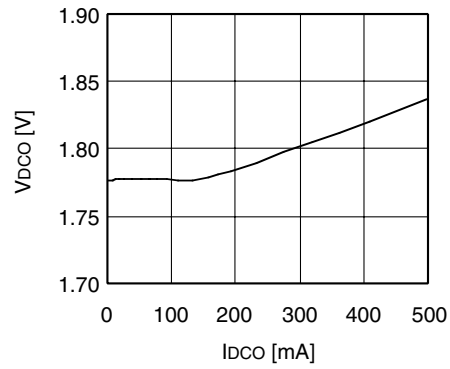| DCOUT [V]	R1 [kΩ]	R2 [kΩ]
1.200	200	200
1.502	200	133
1.800	200	100
2.505	200	63
2.600	200	60
2.802	200	54.5
3.000	200	50

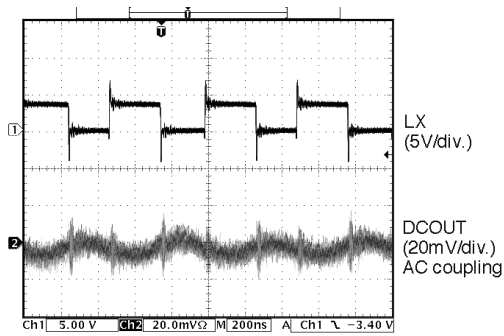**Reference Data**

Efficiency − Load current
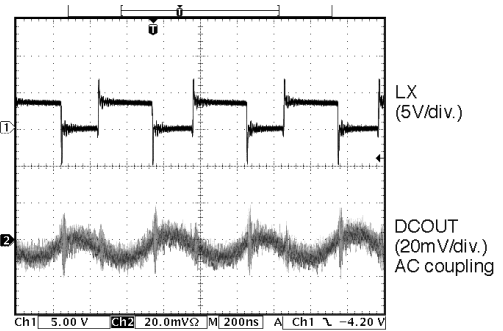

Current consumption (No load, switching stopped)

Line regulation

Load regulation

I_{DCO} = 300mA

I_{DCO} = 500mA

11-5. LDO

V_{IN} =3.6V, V_{EN} = 2.8V, GND = PGND = 0V, Ta = 25°C unless otherwise noted.

| Parameter	Pin	Symbol	Condition		Rating			Unit
					min	typ	max	
Current consumption[*1]	VIN	I_{DD_LDO}	No load		–	0.35	0.8	mA
GND pin current		I_{GND_LDO}	I_{LDO} = 50mA, $I_{GND\_LDO} = I_{DD\_LDO} - I_{LDO}$		–	0.35	1.2	mA
Soft start time[*2]	LDOUT1 to 2	t_{SS_LDO}	I_{LDO} = 1mA		–	1	–	ms
Output voltage		V_{LDO}	I_{LDO} = 1mA, V_{LDO} ≤ VIN − 0.3V		See "Output voltage table".			
Output current		I_{LDO}			–	–	300	mA
Dropout voltage		V_{DROP}	VIN = 3V, V_{LDO} (setting) = 3.3V	I_{LDO} = 100mA	–	0.1	0.2	V
				I_{LDO} = 200mA	–	0.2	0.4	V
				I_{LDO} = 300mA	–	0.3	0.6	V
Line Regulation		ΔV_{OUT1}	3.6V ≤ VIN ≤ 4.6V, V_{LDO} (setting) = 3V, I_{LDO} = 30mA		–	20	60	mV
Load Regulation		ΔV_{OUT2}	V_{LDO} (setting) = 3V, 5mA ≤ I_{LDO} ≤ 100mA		–	10	30	mV
			V_{LDO} (setting) = 3V, 5mA ≤ I_{LDO} ≤ 200mA		–	20	60	mV
Overcurrent protection circuit operating current		I_{OS}			350	650	950	mA

*1. DIN1 to 7 and the DC/DC converter is disabled.
*2. The time taken from when either of LDOUT1 to 2 is enabled until the output is stabilized.
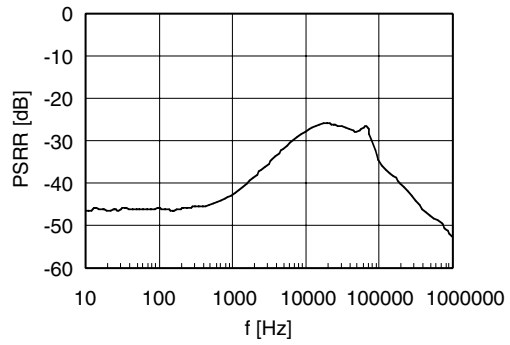
Output voltage table

Setting	min	typ	max	unit
1.5	1.470	1.5	1.530	V
1.8	1.764	1.8	1.836	V
2.5	2.450	2.5	2.550	V
2.6	2.548	2.6	2.652	V
2.8	2.744	2.8	2.856	V
3.0	2.940	3.0	3.060	V
3.1	3.038	3.1	3.162	V
3.3	3.234	3.3	3.366	V

Reference Data
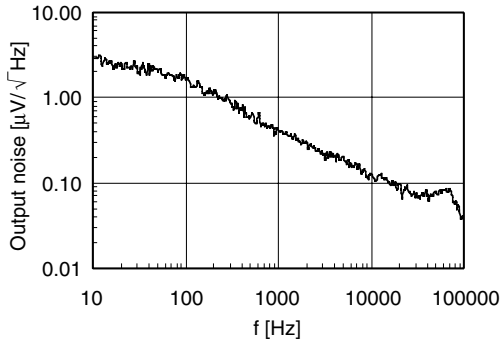
Output noise

VIN3: 2.2µF	VIN = 3.6V
VREF: 0.1µF	V_{LDO} = 1.8V
LDOUT: 2.2µF	I_{LDO} = 10mA

Ripple rejection

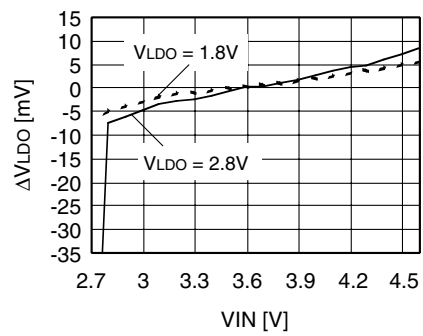| VIN3: 0µF, 500mVp-p | VIN = 3.6V |
| VREF: 0.1µF | V_{LDO} = 1.8V |
| LDOUT: 2.2µF | I_{LDO} = 10mA |
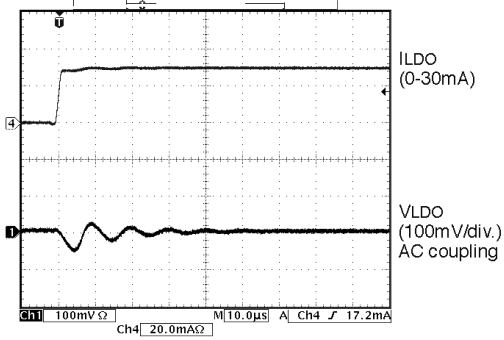
Step response 1
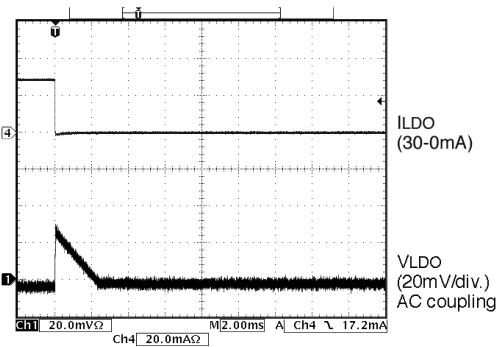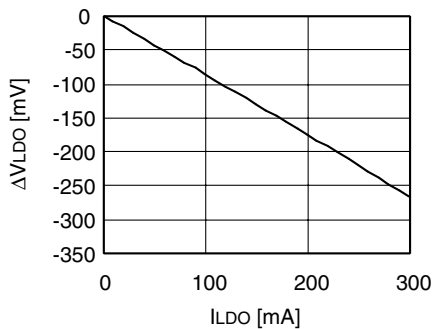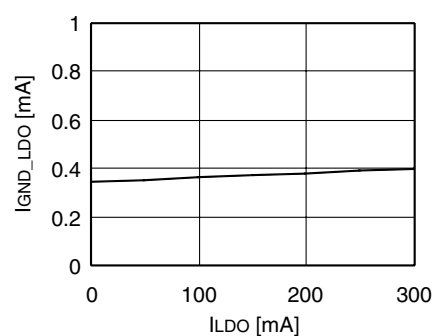

Step response 2
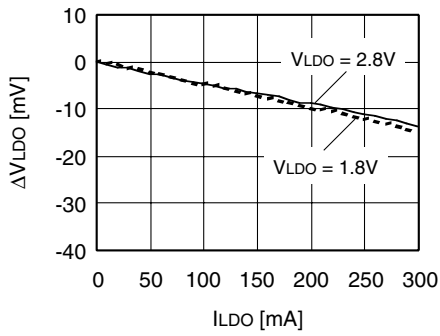
Load regulation

Line regulation

Dropout voltage (V_{LDO} = 2.8V)

GND pin current (V_{LDO} = 1.8V)

12. FUNCTIONAL DESCRIPTION

12-1. Startup Method

The SM8150A enters standby mode when the VIN supply is applied. After the VEN supply is applied, standby mode is released and operation commences when any one of the DIN1 to 4, DIN5 to 6, DIN7, LDOUT1, LDOUT2 outputs or the DC/DC converter is enabled.

12-2. Standby Mode

In standby mode, all SM8150A circuit operation stops, reducing the current consumption. After the VIN supply is applied, the built-in power-ON reset circuit initializes the registers to their default values (see table 1) and the device enters standby mode. Also, when the VEN supply is turned OFF (0V), the registers are initialized to their default values and the device enters standby mode. However, when all the outputs are disabled (enable settings 1 and 2), the register values are stored and the device enters standby mode.

12-3. I^{2}C Interface

The individual SM8150A settings are set using an I^{2}C interface. The SM8150A has a fixed 8-bit address (slave address) and the device must be addressed before inputting each data setting. The set data has an MSB first 8-bit data structure. The first 3 bits select the register, and the next 5 bits are the write data. Each register is write-only, and cannot be read. Transfer speed is in fast mode (400kbit/s).

12-3-1. Basic cycle

I^{2}C start/stop condition
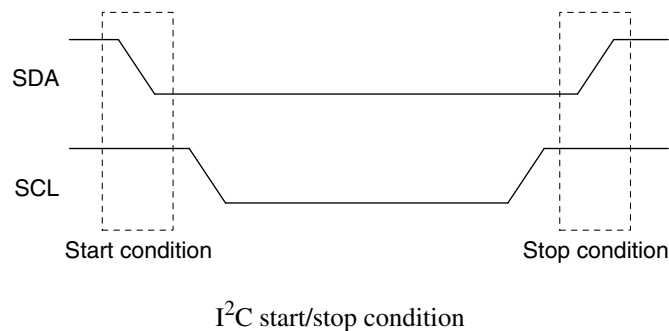
Steps (1) to (4) represent the basic data input cycle.

(1) Start condition
(2) 1st byte (slave address input)
(3) 2nd byte to nth byte (settings data input)
(4) Stop condition

Data transfer begins with the start condition, which is when the SDA input voltage changes from HIGH to LOW while the SCL input voltage is HIGH. Similarly, data transfer ends with the stop condition, which is when the SDA input voltage changes from LOW to HIGH while the SCL input voltage is HIGH. Immediately after each byte (8 bits) in steps (2) and (3), 1 clock cycle is used as an ACK (Acknowledge) cycle. The SM8150A acknowledges that it has recognized the slave address in the first byte by taking the SDA line LOW-level output while the ACK clock cycle is HIGH. No signal is output if the slave address is not recognized. The second to nth bytes are always acknowledged by a LOW-level output bit, regardless of the received data content. The second and successive bytes are received and the corresponding setting is updated until the stop condition is input to the device.

12-3-2. 1st byte: slave address

A6	A5	A4	A3	A2	A1	A0	R/W
0	0	0	1	0	0	1	0

12-3-3. 2nd byte to nth byte: data settings

Data settings summary

Function	Mode select			Set data				
	M3	M2	M1	D5	D4	D3	D2	D1
	MSB	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	LSB
Main group LED dimmer setting (DIN1 to 4)	0	0	0	32-step dimming control (see table 2)				
Sub-group LED dimmer setting (DIN5 to 6)	0	0	1					
Torch LED dimmer setting (DIN7)	0	1	0					
Strobe LED dimmer setting (DIN7)	0	1	1					
LDO1 output voltage setting	1	0	0	0[*1]	0[*1]	8-step voltage settings (see table 3)		
LDO2 output voltage setting	1	0	1	0[*1]	0[*1]			
Enable setting 2[*2] (DC/DC converter)	1	1	0	Buck Enable	0[*1]	0[*1]	0[*1]	0[*1]
Enable setting 1[*2] (DIN1 to 7, LDO1 to 2)	1	1	1	DIN1 to 4 Enable	DIN5 to 6 Enable	DIN7 Enable	LDO1 Enable	LDO2 Enable

*1. Setting used by NPC for testing. Always input 0 for normal operation.
*2. Enable settings are 1 for enabled, 0 for disabled.

12-3-4. Data input precautions

The VIN supply is applied first, and data input should commence after an interval of ≥ 1ms has elapsed after the VEN supply is applied.
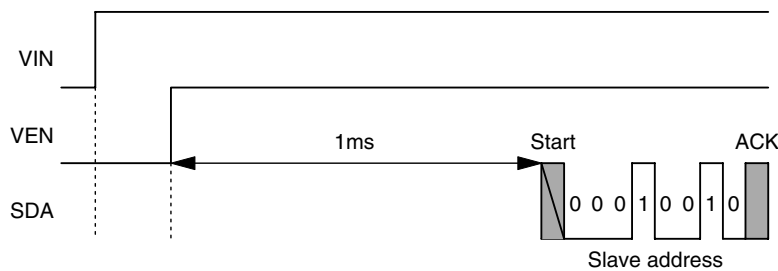
The LDO set voltage is changed using the following procedure. First, a) set to disabled, next b) change the voltage setting, and then c) set to enabled. The gap between steps a) and c) should be ≥ 0.3ms.
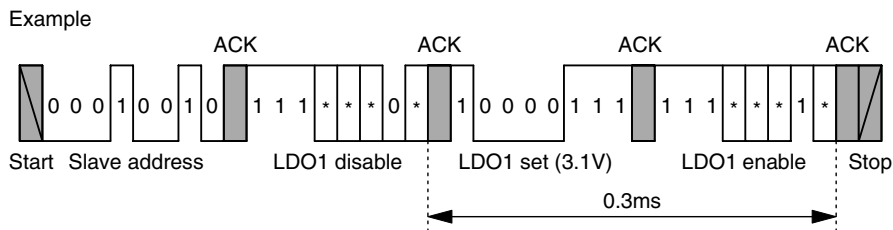
12-4. Torch/Strobe Selecting

The DIN7 pin LED drive current, when DIN7 is enabled, can be switched by the input voltage on the SBN pin. When SBN is HIGH, torch LED dimming is selected. When SBN is LOW, strobe LED dimming is selected. The SM8150A automatically switches the charge pump operating mode ($\times1$, $\times1.5$, $\times2$ boost mode) to optimize the power consumption. However, when SBN is LOW the degree of boost is selected in the direction of increased boost only. That is, selecting in order of $\times1 \rightarrow \times1.5 \rightarrow \times2$ boost only, $\times2 \rightarrow \times1.5 \rightarrow \times1$ selecting does not occur.

12-5. Thermal Shutdown Circuit (TSD)

If for whatever reason the chip temperature reaches approximately 170°C, the overtemperature protection thermal shutdown (TSD) circuit operates, stopping all output. Turn on occurs the IC cools by approximately 150°C.

12-6. Undervoltage Lockout Circuit (UVLO)

If the VIN supply voltage falls below 2.45V, the supply undervoltage lockout (UVLO) circuit operates, initializing the registers to their default values and putting the device in standby mode. In this case, all data settings must be re-input.

12-7. Register Settings Table

Table 1. Default settings (all disabled)

Mode	Mode select			Set data				
	M3	M2	M1	D5	D4	D3	D2	D1
	MSB	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	LSB
Main group LED dimmer setting (DIN1 to 4)	0	0	0	0	0	0	0	0
Sub-group LED dimmer setting (DIN5 to 6)	0	0	1	0	0	0	0	0
Torch LED dimmer setting (DIN7)	0	1	0	0	0	0	0	0
Strobe LED dimmer setting (DIN7)	0	1	1	0	0	0	0	0
LDO1 output voltage setting	1	0	0	0	0	0	0	0
LDO2 output voltage setting	1	0	1	0	0	0	0	0
Enable setting 2 (DC/DC converter)	1	1	0	0	0	0	0	0
Enable setting 1 (DIN1 to 7, LDO1 to 2)	1	1	1	0	0	0	0	0

Table 2. LED drive current settings (not guaranteed values)

| D5	D4	D3	D2	D1	DIN1 to 4	DIN5 to 6	DIN7 (Torch)	DIN7 (Strobe)	Unit
Data 3	Data 4	Data 5	Data 6	LSB					
0	0	0	0	0	0	0	0	0	mA
0	0	0	0	1	0.8	0.8	9.7	9.7	mA
0	0	0	1	0	1.6	1.6	19.4	19.4	mA
0	0	0	1	1	2.4	2.4	29.0	29.0	mA
0	0	1	0	0	3.2	3.2	38.7	38.7	mA
0	0	1	0	1	4.0	4.0	48.4	48.4	mA
0	0	1	1	0	4.8	4.8	58.1	58.1	mA
0	0	1	1	1	5.6	5.6	67.7	67.7	mA
0	1	0	0	0	6.5	6.5	77.4	77.4	mA
0	1	0	0	1	7.3	7.3	87.1	87.1	mA
0	1	0	1	0	8.1	8.1	96.8	96.8	mA
0	1	0	1	1	8.9	8.9	106	106	mA
0	1	1	0	0	9.7	9.7	116	116	mA
0	1	1	0	1	10.5	10.5	126	126	mA
0	1	1	1	0	11.3	11.3	135	135	mA
0	1	1	1	1	12.1	12.1	145	145	mA
1	0	0	0	0	12.9	12.9	155	155	mA
1	0	0	0	1	13.7	13.7	165	165	mA
1	0	0	1	0	14.5	14.5	174	174	mA
1	0	0	1	1	15.3	15.3	184	184	mA
1	0	1	0	0	16.1	16.1	194	194	mA
1	0	1	0	1	16.9	16.9	203	203	mA
1	0	1	1	0	17.7	17.7	213	213	mA
1	0	1	1	1	18.5	18.5	223	223	mA
1	1	0	0	0	19.4	19.4	232	232	mA
1	1	0	0	1	20.2	20.2	242	242	mA
1	1	0	1	0	21.0	21.0	252	252	mA
1	1	0	1	1	21.8	21.8	261	261	mA
1	1	1	0	0	22.6	22.6	271	271	mA
1	1	1	0	1	23.4	23.4	281	281	mA
1	1	1	1	0	24.2	24.2	290	290	mA
1	1	1	1	1	25.0	25.0	300	300	mA

Note. The values of the table 2 "LED drive current settings" are not guaranteed. The actual current values will spread around the values in the table. Especially the variation in 0.8mA setting is wide, and some of actual current may become 0mA. We recommend the usage that the minimum LED driving current value is set at 1.6mA at the brightness adjustment.

Table 3. LDO output voltage settings (not guaranteed values)

| D5	D4	D3	D2	D1	LDOUT1	LDOUT2	Unit
Data 3	Data 4	Data 5	Data 6	LSB			
0	0	0	0	0	1.5	1.5	V
0	0	0	0	1	1.8	1.8	V
0	0	0	1	0	2.5	2.5	V
0	0	0	1	1	2.6	2.6	V
0	0	1	0	0	2.8	2.8	V
0	0	1	0	1	3.0	3.0	V
0	0	1	1	0	3.1	3.1	V
0	0	1	1	1	3.3	3.3	V

13. TYPICAL APPLICATION CIRCUITS
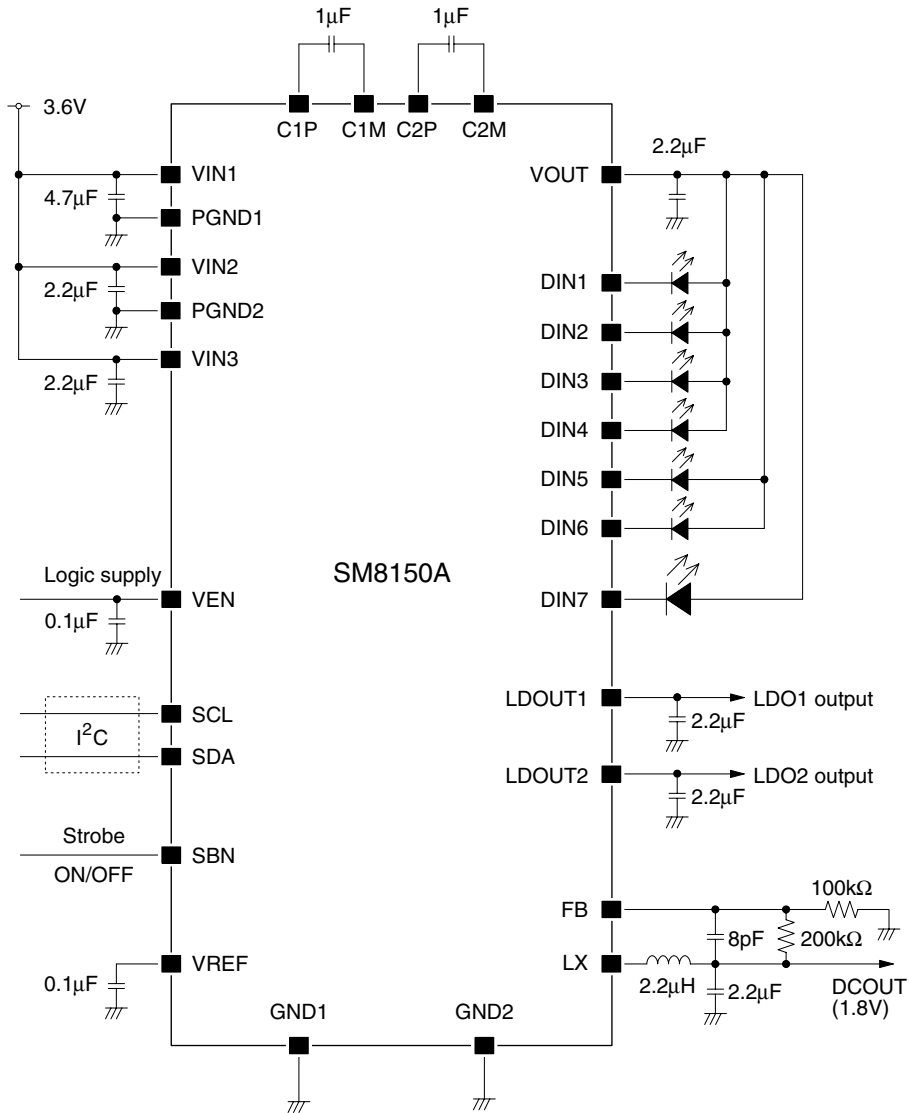
Note. A 2.2μF bypass capacitor should be connected between the VOUT and GND pins. A 4.7μF or greater capacitor value may cause an unstable output voltage condition. Any unused LED drive pins (DIN1 to DIN7) should be connected to GND. If the LDOUT1/2 or LX pins are not used, they should be left open circuit, and not connected to GND or power supply.

13-1. DIN1 to 3, DIN5, DIN7 (Strobe), and LDO1
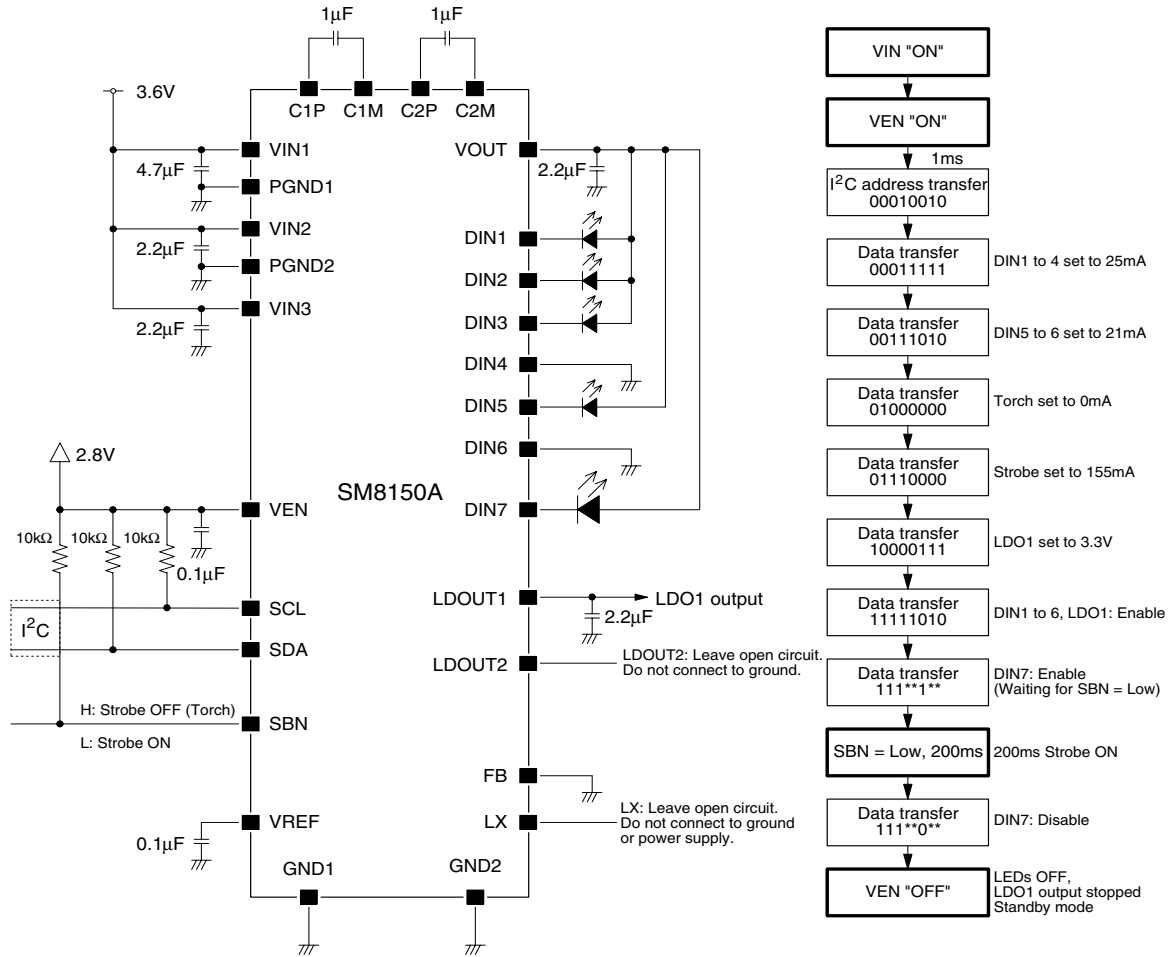
- Unused pins
  - DIN4 and DIN6: Connect to GND.
  - FB: Connect to GND.
  - LDOUT2: Leave open circuit, do not connect to GND.
  - LX: Leave open circuit, do not connect to GND or power supply.

- Logic-level signal input pins
  Connect pull-up resistors to SCL, SDA, and SBN for pull-up to the VEN supply level. The resistances should be of the order of 1k to 10kΩ. The optimal resistance will vary with the actual mounting conditions.

13-2. DIN1 to 2, DIN5 to 6, DIN7 (Torch), and DC/DC Converter
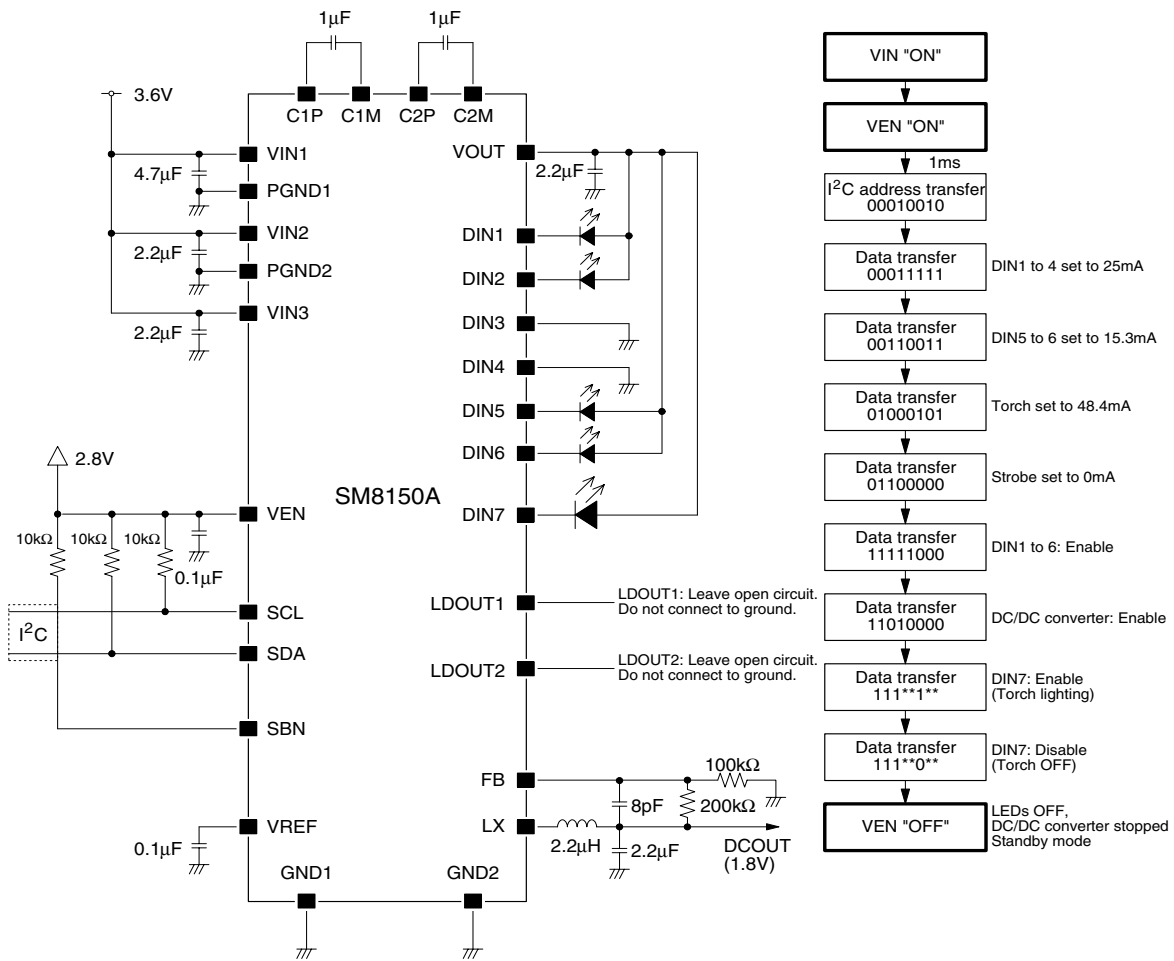
- ■ Unused pins
  - DIN3 and DIN4: Connect to GND.
  - LDOUT1 and LDOUT2: Leave open circuit, do not connect to GND.

- ■ Logic-level signal input pins
  Connect pull-up resistors to SCL, SDA, and SBN for pull-up to the VEN supply level. The resistances should be of the order of 1k to 10kΩ. The optimal resistance will vary with the actual mounting conditions.

14. USAGE NOTES

14-1. External Capacitor Type

The external capacitors connected to the SM8150A should be multi-layer ceramic capacitors, with low temperature coefficient X5R or X7R class (EIA standard) multi-layer ceramic capacitors recommended. Use of high temperature coefficient Z5U or Y5V class multi-layer ceramic capacitors may cause an unstable output voltage condition and should be avoided.

Capacitor temperature coefficient 3-letter codes (EIA standard)

Lower category temperature	Upper category temperature	Maximum deviation in capacitance from +25°C (0V DC) value
X = −55°C	5 = +85°C	F = ± 7.5%
Y = −30°C	6 = +105°C	P = ± 10%
Z = +10°C	7 = +125°C	R = ± 15%
	8 = +150°C	S = ± 22%
		T = +22%/−33%
		U = +22%/−56%
		V = +22%/−82%

Selection	: X5R characteristics

14-2. VIN Supply Input Capacitor

In some cases, the printed board component layout may affect the stability of the output voltages. In such cases, the VIN power supply capacitor should be increased or an additional capacitor connected.

14-3. Mounting

The package rear surface is metallic, and can be connected to the printed circuit board pattern as a heatsink. The connected pattern should be tied to GND level. Furthermore, use of a thermal via structure on the PCB or other technology should be used to provide sufficient heat dissipation. Use a printed circuit board with 4 or more layers. The PCB wiring ratio[1] should exceed 200%, where the wiring ratio is the sum total of printed wiring pattern surface area relative to the circuit board surface area.

*1. Determining the wiring pattern ratio

Example: 4-layer board with the same wiring pattern on 4 layers (left), where the wiring pattern surface area on each layer is represented by S1, and the non-wired surface area is represented by S2. The wiring pattern is connected directly to the IC, and each layer's wiring pattern is connected to the IC by through holes. The circuit board surface area seen from above is S1 + S2. First, calculate the board surface area, here represented by S1 + S2. Next, calculate the wiring pattern surface area on each layer connected to the IC, represented here by S1. Calculate the total wiring pattern surface area for all 4 layers, in this example 4 × S1. Finally, calculate the wiring ratio percentage using the following equation: (Wiring ratio) = (Total wiring pattern surface area connected to the IC) / (PCB surface area) × 100. In this example, 4 × S1/(S1 + S2) × 100 [%], or a wiring ratio of 200% when S1 = S2.
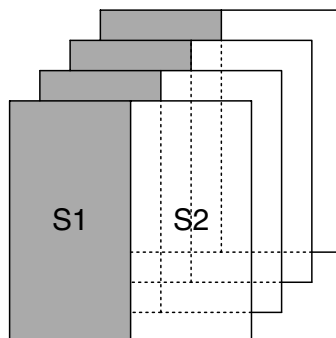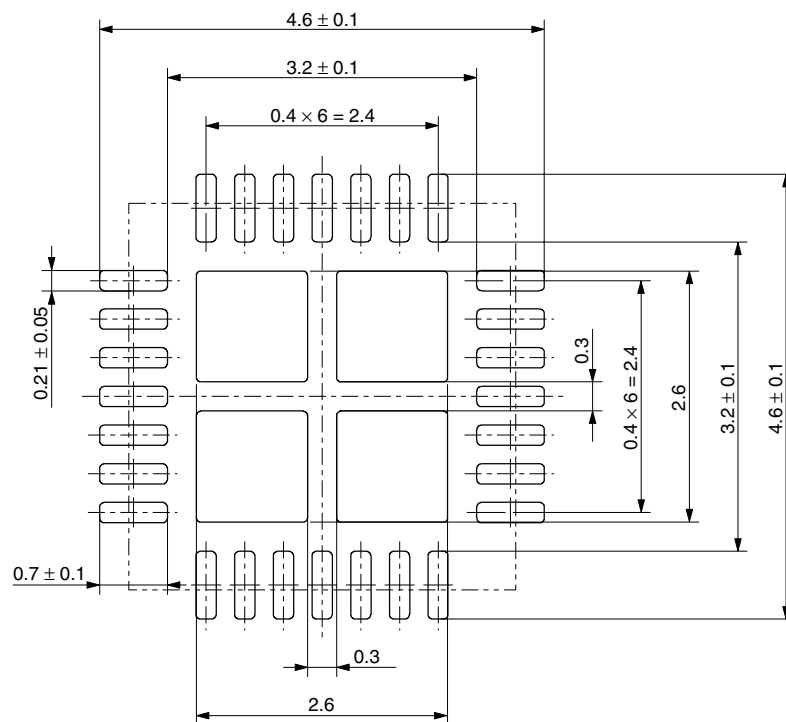
15. PACKAGE DIMENSION

(Unit: mm)

Top view

Bottom view

16. FOOTPRINT PATTERN