



AP2063AEC

2.0A High-side LED Driver for Camera Flash with I²C

1. GENERAL DESCRIPTION

The AP2063 is a white LED driver IC for camera flash applications in portable equipment. The device integrates a current mode synchronous boost DC-DC converter and maximum 2A current sources. The internal boost DC-DC converter integrates a switching FET and synchronous rectifier, and supports a small size multilayer inductor with 4MHz switching frequency. The internal current sources allow for grounded cathode connections for easier heat dissipation and simple LED arrangement. The AP2063 includes seven protections that are inductor current limitation, input voltage detection, over voltage protection, under voltage lock out, device thermal protection, LED open/short protection and output-ground short protection to avoid significant system problems. Flash current, torch current, inductor limit current and flash on-time is programmable through I²C interface. The device uses a small size package (CSP: 1.56mm x 1.64mm, 0.5mm pitch, 9pins) to utilize less board space.

2. FEATURE

- **Power Supply Voltage:** 2.7V~5.5V
- **LED Current:** max 2.0A
- **High-Side Current Source**
- **Switching Frequency:** 4.0 MHz
 - Support small size inductor
- **Automatically Select Operating Mode (DC-DC↔Bypass)**
- **Synchronized with RF power-Amplifier Pulse**
- **Input Voltage Detection Function**
- **I²C Function:**
 - Flash LED current setting
 - Torch LED current setting
 - Flashing on-time setting
 - Current limit value setting
 - Battery detection voltage setting
 - Error read support
- **Protection Function:**
 - Inductor current limit
 - Input voltage detection
 - Over voltage protection (OVP)
 - Under voltage lock out (UVLO)
 - Thermal shutdown
 - LED open/short
 - Output-ground short
- **Ta:** -30 ~ 85°C
- **Package:** 9-pin CSP (1.56 x 1.64mm, 0.5mm pitch)

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4. BLOCK DIAGRAM

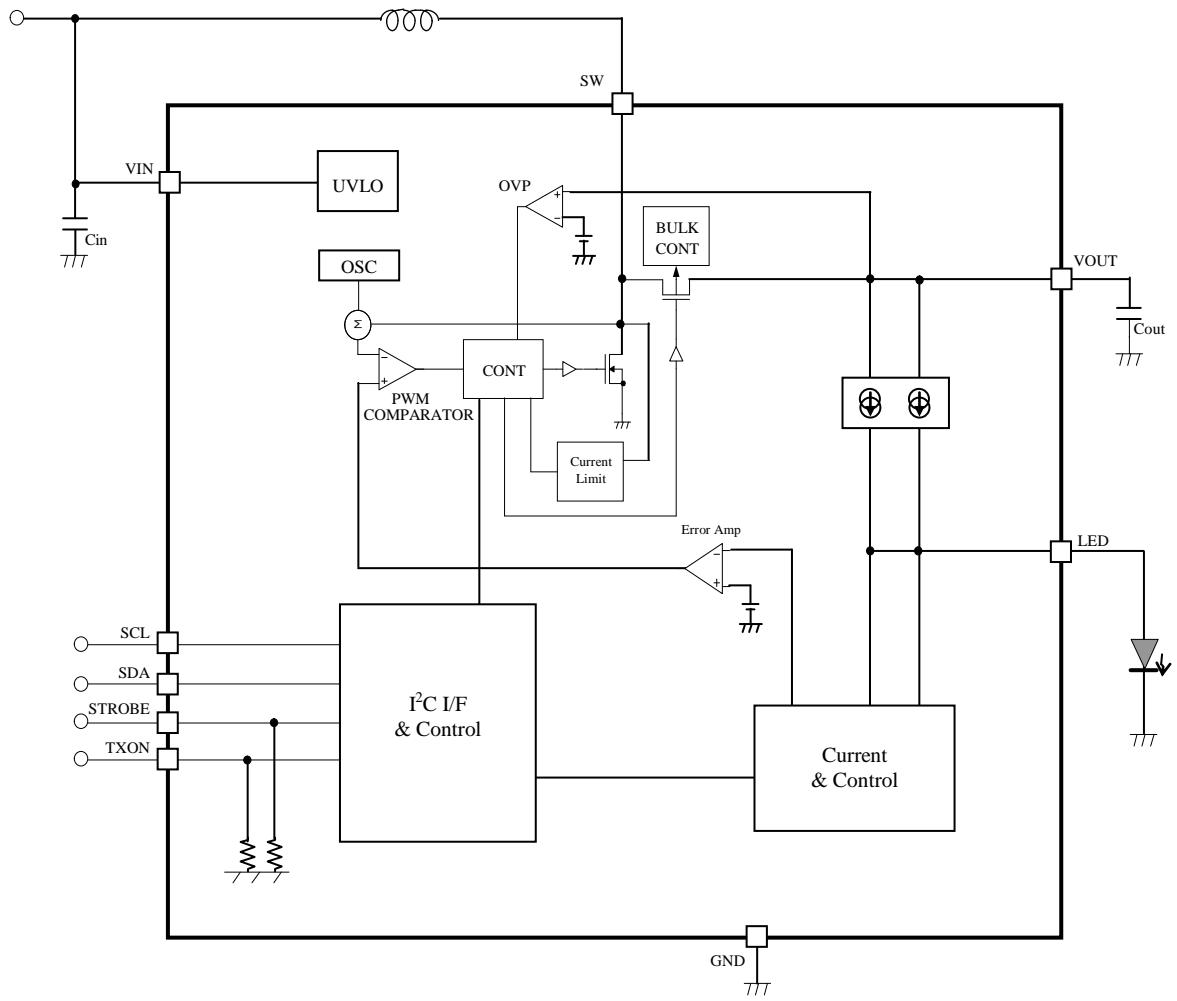


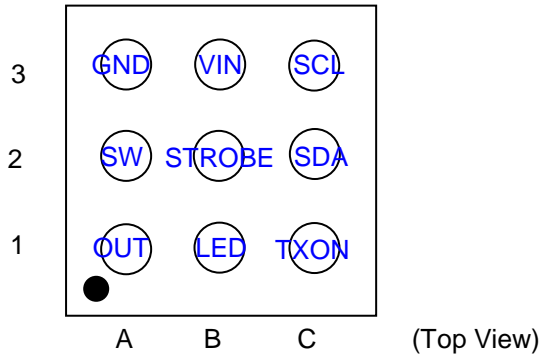
Figure 1. AP2063 Block Diagram

5. PIN CONFIGURATIONS AND FUNCTIONS

■ **Ordering Information**

AP2063AEC Ta= -30 to 85°C 9-pin CSP

■ **PIN CONFIGURATION**



No.	Pin Name	I/O	Function
A1	OUT	O	Voltage Output pin. Connect a 4.7μF or larger ceramic capacitor between this pin and GND.
A2	SW	I	Connect to coil pin.
A3	GND	-	Ground pin.
B1	LED	O	High-side Current Source Output pin for LED. This pin shall be open when unused.
B2	STROBE	I	Flashing control input pin. This pin shall be connected to ground when unused. (Pull-down resistor between this pin and GND = 300kohm @typ)
B3	VIN	I	Input Voltage pin. Connect VIN to the input supply, and bypass to GND with a 4.7μF or larger ceramic capacitor.
C1	TXON	I	Synchronization input pin for RF transmission signal. This pin shall be connected to ground when unused. (Pull-down resistor between this pin and GND = 300kohm @typ)
C2	SDA	I/O	I ² C data input pin.
C3	SCL	I	I ² C clock input pin

6. ABSOLUTE MAXIMUM RATING

(GND=0V; (Note 1))

Parameter	Symbol	min	max	Units
VIN, SW, VOUT, LED pins	V_{IN1}	-0.3	6.5	V
TXON, STROBE, SCL,SDA pins	V_{IN2}	-0.3	VIN+0.3 (Note 2)	V
Junction Temperature	T_{JMAX}	-	125	°C
Storage Temperature	T_{STG}	-55	150	°C

Note 1. All voltages are with respect to ground.

Note 2. The maximum value is low value either (VIN+0.3)V or 6.5V.

WARNING: Operation at or beyond these limits may result in permanent damage to the device.
Normal operation is guaranteed at these extremes.

7. RECOMMENDED OPERATING CONDITIONS

(GND=0V; (Note 1))

Parameter	Symbol	Min.	Typ.	Max.	Units
Input Voltage (VIN)	Vbatt	2.7	3.7	5.5	V
Operation Temperature	Ta	-30	25	85	°C

Note 3. When $4.7V < V_{IN} < 5.5V$, AP2063 can work normally in case of protection function not working, but the analog characteristics cannot be guaranteed.

■ Thermal Properties

Parameter	Symbol	Typ.	Units
Thermal Junction-to-Ambient Resistance (Note 4)	θ_{JA}	75	°C /W

Note 4. This test board is a 4-layer FR-4 board measuring 40mm x 40mm x 2mm.

Ambient temperature is 25°C.

Thicknesses of copper layers are 18um / 35um / 35um / 18um.

Densities of copper layers are more than 80% / 80% / 80% / 80%.

8. ELECTRICAL CHARACTERISTICS

(GND=0V (Note 1), VIN=2.7~4.7V, Ta=-30~85 °C, Recommend Parts, unless otherwise specified)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Power-down Current	I _{SB}	-	1.0	5.0	μA	LED1, LED2 bits = "0" SCL, SDA pins= VIN VIN= 3.7V
Quiescent Current (from VIN pin)	I _Q	-	1	2.5	mA	LED=50mA setting VOUT= 4.5V
LED Current Accuracy1 (flash mode)	I _{ACCU1}	-8	-	8	%	I _{LED} = 1600mA (flash mode, VIN=3.7V, VOUT=3.85V, T _A =25 °C)
LED Current Accuracy2 (flash mode)	I _{ACCU2}	-10	-	10	%	I _{LED} = 1600mA
LED Current Accuracy3 (torch mode)	I _{ACCU3}	-12	-	12	%	I _{LED} = 380mA
Current Source Dropped Voltage 1 (VOUT-LED pin voltage)	V _{DROP1}	-	0.35	0.39	V	2.8V ≤ V _{LED} ≤ 4.2V CB bit= "0"
Current Source Dropped Voltage 2 (VOUT-LED pin voltage)	V _{DROP2}	-	0.43	0.47	V	2.8V ≤ V _{LED} ≤ 4.2V CB bit= "1"
Over Voltage Protection Hysteresis	OVP	4.9	5.1 0.21	5.3	V	
Under Voltage Lock Out (UVLO) Hysteresis	V _{UVLO}	2.4	2.5 0.1	2.6	V	
Boost Frequency	F _{BOOST}	2.6	4.0	4.4	MHz	
Timeout Time Accuracy	T _{OUTA}	-10	-	35	%	
Inductor Current Limit Accuracy	I _{LIMITA}	-30	-	30	%	T _a =25°C, VIN=3.7V
Time (Flash to Torch)	T _{FtoT}	-	-	5	μs	TXON pin= "L" to "H" I _{LED1} =I _{LED2} =1000mA to 30mA
VIN Detection Accuracy	V _{DETA}	-5		5	%	
VIN Detection Hysteresis	V _{DETH}	-	0.1	-	V	
Thermal Protection Temperature Hysteresis	T _{reg} T _{regH}	140 -	170 15	- -	°C	

■ Logic Input/output Characteristics

(Ta= -30 ~ 85°C; VIN=2.7 ~ 5.5V), SCL, SDA, TXON, STROBE pins.

Parameter	Symbol	Min.	Typ.	Max.	Units
High-Level Input Voltage	VIH	1.2	-	VIN	V
Low-Level Input Voltage	VIL	-	-	0.4	V
Low-Level Output Voltage (Iout= 3mA) (SDA pin)	VOL	-	-	0.4	V
Input Leakage Current (SCL, SDA pins)	IIN1	-2	-	2	μA
Pull-down Resistance TXON, STROBE pins	RIN	100	300	700	kΩ
Control Interface Timing:					
SCL Clock Frequency	FSCL	-	-	400	kHz
Bus Free Time Between Transmissions	tBUF	1.3	-	-	μs
Start Condition Hold Time (prior to first clock pulse)	tHD:STA	0.6	-	-	μs
Clock Low Time	tLOW	1.3	-	-	μs
Clock High Time	tHIGH	0.6	-	-	μs
Setup Time for Repeated Start Condition	tSU:STA	0.6	-	-	μs
SDA Hold Time from SCL Falling (Note 5)	tHD:DAT	0	-	-	μs
SDA Setup Time from SCL Rising	tSU:DAT	0.1	-	-	μs
Rise Time of Both SDA and SCL Lines	tR	-	-	0.3	μs
Fall Time of Both SDA and SCL Lines	tF	-	-	0.3	μs
Setup Time for Stop Condition	tSU:STO	0.6	-	-	μs
Capacitive load on bus	Cb	-	-	400	pF
Pulse Width of Spike Noise Suppressed by Input Filter	tSP	0	-	50	ns

Note 5. Data must be held long enough to bridge the 300ns transition time of SCL.

■ Timing Diagram

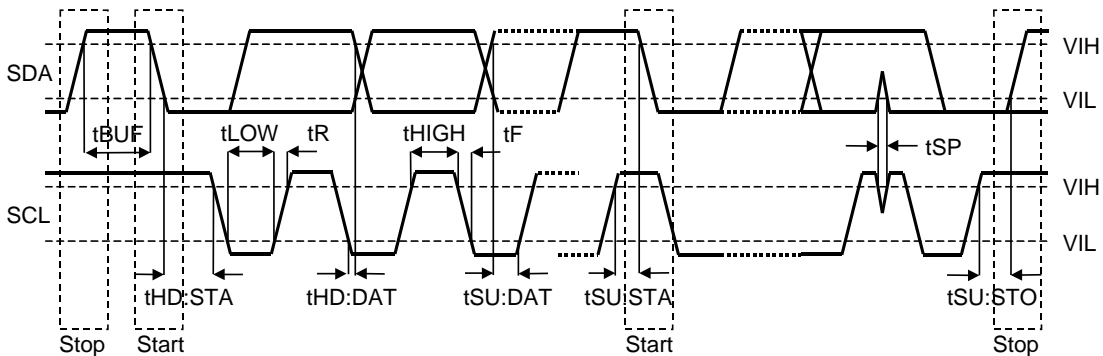


Figure 2. I²C Bus Mode Timing

9. FUNCTIONAL DESCRIPTIONS

The AP2063 is a synchronically boost DC-DC converter with 4MHz switching frequency. The AP2063 can drive LED which connects to LED pin with internal regulated current sources. The regulated current sources (high-side current sources) use PMOS FETs, allowing the LED to be directly connected to ground and providing better LED heat dissipation and simpler LED arrangement. The AP2063 can automatically regulate output voltage with different LED Forward Voltages (VF).

The AP2063 integrates a TXON input which can be used to change the LED current from flash mode to torch mode immediately in order to reduce the battery current during RF transmission or high current events.

■ Protection Function

To protect against system trouble or device damage, the AP2063 protection functions are as shown below.

(GND=0V; (Note 1), VIN=3.7V, Ta=25°C, Recommend Parts, unless otherwise specified)

Protection	Working condition	Device status	Return condition
1) Over current protection (OCP)	Inductor peak current > setting current (LIMIT[1:0])	Switching NMOSFET change to off when inductor current reach to limited current	Return automatically (1 cycle detected)
2) battery voltage detection protection	In the case of flashing VIN pin voltage < setting voltage (VIN[1:0])	Change to torch mode	Next flash signal, Return automatically VIN pin voltage > setting voltage+0.1V
3) Over Voltage Protection (OVP)	VOUT pin voltage > 5.1V	Boost circuit power-down	Return automatically VOUT pin voltage < 5.1V-0.215V
4) Under Voltage Lock Out (UVLO)	VIN pin voltage < 2.5V	All circuits power-down Address= "06H", UVLO= "1"	Set LED1= LED2= "0" again
5) Thermal Shut-Down (TSD)	Device temperature > 170 °C	TSDSEL bit= "0": All circuits power-down Address= "06H", TSD= "1" TSDSEL bit= "1": Boost circuit and current source circuit power-down	TSDSEL bit= "0": Set LED1= LED2= "0" again TSDSEL bit= "1": Return automatically Device temperature >170 °C
6) LED pin in the state of open or short to GND	VOUT-LED1 < 0.1V and OVP is detected During 20us, LED pin < 1.0V	All circuit power-down Address= "06H", LO= "1" All circuit power-down Address= "06H", LS= "1"	Set LED1= LED2= "0" again
7) VOUT short to GND	VOUT pin voltage < 1.0V or in the case of start-up, during 1ms, VOUT voltage < VIN-0.1V during 1ms (COUT<=10uF)	All circuit power-down Address= "06H", VOS= "1"	

Note 6. When set LED1=LED2= "0" again, the register will be reset too.

■ Recommend Sequence Examples

The AP2063 deleted the enable pin and automatically power-up with internal power-on-reset for decreasing the load of CPU. AP2063 can select LEVEL control (EDGE bit= "0") or EDGE control (EDGE bit= "1")

- LEVEL control:

- Flashing: A) The time of STROBE pin= "H" or the time of FLASH bit= "1" < setting timer
Driving LED while STROBE pin= "H" or FLASH bit= "1".
B) The time of STROBE pin= "H" or the time of FLASH bit= "1" > setting timer
The time of driving LED= setting time (TIME [3-0] bits).

Torching: Driving LED while TORCH bit= "1".

- EDGE control:

Flashing: Driving LED with the edge of STROBE pin= "L" to "H" or the edge of FLASH bit= "0" to "1".
Maximum driving time is limited by setting time.

Torching: Driving LED while TORCH bit= "1".

1) Flashing sequence (LEVEL control)

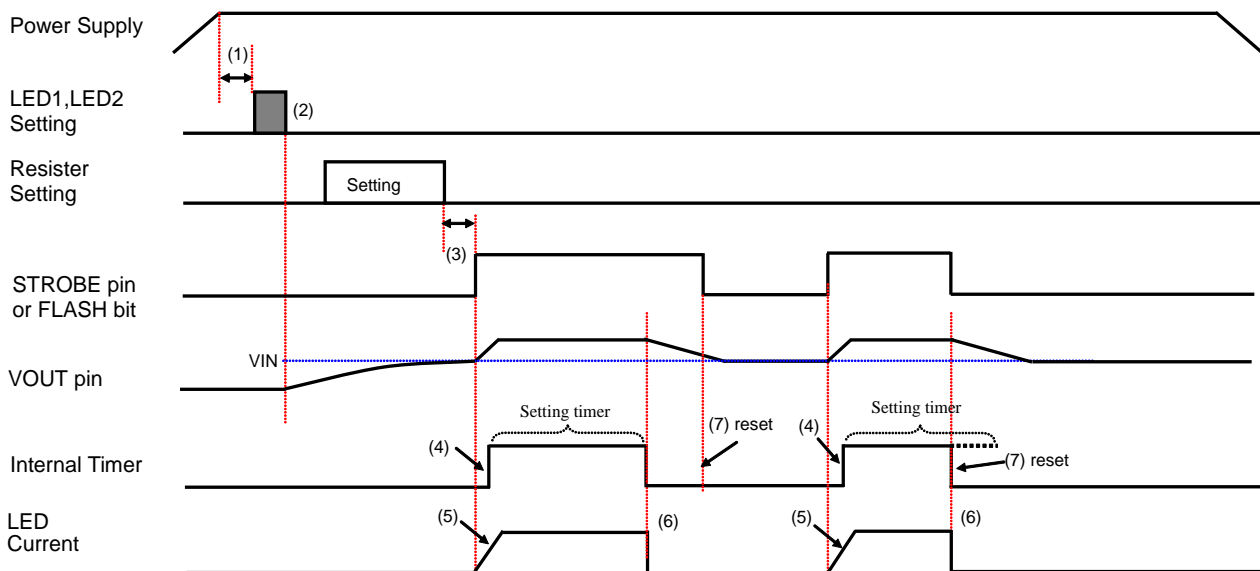


Figure 3. Flashing sequence (LEVEL control)

- (1) After power supplied ($V_{IN} \geq 2.7V$), for resetting AP2063 internal circuits, please wait 5ms, then set LED1, LED2 bits= "01" or "10" or "11".
- (2) After LED1, LED2 bits are set, VOUT pin voltage change to $V_{IN} * 95\%$ within 5ms with inrush current < 500mA.
- (3) After register setting finished, Please set STROBE pin= "H" or FLASH bit= "1".
AP2063 can drive LED with STROBE pin or FLASH bit, did not depend on VOUT voltage.
After LED1, LED2 bits is set, please wait 5ms, then set STROBE pin= "H" or FLASH bit= "1".
- (4) After STROBE pin= "L" to "H" or FLASH bit= "0" to "1", internal timer will start.
- (5) In the case of $V_{OUT} = V_{IN}$, after STROBE pin= "L" to "H" or FLASH bit= "0" to "1", LED current will reach setting current within 1ms.
- (6) When STROBE pin= "H" to "L" or FLASH bit= "1" to "0",
The time of STROBE= "H" or the time of FLASH bit= "1" > setting time:
After timer finished, LED current is change to 0mA immediately.
The time of STROBE= "H" or the time of FLASH bit= "1" < setting time:
LED current is change to 0mA immediately.
- (7) The timer will be reset wit STROBE pin= "H" to "L" or FLASH bit= "1" to "0".

2) Flashing sequence (EDGE control)

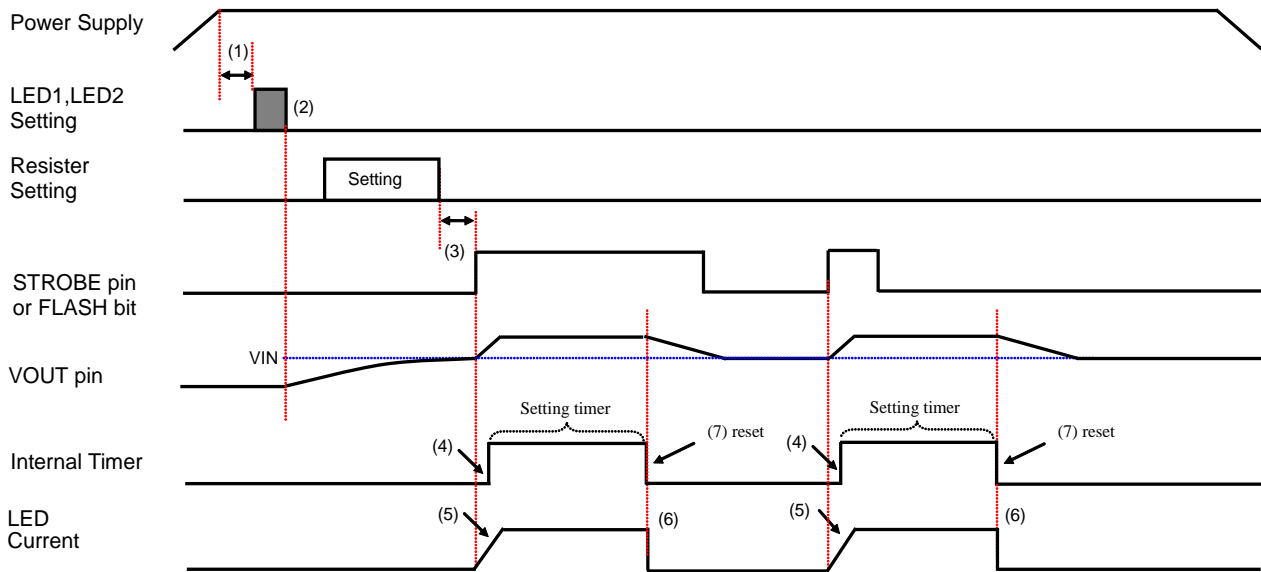


Figure 4. Flashing sequence (EDGE control)

- (1) After power supplied ($V_{IN} \geq 2.7V$), for resetting AP2063 internal circuits, please wait 5ms, then set LED1, LED2 bits = "01" or "10" or "11".
- (2) After LED1, LED2 bits is set, VOUT pin voltage change to $V_{IN} * 95\%$ within 5ms, and inrush current $< 500mA$.
- (3) After register setting finished, Please set STROBE pin = "H" or FLASH bit = "1".
AP2063 can drive LED with STROBE pin or FLASH bit, did not depend on VOUT voltage.
After LED1, LED2 bits is set, please wait 5ms, then set STROBE pin = "H" or FLASH bit = "1".
- (4) After STROBE pin = "L" to "H" or FLASH bit = "0" to "1", internal timer will start.
- (5) In the case of $V_{OUT} = V_{IN}$, after STROBE pin = "L" to "H" or FLASH bit = "0" to "1", LED current will reach setting current within 1ms.
- (6) After timer finished, LED current will change to 0mA, even STROBE pin = "H" or FLASH bit = "1".
- (7) When timer finished, it will be reset automatically.

3) Torching sequence (LEVEL control or EDGE control)

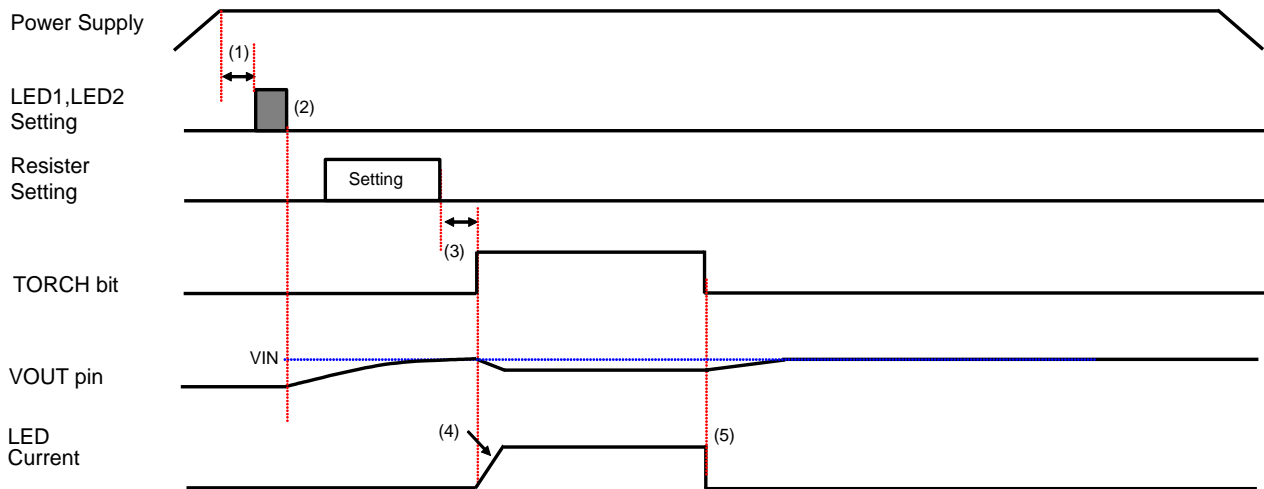


Figure 5. Torching sequence

- (1) After power supplied ($V_{IN} \geq 2.7V$), for resetting AP2063 internal circuits, please wait 5ms, then set LED1, LED2 bits = "01" or "10" or "11".
- (2) After LED1, LED2 bits is set, VOUT pin voltage change to $V_{IN} * 95\%$ within 5ms, and inrush current $< 500mA$.
- (3) After register setting finished, please set TORCH bit = "1".
AP2063 can drive LED with TORCH bit, did not depend on VOUT voltage.
After LED1, LED2 bits is set, please wait 5ms, then set TORCH bit = "1".
- (4) In the case of $V_{OUT} = V_{IN}$, after TORCH bit = "0" to "1", LED current will reach setting current within $300\mu s$.
- (5) After TORCH bit = "1" to "0", LED current will change to 0mA.

4) Off → Torch → Flash → Torch → OFF sequence (LEVEL control)

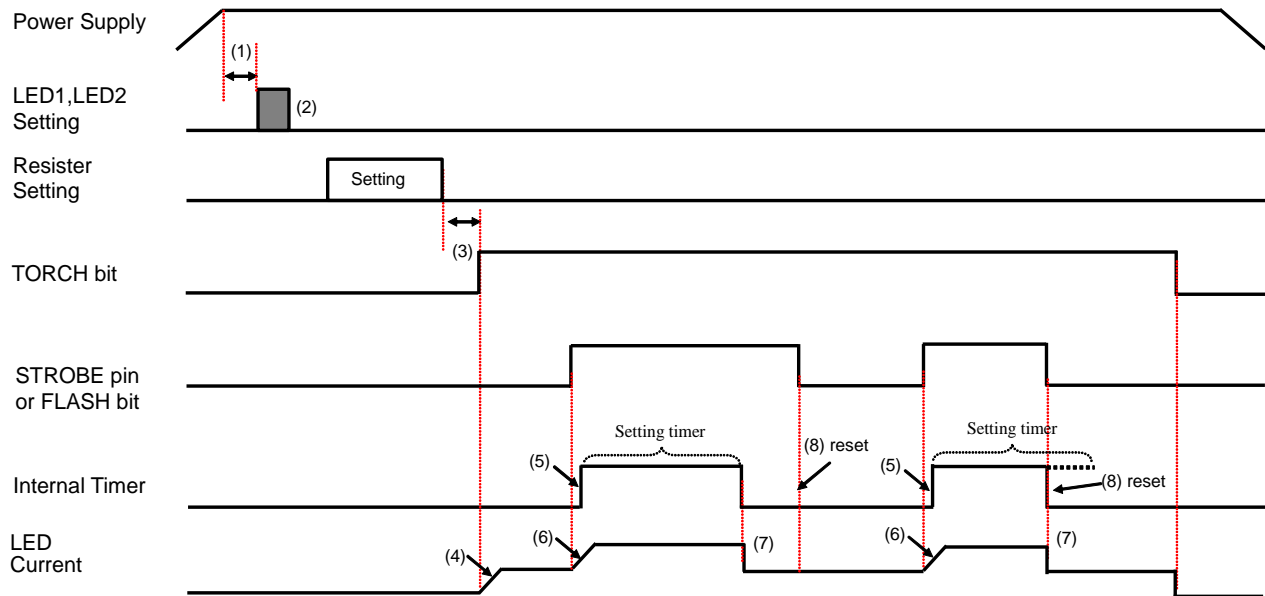


Figure 6. Torching to flashing sequence (LEVEL control)

- (1) After power supplied ($V_{IN} \geq 2.7V$), for resetting AP2063 internal circuits, please wait 5ms, then set LED1, LED2 bits = "01" or "10" or "11".
- (2) After LED1, LED2 bits is set, VOUT pin voltage change to $V_{IN} * 95\%$ within 5ms, and inrush current $< 500mA$.
- (3) After register setting finished, please set TORCH bit = "1".
After LED1, LED2 bits is set, please wait 5ms, then set TORCH bit = "1".
- (4) After TORCH bit = "0" to "1", LED current will reach to setting current within $300\mu s$.
- (5) After STROBE pin = "L" to "H" or FLASH bit = "0" to "1", internal timer will start.
- (6) After STROBE pin = "L" to "H" or FLASH bit = "0" to "1", LED current will reach to setting current within $500\mu s$.
- (7) When STROBE pin = "H" to "L" or FLASH bit = "1" to "0",
The time of STROBE = "H" or the time of FLASH bit = "1" $>$ setting time:
After timer finished, LED current is change to 0mA.
The time of STROBE = "H" or the time of FLASH bit = "1" $<$ setting time:
LED current is change to 0mA immediately".
- (8) The timer will be reset wit STROBE pin = "H" to "L" or FLASH bit = "1" to "0".

5) OFF → Torch → Flash → Torch → OFF (EDGE control)

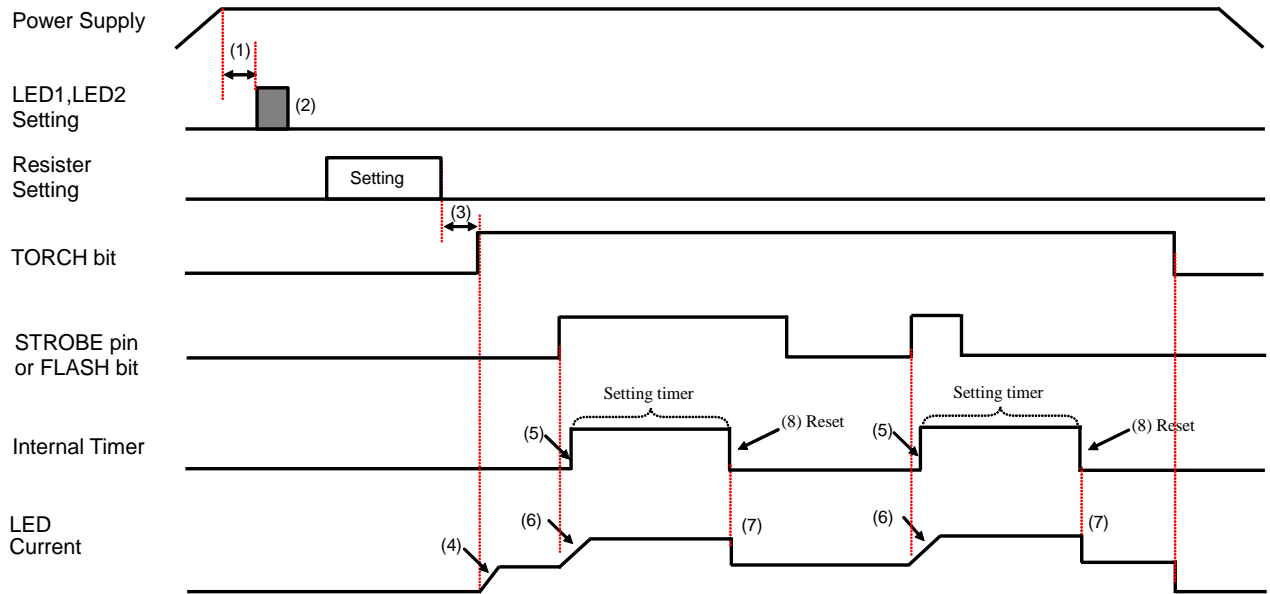


Figure 7. Torching to flashing sequence (EDGE control)

- (1) After power supplied ($V_{IN} \geq 2.7V$), for resetting AP2063 internal circuits, please wait 5ms, then set LED1, LED2 bits = "01" or "10" or "11".
- (2) After LED1, LED2 bits is set, VOUT pin voltage change to $V_{IN} * 95\%$ within 5ms, and inrush current $< 500mA$.
- (3) After register setting finished, Please set TORCH bit = "1".
After LED1, LED2 bits is set, please wait 5ms, then set TORCH bit = "1".
- (4) After TORCH bit = "0" to "1", LED current will reach to setting current within $300\mu s$.
- (5) After STROBE pin = "L" to "H" or FLASH bit = "0" to "1", internal timer will start.
- (6) After STROBE pin = "L" to "H" or FLASH bit = "0" to "1", LED current will reach setting current within $500\mu s$.
- (7) After timer finished, LED current will change to 0mA, even STROBE pin = "H" or FLASH bit = "1".
- (8) When timer finished, it will be reset automatically.

■ Typical Performance Characteristics

(VIN=3.7V, Ta=25 °C, Recommend Parts, use MAMK2520TR47M(0.47uH) inductor, GRM188B31A106ME69(10uF), unless otherwise specified)

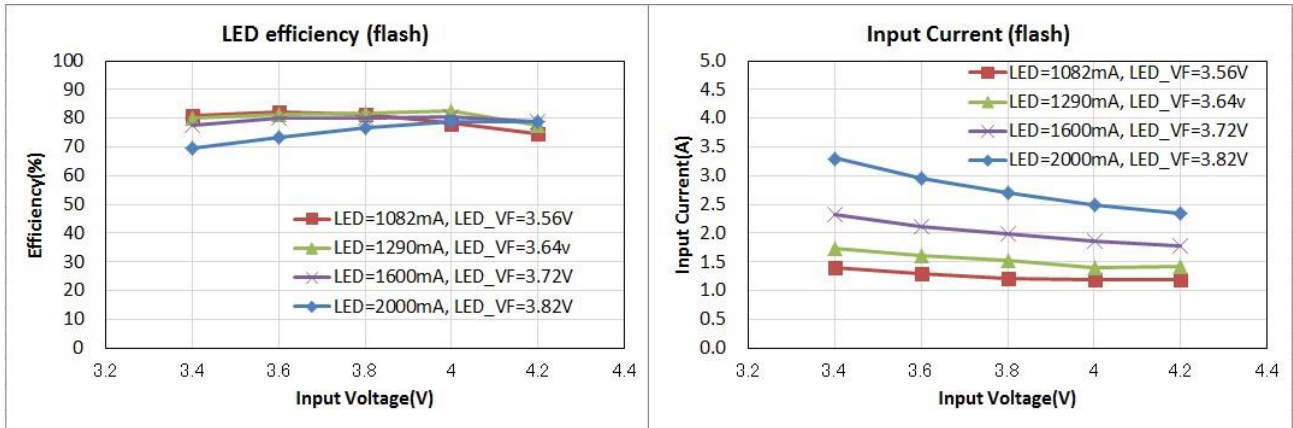


Figure 8. Efficiency and Input current characteristics (flash mode)

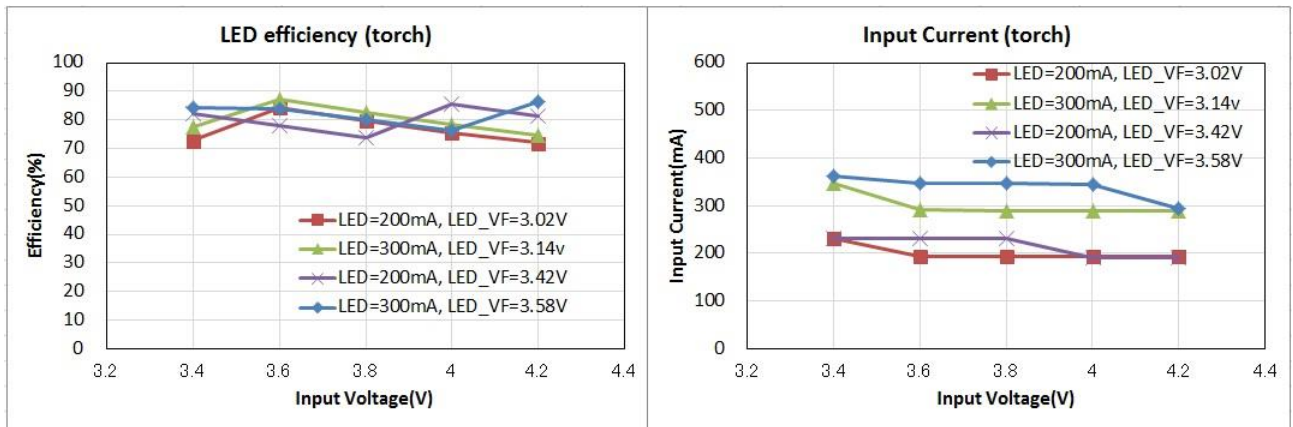


Figure 9. Efficiency and Input current characteristics (torch mode)

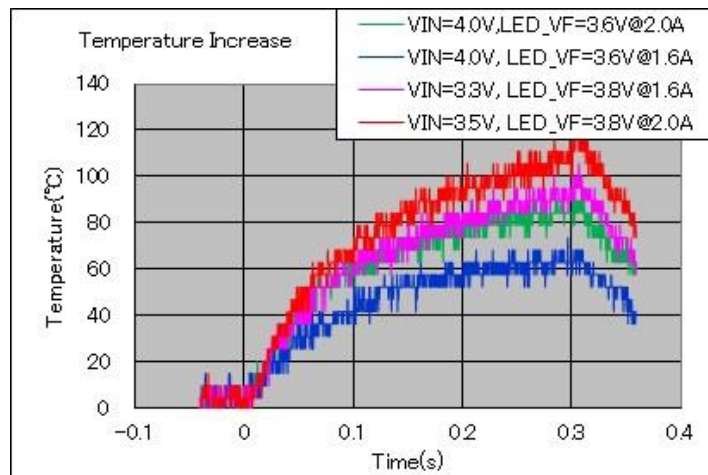


Figure 10. Device temperature increase characteristics

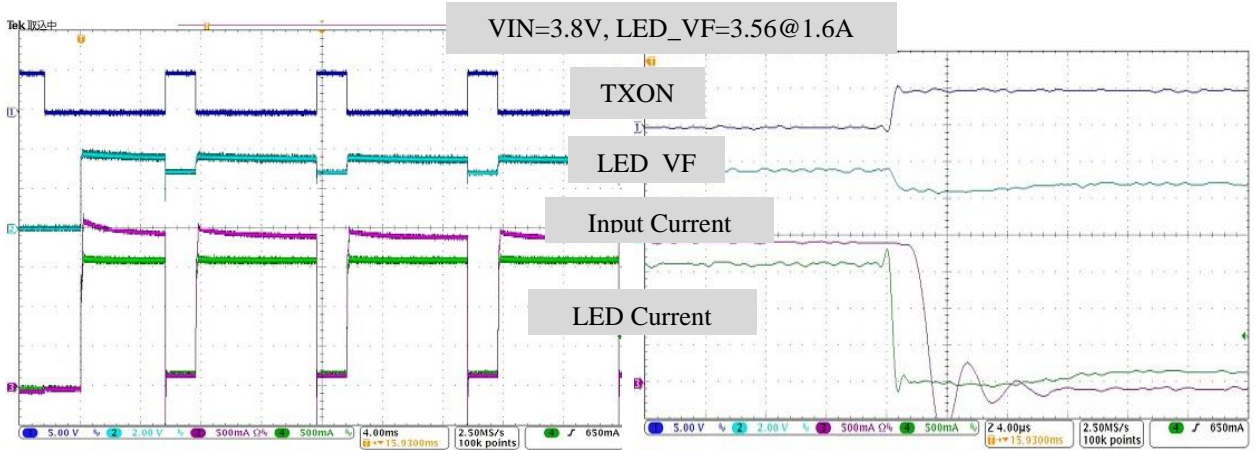


Figure 11. TXON function characteristics

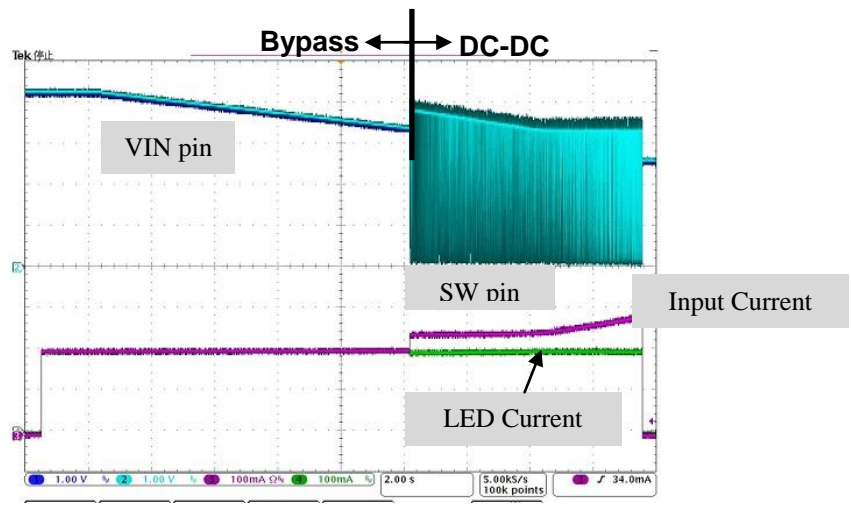


Figure 12. Bypass and DC-DC switching characteristics

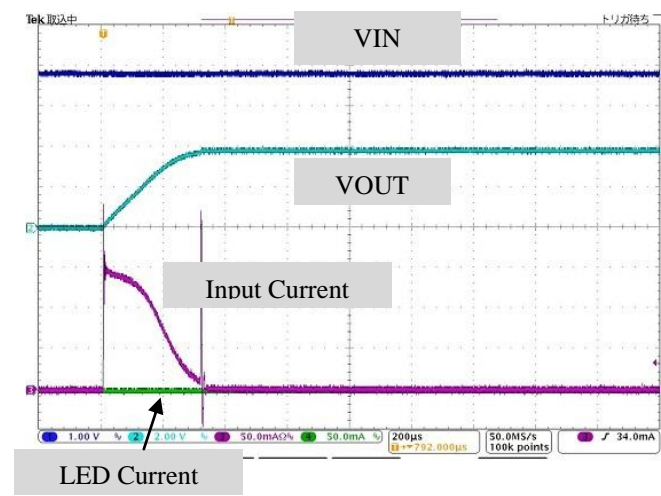


Figure 13. Start-up characteristics

■ Serial Control Interface

The AP2063 supports a fast-mode I²C-bus system (max: 400kHz). Pull-up resistors at the SCL and SDA pins should be connected to VIN pin or less.

1. WRITE Operations

Figure 14 shows the data transfer sequence for the I²C-bus mode. All commands are preceded by START condition. A HIGH to LOW transition on the SDA line while SCL is HIGH indicates START condition (Figure 19). After the START condition, a slave address is sent. This address is 7 bits long followed by the eighth bit that is a data direction bit (R/W). The most significant seven bits of the slave address are fixed as “0110111” (Figure 15). If the slave address matches that of the AP2063, the AP2063 generates an acknowledge and the operation is executed. The master must generate the acknowledge-related clock pulse and release the SDA line (HIGH) during the acknowledge clock pulse (Figure 20). An R/W bit value of “1” indicates that the read operation is to be executed. “0” indicates that the write operation is to be executed.

The second byte consists of the control register address of the AP2063. The format is MSB first, and those most significant 3-bits are fixed to zero (Figure 16). The data after the second byte contains control data. The format is MSB first, 8-bits (Figure 17). The AP2063 generates an acknowledge after each byte is received. A data transfer is always terminated by STOP condition generated by the master. A LOW to HIGH transition on the SDA line while SCL is HIGH defines STOP condition (Figure 19).

The AP2063 can perform more than one byte write operation per sequence. After receipt of the third byte the AP2063 generates an acknowledge and awaits the next data. The master can transmit more than one byte instead of terminating the write cycle after the first data byte is transferred. After receiving each data packet the internal 5-bit address counter is incremented by one, and the next data is automatically taken into the next address. If the address exceeds 0BH prior to generating the stop condition, the address counter will “roll over” to 00H and the previous data will be overwritten.

The data on the SDA line must remain stable during the HIGH period of the clock. The HIGH or LOW state of the data line can only change when the clock signal on the SCL line is LOW (Figure 21) except for the START and STOP conditions.

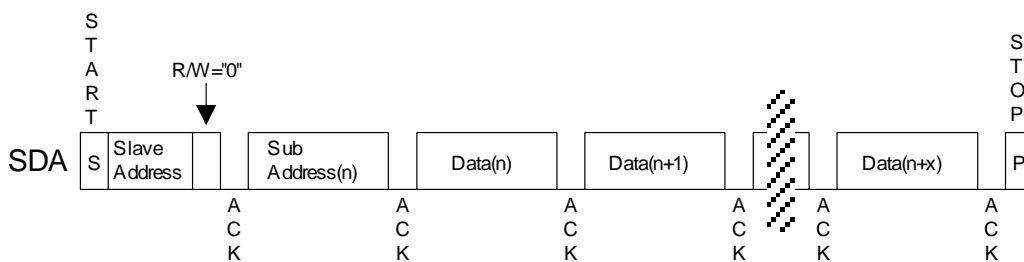


Figure 14. Data transfer sequence

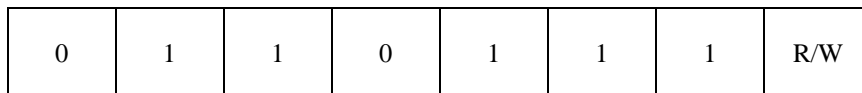


Figure 15. The first byte

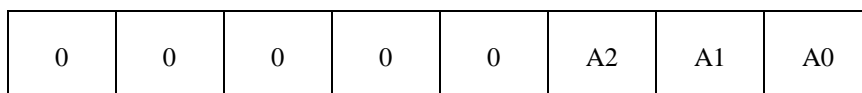


Figure 16. The second byte

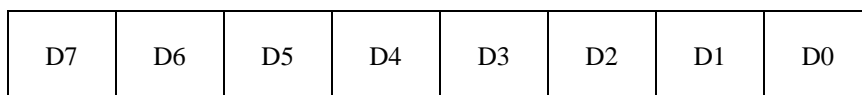


Figure 17. Byte structure after the second byte

2. READ Operations

Set the R/W bit = “1” for the READ operation of the AP2063. The master can read the next address’s data by generating an acknowledge instead of terminating the write cycle after the receipt of the first data word. After receiving each data packet the internal 5-bit address counter is incremented, and the next data is automatically taken into the next address. If the address exceeds 04H prior to generating stop condition, the address counter will “roll over” to 00H and the previous data will be overwritten.

The AP2063 supports two basic read operations: RANDOM ADDRESS READ.

2-1. RANDOM ADDRESS READ

The random read operation allows the master to access any memory location at random. Prior to issuing the slave address with the R/W bit “1”, the master must first perform a “dummy” write operation. The master issues start request, a slave address (R/W bit = “0”) and then the register address to read. After the register address is acknowledged, the master immediately reissues the start request and the slave address with the R/W bit “1”. The AP2063 then generates an acknowledge, 1 byte of data and increments the internal address counter by 1. If the master does not generate an acknowledge to the data but generates a stop condition, the AP2063 ceases transmission.

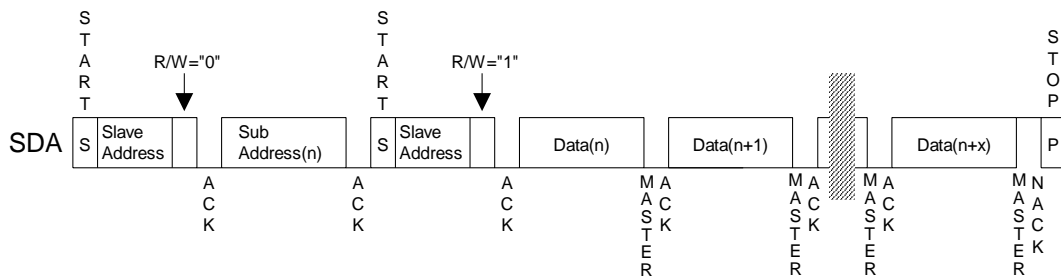


Figure 18. Random address read

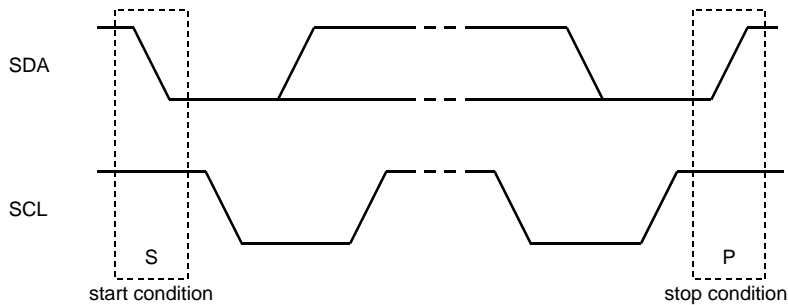


Figure 19. START and STOP conditions

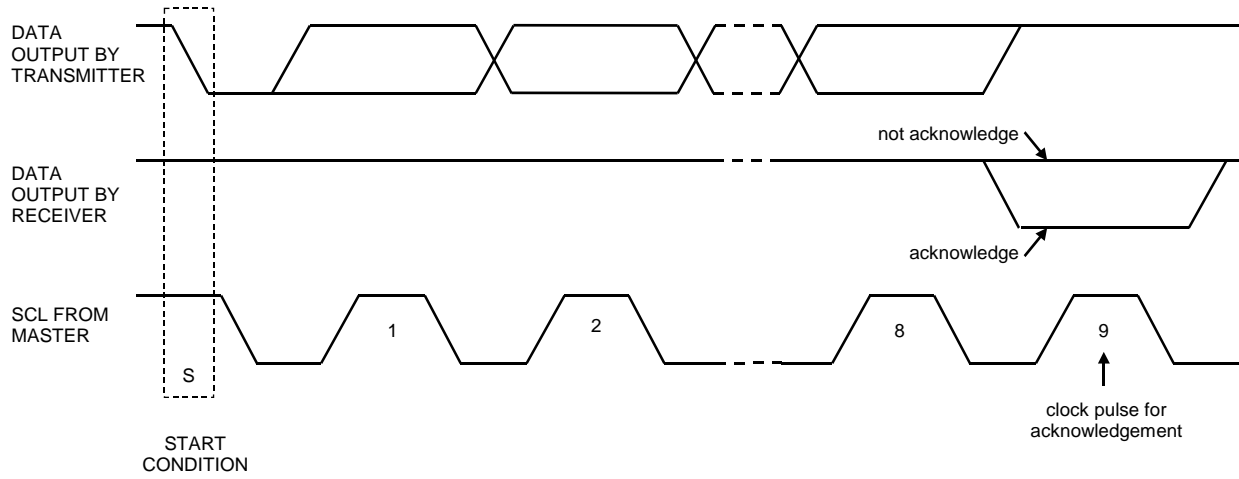


Figure 20. Acknowledge on the I²C-Bus

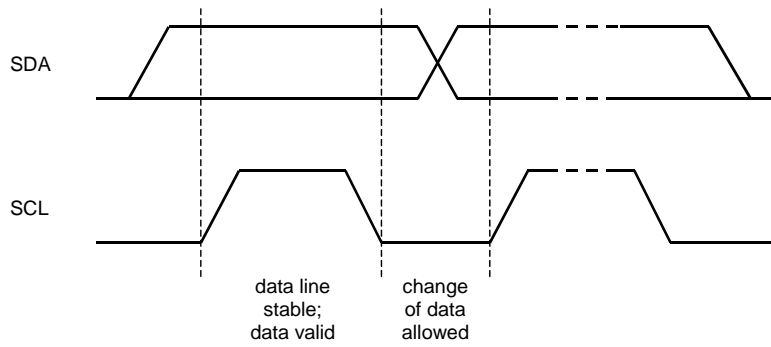


Figure 21. Bit transfer on the I²C-Bus

10. REGISTER MAP

■ Register Map

(GND=0V; (Note 1), VIN=3.7V, Ta=25°C, Recommend Parts, unless otherwise specified)

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
00H	Instruction	INST7	INST6	INST5	INST4	INST3	INST2	INST1	INST0
01H	LED Control 1							LED2	LED1
02H	LED Control 2		TSDSEL	CB	EDGE	TIME3	TIME2	TIME1	TIME0
03H	LED Control 3		DIM	LEDT2	LEDT1	LEDT0	LEDF2	LEDF1	LEDF0
04H	Others		VIN1	VIN0	TXON_ MODE			LIMIT1	LIMIT0
05H	Light Control							FLASH	TORCH
06H	Fault/Status	LIGHT_ NG	EN_ NG	TSD		LO	UVLO	VOS	LS

Note 7. The writing of Addr >= "07H" is prohibited.

■ Register Map Details

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
00H	Instruction	INST7	INST6	INST5	INST4	INST3	INST2	INST1	INST0
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
	Default	0	0	0	0	0	0	0	0

INST[7:0]: The instruction for error protection.

IF INST[7:0] = 01101001 is not written, the access for other register is not effective.

At first, please set INST[7:0] = 01101001.

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
01H	LED Control							LED2	LED1
	Read/Write	RD	RD	RD	RD	RD	RD	R/W	R/W
	Default	0	0	0	0	0	0	0	0

LED1, LED2: The power ON/OFF for AP2063 and the ON/OFF control for LED that connect to LED pin.

Table 1. AP2063&LED status setting

LED2	LED1	AP2063 Status
0	0	Power-down
0	1	Prohibit
1	0	Prohibit
1	1	LED=on

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
02H	LED Control 2		TSDSEL	CB	EDGE	TIME3	TIME2	TIME1	TIME0
	R/W	RD	R/W	R/W	R/W	R/W	R/W	R/W	R/W
	Default	0	0	0	0	0	1	1	1

TIME0, TIME1, TIME2, TIME3: The on-time setting for LEDs that connect to LED1, LED2 in flash mode.

Table 2. LED on-time setting in the case of flash mode

TIME3	TIME2	TIME1	TIME0	Time	TIME3	TIME2	TIME1	TIME0	Time
0	0	0	0	5ms	1	0	0	0	120ms
0	0	0	1	10ms	1	0	0	1	150ms
0	0	1	0	20ms	1	0	1	0	200ms
0	0	1	1	30ms	1	0	1	1	250ms
0	1	0	0	40ms	1	1	0	0	300ms
0	1	0	1	50ms	1	1	0	1	400ms
0	1	1	0	70ms	1	1	1	0	600ms
0	1	1	1	90ms	1	1	1	1	800ms

EDGE: Change flashing time control method

0: Level control

1: Edge control (flashing time is controlled by internal timer)

CB: Change current source dropping voltage (VOUT-LED)

0: 0.35V

1: 0.43V

Use this register can set current source dropped voltage (VOUT-LED pins).

If use the LED which VF is very low, please set CB= "1". (Example: LED current= 2A, LED VF ≤ 2.8V @2A)

TSDSEL: Thermal Shut Down return mode

0: not return, should set LED1 bit= LED2 bit= "0" again.

1: Return automatically

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
03H	LED Control 3		DIM	LEDT2	LEDT1	LEDT0	LEDF2	LEDF1	LEDF0
	R/W	RD	R/W	R/W	R/W	R/W	R/W	R/W	R/W
	Default	0	0	0	0	1	1	0	0

LEDF0, LEDF1, LEDF2: The current setting for LEDs that connect to LED pin.

Table 3. LED current setting in the case of flash mode

LEDF2	LEDF1	LEDF0	FLASH (mA) LED1=LED2= "1"
0	0	0	274
0	0	1	472
0	1	0	674
0	1	1	878
1	0	0	1082
1	0	1	1290
1	1	0	1600
1	1	1	2000

LEDT0, LEDT1, LEDT2: The current setting for LEDs that connect to LED pin.

DIM: Small torching current setting

0: normal setting

1: torching current= torching setting current / 5

Table 4. LED current setting in the case of torch mode

LEDT2	LEDT1	LEDT0	TORCH (mA) LED1=LED2= "1"	
			DIM= "0"	DIM= "1"
0	0	0	50	10
0	0	1	86	17.2
0	1	0	124	24.8
0	1	1	162	32.4
1	0	0	200	40
1	0	1	240	48
1	1	0	300	60
1	1	1	380	76

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
04H	Others		VIN1	VIN0	TXON_MODE			LIMIT1	LIMIT0
	R/W	RD	R/W	R/W	R/W	RD	RD	R/W	R/W
	Default	0	0	0	0	0	0	1	0

LIMIT1, LIMIT0: Inductor limit current setting

Table 5. Inductor current limit setting

LIMIT1	LIMIT0	Limit Current
0	0	4.4A
0	1	3.5A
1	0	2.5A
1	1	1.5A

TXON_MODE: TXON function select mode

0: TXON function available (Change LED current from flashing mode to torching mode when TXON pin= "high")

1: TORCH mode (Drive LED with torching current when TXON pin= "high")

VIN1, VIN0: Input voltage detection

When input voltage is detected, LED current will be changed to torching current in case of flashing.

If do not use this function, please set VIN [1:0]= "00".

Table 6. Input voltage detection

VIN1	VIN0	Detection voltage
0	0	off
0	1	3.3V
1	0	3.1V
1	1	2.9V

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
05H	Light Control							FLASH	TORCH
	R/W	RD	RD	RD	RD	RD	RD	R/W	R/W
	Default	0	0	0	0	0	0	0	0

FLASH: Drive LED with flashing current

TORCH: Drive LED with torching current

Table 7. LED Control Status (LED1=LED2 bits= "11")

TXON pin	STROBE pin	FLASH bit	TROCH bit	Status
Low	Low	0	0	Standby
Low	Low	0	1	TORCH
Low	Low	1	0	FLASH
Low	Low	1	1	FLASH
Low	High	*	*	FLASH
High	Low	0	0	Standby
High	STROBE pin= High or FLASH bit=1			TORCH

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
06H	Fault/Status	LIGHT_ NG	EN_ NG	TSD		LO	UVLO	VOS	LS
	R/W	RD	RD	RD	RD	RD	RD	RD	RD
	Default	0	0	0	0	0	0	0	0

LS: Show LED1 pin short to GND or LED2 pin short to GND.
 0: not short 1: short

VOS: Show VOUT1 pin short to GND or VOUT2 short to GND.
 0: not short 1: short

UVLO: Show UVLO is detected or not.
 0: not in the status of UVLO 1: UVLO

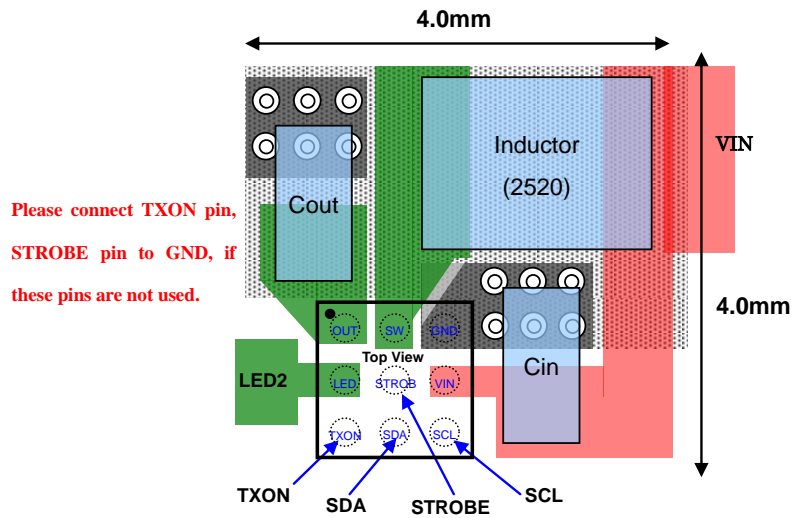
LO: show LED is open or not.
 0: not open 1: open

TSD: Thermal shut down is detected or not.
 0: not in the status of TSD 1: TSD

EN_ NG: for Start-up Stand-by
 0: $V_{OUT} \geq V_{IN} - 0.1V$ (Stand-by) 1: $V_{OUT} < V_{IN} - 0.1V$ (not Stand-by)

LIGHT_ NG: for Second Start-up Stand-by
 0: $V_{OUT} \doteq V_{IN}$ (Stand-by) 1: $V_{OUT} \neq V_{IN}$ (not Stand-by)

11. RECOMMEND EXTERNAL CIRCUITS



Recommended external components (LED=1.6A, VIN=3.3~4.2V, LED_VF<4.2V)

Table 8. Recommend external parts example

Item	Symble	Value	Type (example)	Size	Marker	
Inductor	L	0.47uH	MAMK2520TR47M	2.5 x 2.0 x 1.2mm	TAIYO-YUDEN	
		1uH	DFE252010C	2.5x2.0x1.2 mm	TOKO	
		1uH	LQH44PN1R0NP0	3.7x4.0x1.8mm	MURATA	
		1uH	VLF4014ST-1R0N2R3	3.8x3.6x1.4mm	TDK	
		1uH	TFM252010 (DCR<65mohm)	2.5x2.0x1.0 mm	TDK	
Capacitor	Cin	4.7uF	GRM188B30J475KE18 (6.3V)	1.6 x 0.8 x 0.8mm	MURATA	
			GRM188B31C475MAAJ (16V)	1.6 x 0.8 x 0.8mm		
			C1608JB0J475K, C1608JB0J475M C1608X5R0J475K, C1608X5R0J475M	1.6 x 0.8 x 0.8mm	TDK	
	Cin	10uF	GRM219B31C106KA73 (16V)	2.0 x 1.3 x 0.85mm	MURATA	
			GRM219R61C106KA73 (16V)	2.0 x 1.3 x 0.85mm		
			GRM188B31A106ME6 (10V)	1.6 x 0.8 x 0.8mm	TDK	
			C2012JB1A106K085AC (10V)	2.0 x 1.3 x 0.85mm		
			C2012JB0J106K085AB (6.3V)	2.0 x 1.3 x 0.85mm		
	Cout (Note 8)	10uF	4.7uF C1608JB0J475K, C1608JB0J475M		1.6 x 0.8 x 0.8mm	TDK
			10uF		GRM219B31C106KA73 (16V)	2.0 x 1.3 x 0.85mm
GRM219R61C106KA73 (16V)					2.0 x 1.3 x 0.85mm	
GRM188B31A106ME6 (10V)					1.6 x 0.8 x 0.8mm	
C2012JB1A106K085AC (10V)					2.0 x 1.3 x 0.85mm	
C2012JB0J106K085AB (6.3V)					2.0 x 1.3 x 0.85mm	

Note 8. Recommend to use the capacitor which the value is more than 2.2uF @5.0V DC bias.

Note 9. GND shall be connected to the same ground plane.

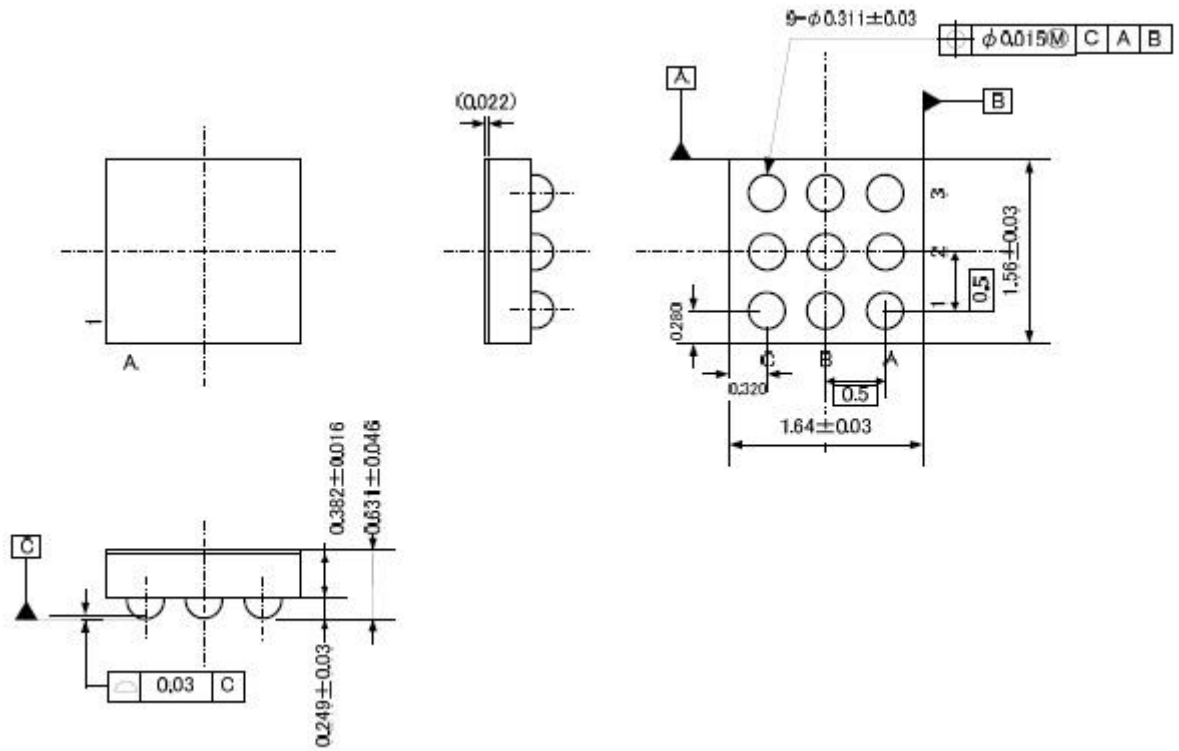
Inductor shall be placed as close as possible to the chip.

Capacitors shall be placed as close as possible to the chip.

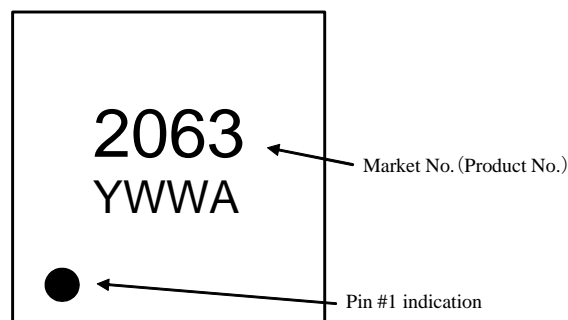
Low ESR (Equivalent Series Resistance) capacitors are recommended.

12. PACKAGE

CSP (Unit: mm)



13. MARKING



YWWA : date code (4 digit)
 A: manage number
 WW: the week of manufacture
 Y: the year of manufacture (Ex: 2013-> "3")

14. REVISE HISTORY

Date (YY/MM/DD)	Revision	Page	Contents
14/04/03	00		First edition

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