

AsahiKASEI

= Preliminary=

AP2061

ASAHI KASEI MICRODEVICES

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

The AP2061 is a white LED driver IC for camera flash applications in portable equipments. 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. AP2061 includes eight protections that are LED thermal detection, 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: 1.6mm x 1.6mm, 0.4mm pitch, 16pins) to utilize less board space.

FEATURE

- ☐ Power Supply Voltage: 2.7V~5.5V
- ☐ LED Current: max 2.0A, total (max 1A/ch)
- ☐ High-Side current source
- ☐ Switching Frequency: 4.0 MHz
- ☐ Automatically select working mode (DC/DC↔Bypass)
- ☐ Synchronized with RF power-Amplifier pulse
- ☐ I²C Function:
 - Flash LED current setting
 - Torch LED current setting
 - Flashing on-time setting
 - Current limit value setting
 - LED thermal detection voltage setting
 - Battery detection voltage setting
 - Error read support
- ☐ Protection Function:
 - LED thermal detection
 - Inductor current limit
 - Battery voltage detection
 - Over voltage protection (OVP)
 - Under voltage lock out (UVLO)
 - Thermal shutdown
 - LED open/short
 - Output-ground short
- ☐ Ta: -30 ~ 85°C
- ☐ Package: 16 pins CSP (1.6 x 1.6mm, 0.4mm pitch)

BLOCK DIAGRAM

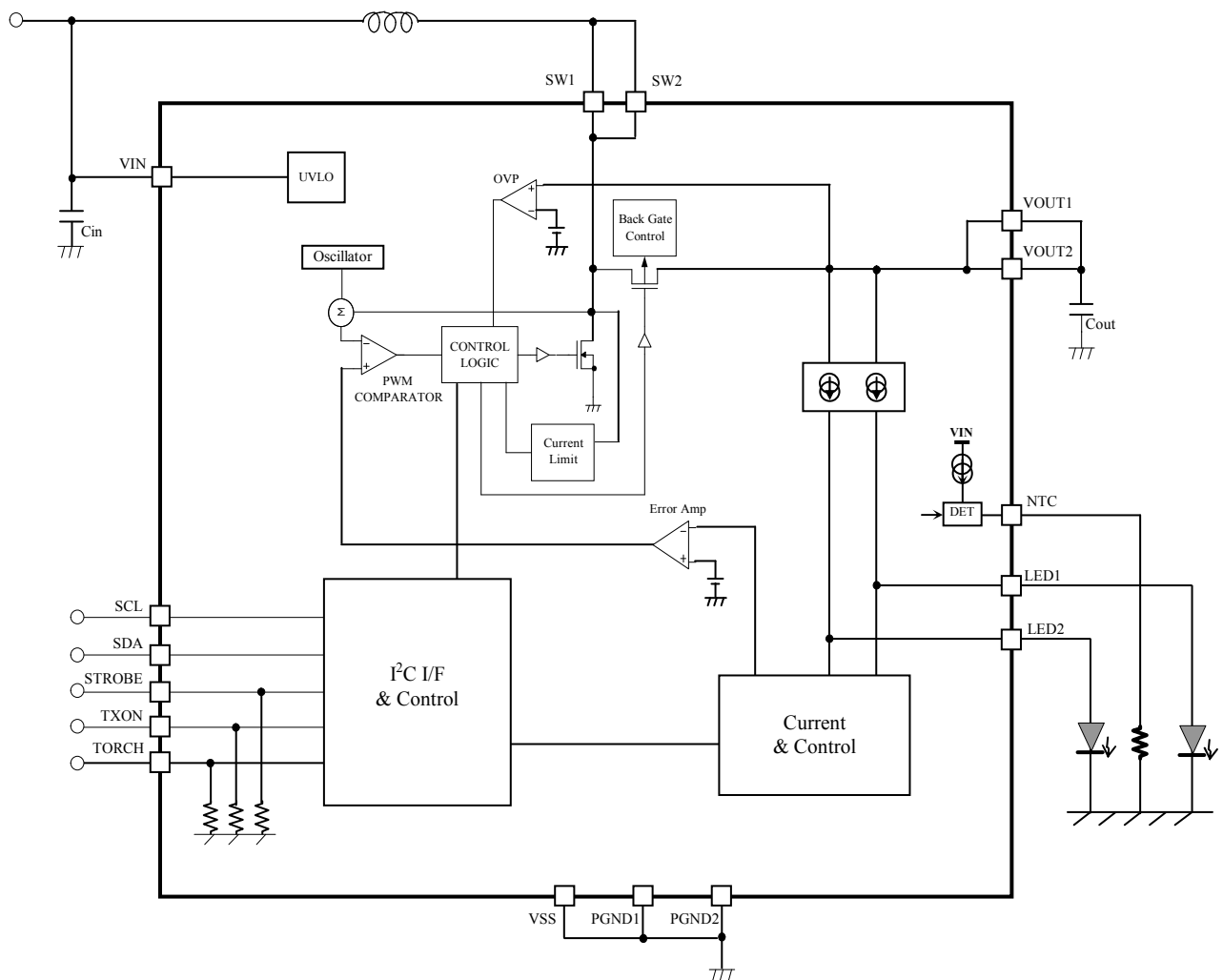
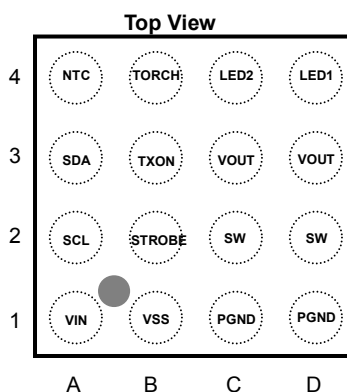


Figure 1. AP2061 Block Diagram

■ Pin Layout



PIN/FUNCTION

No.	Pin Name	I/O	Function
C3, D3	VOUT	O	Voltage Output pin
C2, D2	SW	I	Connect to coil pin
A1	VIN	-	Connect to battery pin
C1, D1	PGND	-	Power ground pin
B1	VSS	-	Analog ground pin
D4	LED1	O	Connect to Flash/Torch LED pin1 (This pin shall be open when unused)
C4	LED2	O	Connect to Flash/Torch LED pin2 (This pin shall be open when unused)
A4	NTC	I/O	LED temperature detection pin (connect to NTC thermistor) (This pin shall be connected to ground when unused)
B3	TXON	I	Synchronization input pin for RF transmission signal (This pin shall be connected to ground when unused) Pull-down resistor= 300kohm @typ
A2	SCL	I	I ² C clock input pin
A3	SDA	I/O	I ² C data input pin
B2	STROBE	I	Flashing control input pin (This pin shall be connected to ground when unused) Pull-down resistor= 300kohm @typ
B4	TORCH	I	Torching control input pin (This pin shall be connected to ground when unused) Pull-down resistor= 300kohm @typ

ABSOLUTE MAXIMUM RATING

(PGND=VSS=0V; (Note 1))

Parameter	Symbol	min	max	Units
VIN, SW, VOUT, LED1, LED2, NTC pins	V_{IN1}	-0.3	6.5	V
TXON, STROBE, SCL, SDA, TORCH pins	V_{IN2}	-0.3	VIN+0.3 (Note 2)	V
Junction Temperature	T_{JMAX}	-	125	°C
Storage Temperature	T_{STG}	-55	150	°C
Maximum Power Dissipation (Note 3)	P_D		TBD	W

Note 1. All voltages are with respect to ground. PGND and VSS pins shall be connected to same ground.

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

Note 3. In the case that PCD (size: TBD x TBDmm, TBDmm, TBD layer), wiring density is 100% or more.

The value is internal power loss of AP2061 and does not include external parts power dissipation.

Note: Operation at or beyond these limits may result in permanent damage to the device.

Normal operation is guaranteed at these extremes.

RECOMMENDED OPERATING CONDITIONS

(PGND=VSS=0V; (Note 1))

Parameter	Symbol	min	typ	max	Units
Input Voltage (VIN)	V_{batt1}	2.7	3.7	5.5	V
Operation Temperature	T_A	-30	25	85	°C

Note: When $4.7V < V_{IN} < 5.5V$, AP2061 can work normally in the case that protection function is not working, but the analog characteristics cannot be guaranteed.

ANALOG CHARACTERISTICS(PGND=VSS=0V (Note 1), VIN=2.7~4.7V, T_A=-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	1.5	mA	LED1=LED2=30mA setting VOUT= 4.5V
LED Current Accuracy1	I _{ACCU1}	-5		5	%	I _{LED1} =I _{LED2} = 1000mA (flash mode, VDD=3.7V, T _A =25 °C)
LED Current Accuracy2	I _{ACCU2}	-8		8	%	I _{LED1} =I _{LED2} = 1000mA
LED Current Accuracy3	I _{ACCU3}	-12		12	%	I _{LED1} =I _{LED2} = 200mA
Current Source Dropped Voltage 1 (VOUT-(LED1 or 2) pin voltage)	V _{DROP1}	TBD	0.35	TBD	V	V _{LED1} , V _{LED2} >=2.8V I _{LED1} =I _{LED2} = 0.03~0.8A CB bit= "0"
Current Source Dropped Voltage 2 (VOUT-(LED1 or 2) pin voltage)	V _{DROP2}	TBD	0.43	TBD	V	V _{LED1} , V _{LED2} >=2.8V I _{LED1} =I _{LED2} = 1A CB bit= "1"
Over Voltage Protection Hysteresis	OVP	TBD	5.1 0.21	TBD	V	
Under Voltage Lock Out (UVLO) Hysteresis	V _{UVLO}	2.4	2.5 0.1	2.6	V	
Boost Frequency	F _{BOOST}	3.7	4.0	4.3	MHz	
Timeout Time Accuracy	T _{OUTA}	-10		10	%	
Inductor Current Limit Accuracy	I _{LIMITA}	-15		15	%	
Time (Flash to Torch)	T _{FtoT}			5	μs	TXON pin= "L" to "H" I _{LED1} =I _{LED2} =1000mA to 30mA
NTC pin Detection Accuracy	V _{DETA}	-8		8	%	
NTC pin current	V _{CURRENT}	TBD	35	TBD	μA	
VIN Detection Accuracy	V _{DETA}	-5		5	%	
VIN Detection Hysteresis	V _{DETH}		0.1		V	
Thermal Protection Temperature Hysteresis	T _{REG} T _{REGH}	150	170 15	190	degree	

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

Parameter	Symbol	min	typ	max	Units
High-Level Input Voltage	V _{IH}	1.2	-	VIN	V
Low-Level Input Voltage	V _{IL}	-	-	0.4	V
Low-Level Output Voltage (I _{out} = 3mA) (SDA pin)	V _{OL}	-	-	0.4	V
Input Leakage Current 1 (SCL, SDA pins)	I _{IN1}	-2	-	2	μA
Pull-down Resistance TXON, STROBE, TORCH pins	R _{IN}	100	300	700	kΩ

LOGIC CHARACTERISTICS

($T_A = -30 \sim 85^\circ\text{C}$; $V_{IN} = 2.7 \sim 5.5\text{V}$)

Parameter	Symbol	min	typ	max	Units
Control Interface Timing:					
SCL Clock Frequency	F _{SCL}	-	-	400	kHz
Bus Free Time Between Transmissions	t _{BUF}	1.3	-	-	μs
Start Condition Hold Time (prior to first clock pulse)	t _{HD:STA}	0.6	-	-	μs
Clock Low Time	t _{LOW}	1.3	-	-	μs
Clock High Time	t _{HIGH}	0.6	-	-	μs
Setup Time for Repeated Start Condition	t _{SU:STA}	0.6	-	-	μs
SDA Hold Time from SCL Falling (Note 4)	t _{HD:DAT}	0	-	-	μs
SDA Setup Time from SCL Rising	t _{SU:DAT}	0.1	-	-	μs
Rise Time of Both SDA and SCL Lines	t _R	-	-	0.3	μs
Fall Time of Both SDA and SCL Lines	t _F	-	-	0.3	μs
Setup Time for Stop Condition	t _{SU:STO}	0.6	-	-	μs
Capacitive load on bus	C _b	-	-	400	pF
Pulse Width of Spike Noise Suppressed by Input Filter	t _{SP}	0	-	50	ns

Note 4. Data must be held long enough to bridge the 300ns transition time of SCL.

■ Timing Diagram

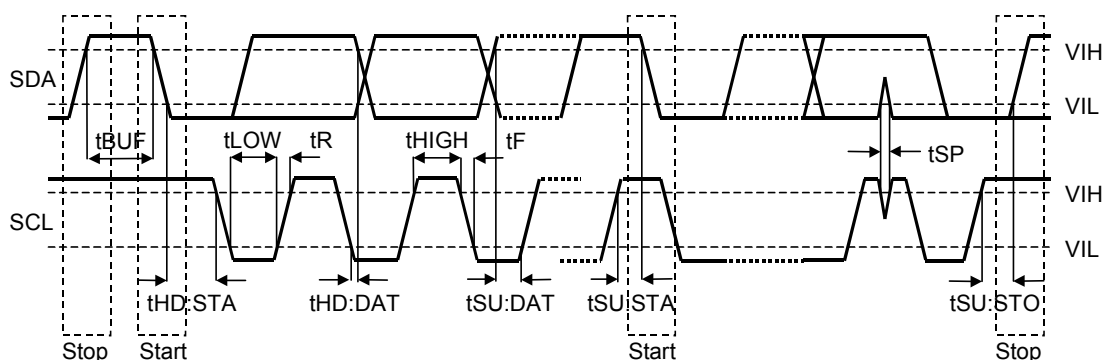


Figure 2. I²C Bus Mode Timing

OPERATION OVERVIEW

■ Boost DC/DC Converter

The AP2061 is a synchronically boost DC/DC converter with 4MHz switching frequency. The AP2061 can drive LEDs which connect to LED1 and LED2 pins with internal regulated current sources. The regulated current sources (high-side current sources) use PMOS FETs, allowing the LEDs to be directly connected to ground and providing better LED heat dissipation and simpler LED arrangement. The AP2061 can automatically regulate output voltage with different LED Forward Voltages (Vf).

The AP2061 integrates a TXON input which can be used to change the LED current from flash mode to torch mode 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 AP2061 protection functions are as shown below.
(PGND=VSS=0V; (Note 1), VIN=3.7V, Ta=25°C, Recommend Parts, unless otherwise specified)

Protection	Working condition	Device status	Return condition
1) LED thermal protection (refer to next page)	NTC pin voltage < setting voltage (DET[2:0])	All circuits power-down Address= "06H", NTC= "1"	Set LED1= LED2= "0" again
2) Over current protection (OCP)	Inductor peak current > setting current (LIMIT[1:0])	NMOS change to off when inductor current reach to limited current	Return automatically (1 cycle detected)
3) battery voltage detection protection	In the case of flashing VIN pin voltage < setting voltage (VIN[1:0])	VINDET bit= "0": Change to torch mode VINDET bit= "1": Boost circuit and current source circuit power-down	Next flash signal, Return automatically VIN pin voltage >setting voltage+0.1V
4) Over Voltage Protection (OVP)	VOUT pin voltage > 5.1V	Boost circuit power-down	Return automatically VOUT pin voltage < 5.1V-0.215V
5) Under Voltage Lock Out (UVLO)	VIN pin voltage < 2.5V	All circuits power-down Address= "06H", UVLO= "1"	Set LED1= LED2= "0" again
6) Thermal Shut-Down (TSD)	Device temperature > 170 degree	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 degree
7) LED1,LED2 pin in the state of open or short to GND	(VOUT-LED1<0.1V or VOUT-LED2<0.1V) and OVP is detected During 20us, LED1 pin < 1.0V or LED2 < 1.0V	All circuit power-down Address= "06H", LO= "1" All circuit power-down Address= "06H", LS= "1"	Set LED1= LED2= "0" again
8) 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) When set LED1=LED2= "0" again, the register will be reset.

■ LED Temperature Detection Function

AP2061 can detect LED temperature with NTC thermistor (Negative Temperature Coefficient Thermistor) which connect to NTC pin. The current which flow at NTC thermistor is 35uA.

Protection	Working condition	Device status	Return condition
LED1~2 temperature protection (Note 5)	NTC pin voltage < setting voltage(DET[2:0])	All circuits power-down Address= "06H", NTC= "1"	Set LED1= LED2= "0" again

Note 5. The parasitic capacitor of NTC pin should be lower 50pF.

Example)

NTC thermistor: NCP15WM154(150k @25°C、B constant=4582, 1005 size, Murata)

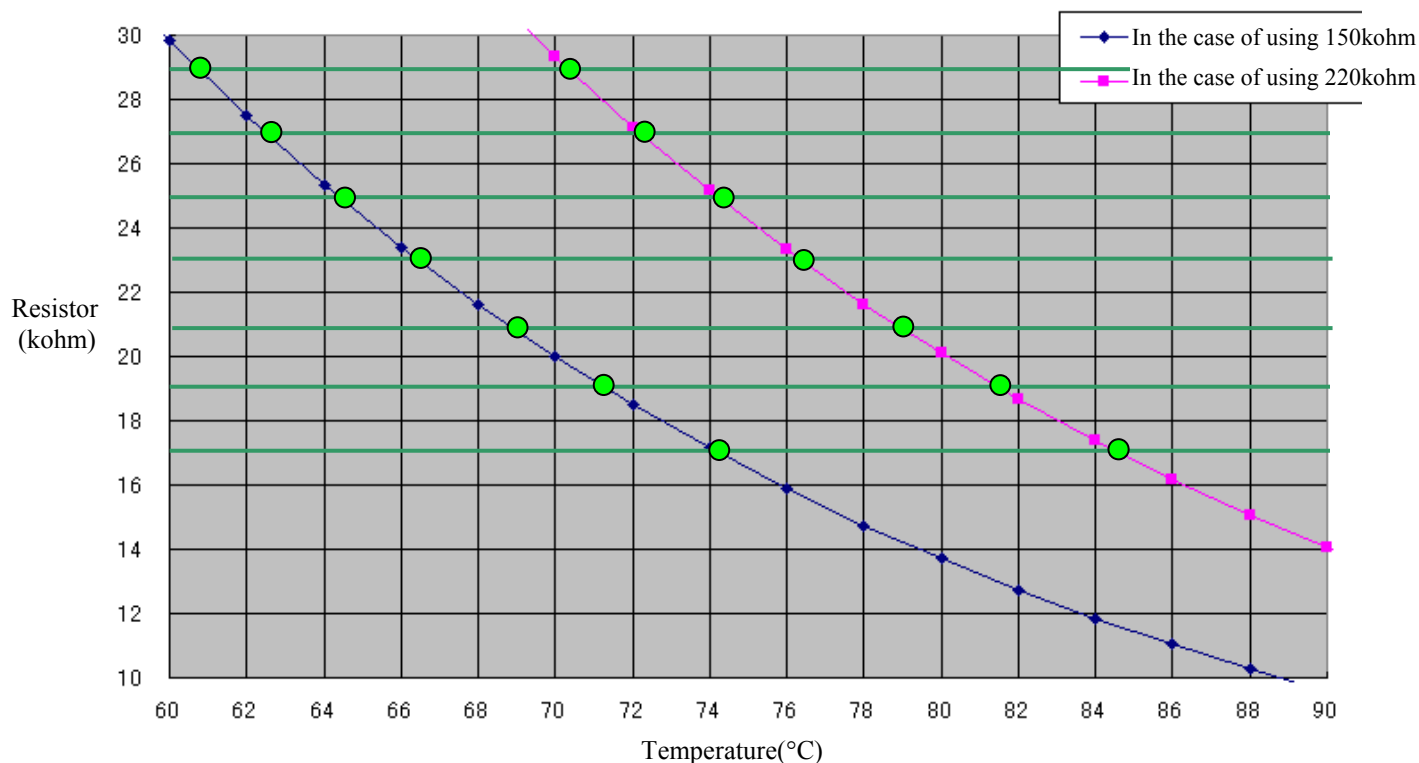
NCP15WM224(220k @25°C、B constant=4582, 1005 size, Murata)

Formula: $R=R_0 \cdot \exp(B \cdot (1/T - 1/T_0))$

(R: The value in the case of ambient temperature T(k);

R₀: The value in the case of ambient temperature T₀(k))

Detection voltage(V) @typ (set by resistor)	0.60	0.67	0.74	0.81	0.88	0.95	1.02
Detection resistor (kohm)	17.1	19.1	21.1	23.1	25.1	27.1	29.1
Detection temperature(°C) (in the case of using 150kohm)	74	71	69	66	64	62	61
Detection temperature(°C) (in the case of using 220kohm)	84	82	79	76	74	72	70



■ Recommend Sequence Examples

AP2061 automatically power-up with internal power-on-reset. Enable pin is not needed, so decrease the load of CPU
AP2061 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= "H" or FLASH bit= "1".

B) The time of STROBE pin= "H" or the time of FLASH bit= "1" > setting timer
Maximum driving time is limited by setting time.

Torching: Driving LED while TORCH pin= "H" or 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 pin= "H" or TORCH bit= "1".

1) Flashing sequence (LEVEL control)

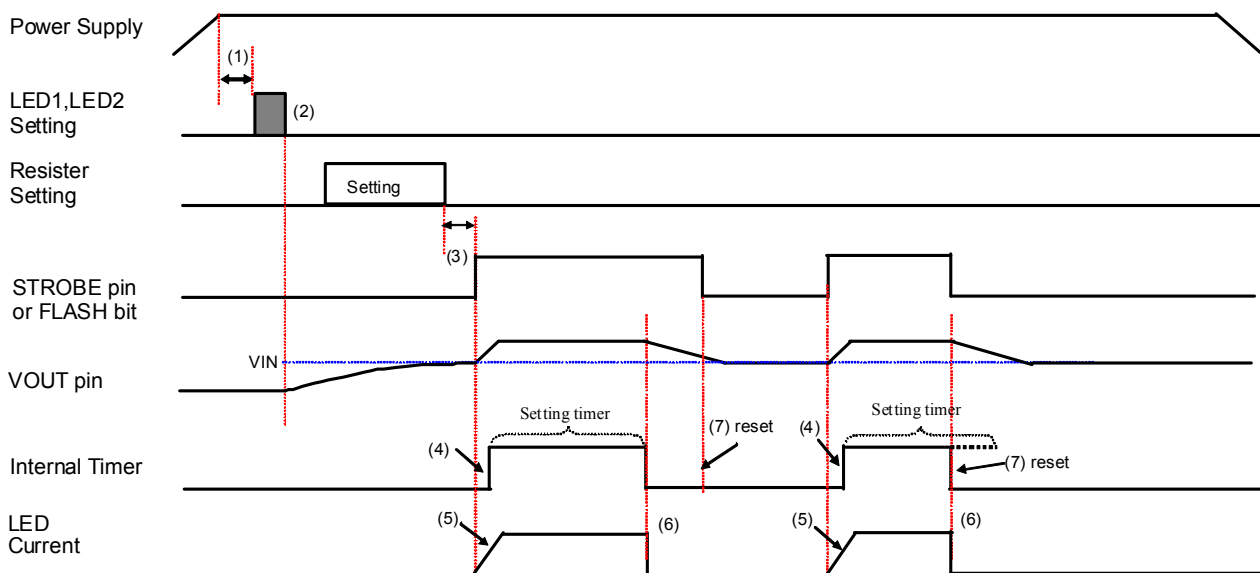


Figure 3. Flashing Sequence (LEVEL control)

- (1) After power supplied ($V_{IN} \geq 2.7V$), for resetting AP2061 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 $V_{IN} \times 95\%$ within 5ms, and inrush current < 500mA.
- (3) After register setting finished, Please set STROBE pin= "H" or FLASH bit= "1".
AP2061 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 LIGHT bit= "0" to "1",
The time of STROBE= "H" or the time of LIGHT bit= "1" > setting time:
After timer finished, LED current is change to 0mA.
The time of STROBE= "H" or the time of LIGHT 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)

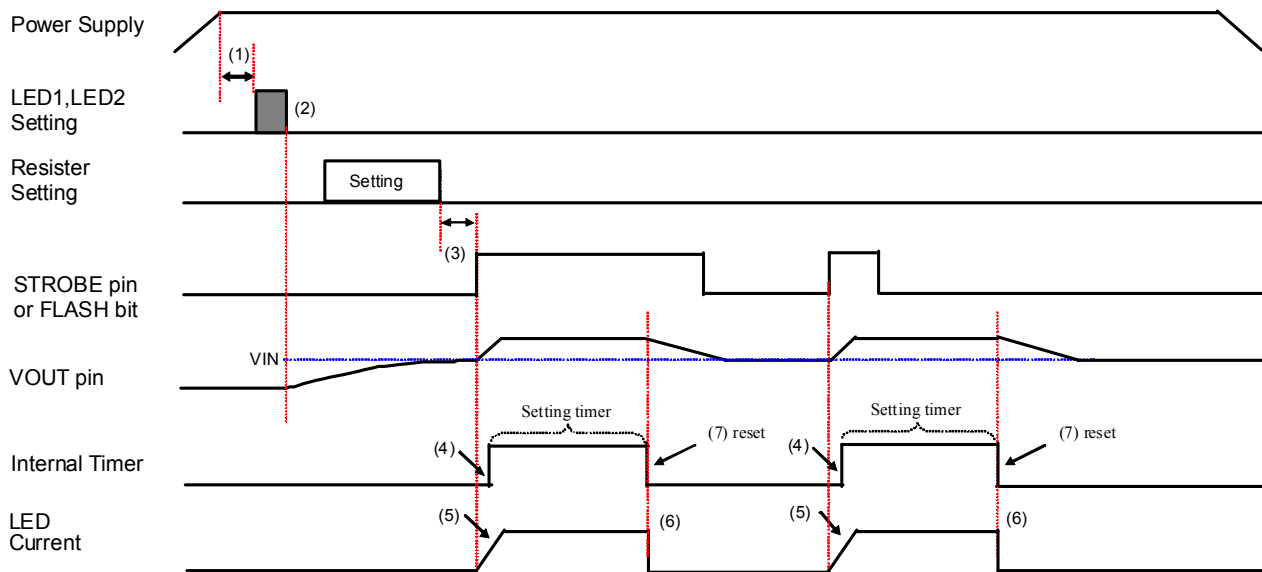


Figure 4. Flashing Sequence (EDGE control)

- (1) After power supplied ($V_{IN} \geq 2.7V$), for resetting AP2061 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 $V_{IN} \times 95\%$ within 5ms, and inrush current $< 500mA$.
- (3) After register setting finished, Please set STROBE pin = "H" or FLASH bit = "1".
AP2061 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)

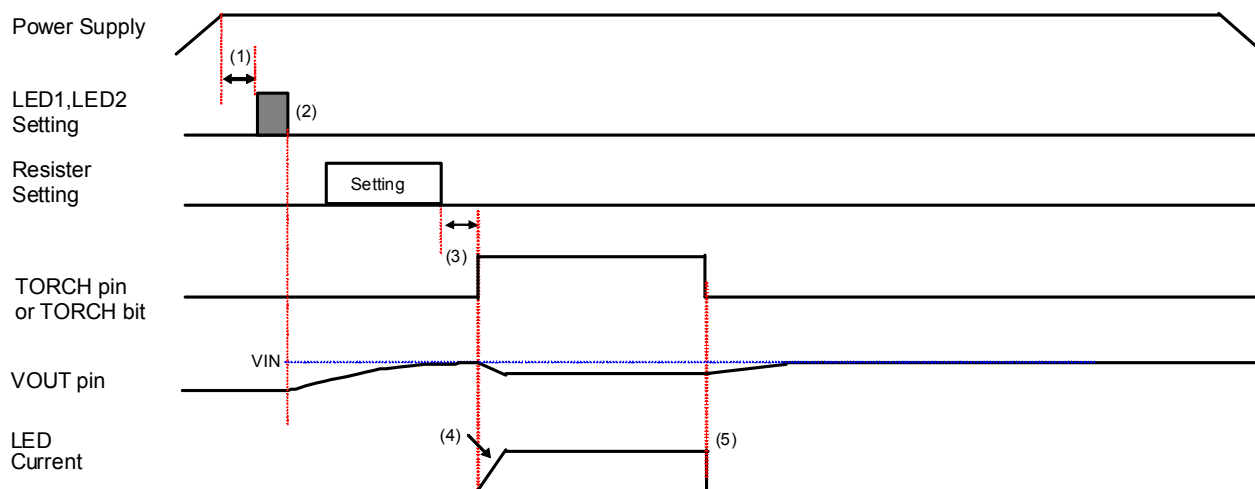


Figure 5. Torching Sequence

- (1) After power supplied ($V_{IN} \geq 2.7V$), for resetting AP2061 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 $V_{IN} \times 95\%$ within 5ms, and inrush current $< 500mA$.
- (3) After register setting finished, Please set TORCH pin = "H" or TORCH bit = "1".
AP2061 can drive LED with TORCH pin or TORCH bit, did not depend on VOUT voltage.
After LED1, LED2 bits is set, please wait 5ms, then set TORCH pin = "H" or TORCH bit = "1".
- (4) In the case of $V_{OUT} = V_{IN}$, after TORCH pin = "L" to "H" or TORCH bit = "0" to "1", LED current will reach setting current within $300\mu s$.
- (5) After TORCH pin = "1" to "0" or TORCH bit = "1" to "0", LED current will change to 0mA.

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

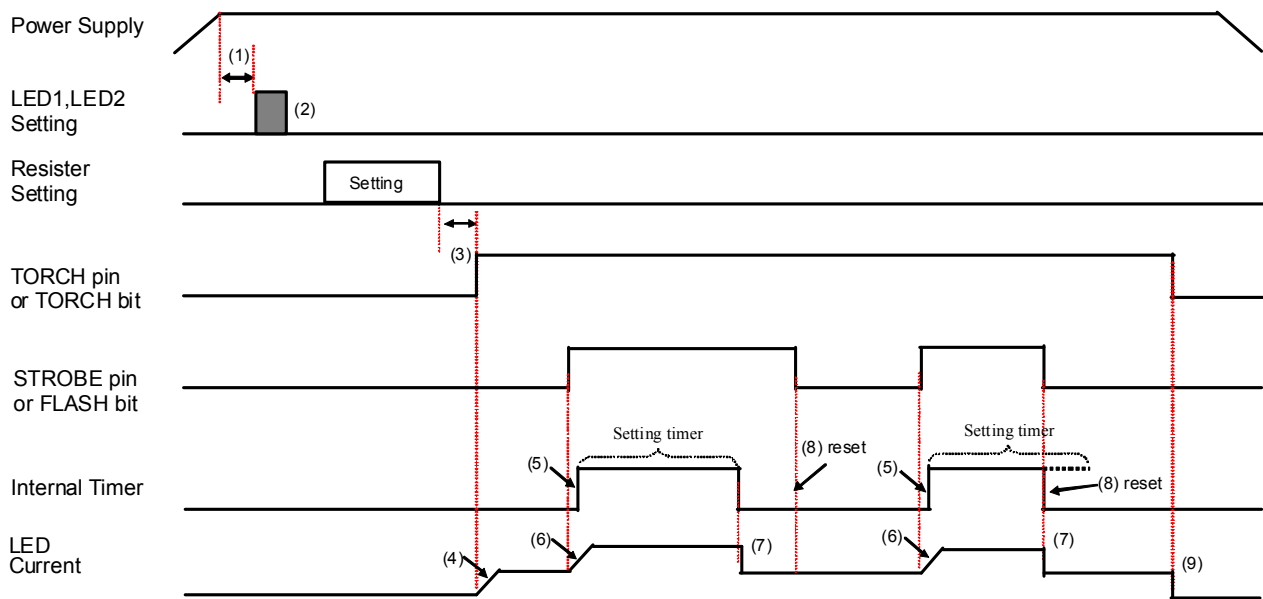


Figure 6. Torching to Flashing sequence (LEVEL control)

- (1) After power supplied ($V_{IN} \geq 2.7V$), for resetting AP2061 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 $V_{IN} \times 95\%$ within 5ms, and inrush current < 500mA.
- (3) After register setting finished, waiting Please set TORCH pin = "H" or TORCH bit = "1".
After LED1, LED2 bits is set, please wait 5ms, then set TORCH pin = "H" or TORCH bit = "1".
- (4) After TORCH pin = "L" to "H" or TORCH bit = "0" to "1", LED current will reach to setting current within 300 μ 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 μ s.
- (7) When STROBE pin = "H" to "L" or LIGHT bit = "0" to "1",
The time of STROBE = "H" or the time of LIGHT bit = "1" > setting time:
After timer finished, LED current is change to 0mA.
The time of STROBE = "H" or the time of LIGHT bit = "1" > setting time:
LED current is change to 0mA immediately.
- (8) The timer will be reset with STROBE pin = "H" to "L" or FLASH bit = "1" to "0".

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

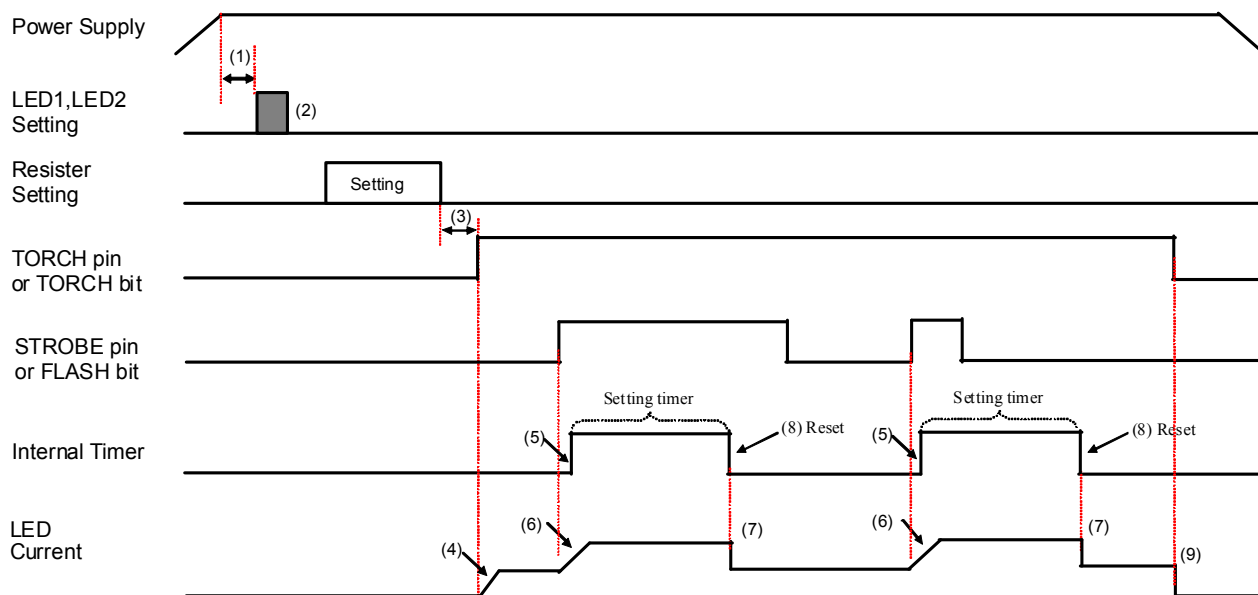


Figure 7. T orching to Flashing sequence (EDGE control)

- (1) After power supplied($V_{IN} \geq 2.7V$), for resetting AP2061 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 $V_{IN} \times 95\%$ within 5ms, and inrush current < 500mA.
- (3) After register setting finished, Please set TORCH pin= "H" or TORCH bit= "1".
After LED1, LED2 bits is set, please wait 5ms, then set TORCH pin= "H" or TORCH bit= "1".
- (4) After TROCH pin= "L" to "H" or TORCH bit= "0" to "1", LED current will reach to setting current within 300 μ 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 μ 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.

■ Serial Control Interface

The AP2061 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 8 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 13). 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 9). If the slave address matches that of the AP2061, the AP2061 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 14). 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 AP2061. The format is MSB first, and those most significant 3-bits are fixed to zero (Figure 10). The data after the second byte contains control data. The format is MSB first, 8-bits (Figure 11). The AP2061 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 13).

The AP2061 can perform more than one byte write operation per sequence. After receipt of the third byte the AP2061 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 15) except for the START and STOP conditions.

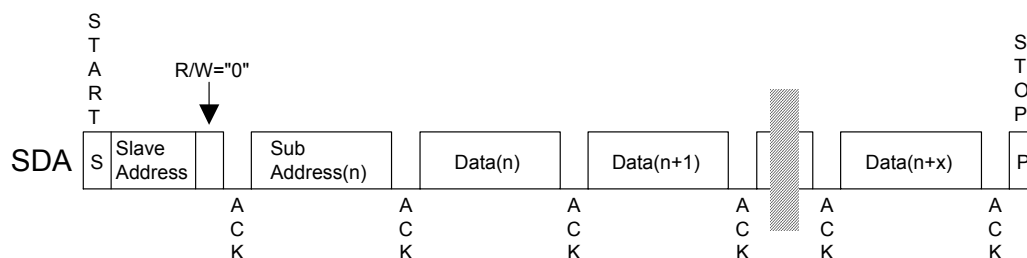


Figure 8. Data Transfer Sequence

0	1	1	0	1	1	1	R/W
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Figure 9. The First Byte

X	X	X	X	X	A2	A1	A0
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Figure 10. The Second Byte (X: Don't care)

D7	D6	D5	D4	D3	D2	D1	D0
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Figure 11. Byte Structure after the second byte

2. READ Operations

Set the R/W bit = “1” for the READ operation of the AP2061. 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 AP2061 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 AP2061 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 AP2061 ceases transmission.

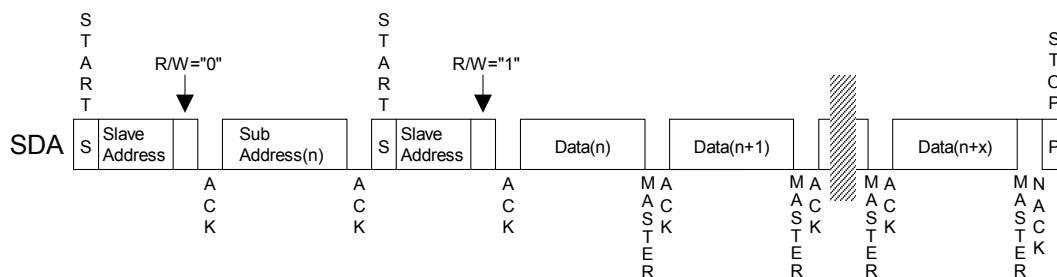


Figure 12. RANDOM ADDRESS READ

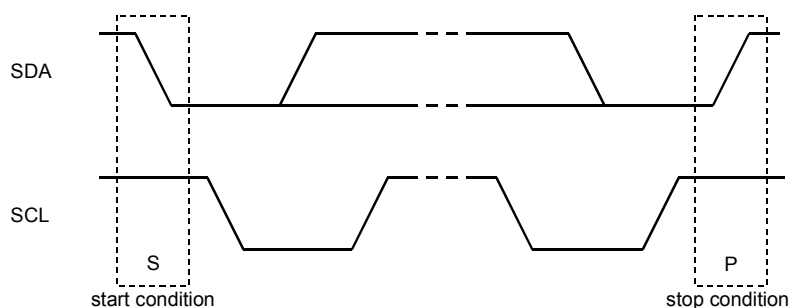
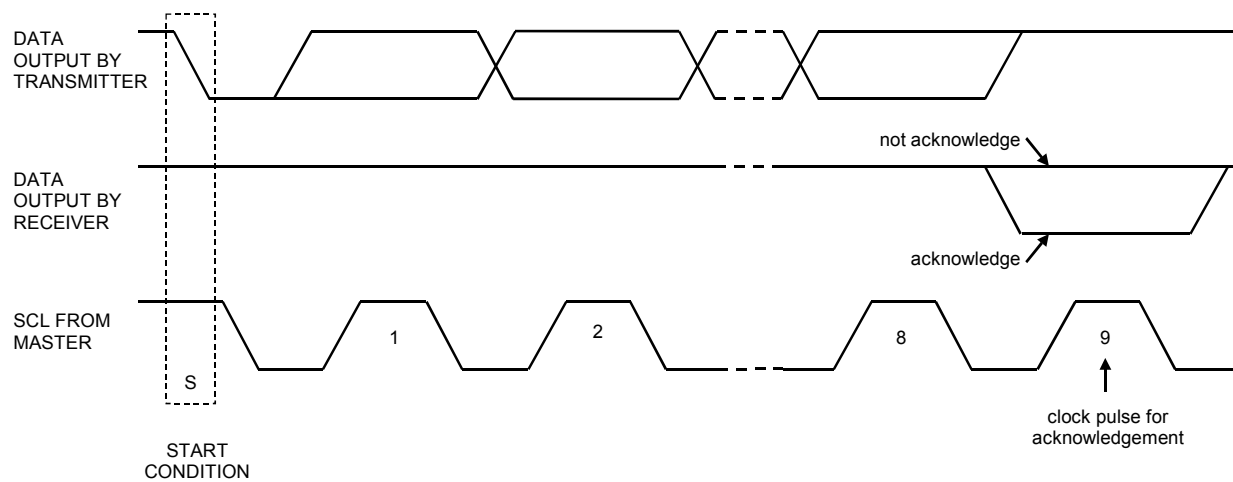
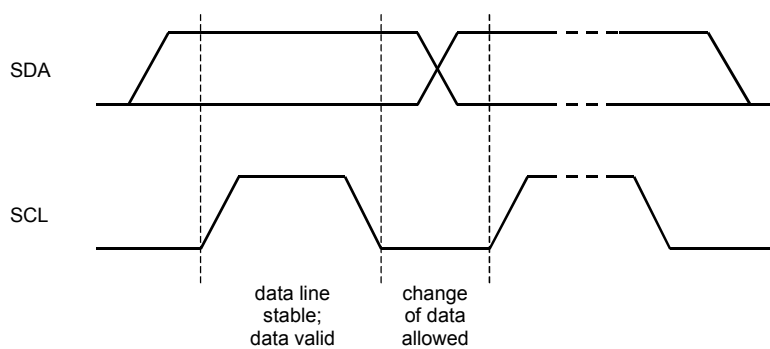


Figure 13. START and STOP Conditions

Figure 14. Acknowledge on the I²C-BusFigure 15. Bit Transfer on the I²C-Bus

■ Register Map

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
00H	Instruction	INST7	INST6	INST5	INST4	INST3	INST2	INST1	INST0
01H	LED1/2 Control 1							LED2	LED1
02H	LED1/2 Control 2		TSDSEL	CB	EDGE	TIME3	TIME2	TIME1	TIME0
03H	LED1/2 Control 3		DIM	LEDT2	LEDT1	LEDT0	LEDF2	LEDF1	LEDF0
04H	Others	VINDET	VIN1	VIN0	DET2	DET1	DET0	LIMIT1	LIMIT0
05H	Light Control							FLASH	TORCH
06H	Fault/Status	LIGHT_ NG	EN_NG	TSD	NTC	LO	UVLO	VOS	LS

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

■ Register Definitions

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] = 0110110 is not written, the access for other register is not effective.

At first, please set INST[7:0] = 0110110.

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
01H	LED1/2 Control							LED2	LED1
	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

LED1, LED2: The power ON/OFF for AP2061 and the ON/OFF control for LEDs that connect to LED2, LED1.

LED2	LED1	AP2061 Status
0	0	Power-down
0	1	LED1=on, LED2=off
1	0	LED1= off, LED2=on
1	1	LED1=on, LED2=on

Table 1. AP2061&LED status setting

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
02H	LED1/2 Control 2		TSDSEL	CB	EDGE	TIME3	TIME2	TIME1	TIME0
	R/W	R/W	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.

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

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

Note) In the case of LED current = 1A/ch, if the flashing time more than 90ms, thermal protection is possible working.

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-LED1/2)

0: 0.35V

1: 0.43V

TSDSEL: Thermal Shut Down return mode

0: Set LED1= LED2= "0" again

1: Return automatically

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
03H	LED1/2 Control 3		DIM	LEDT2	LEDT1	LEDT0	LEDF2	LEDF1	LEDF0
	R/W	R/W	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 LED1, LED2.

LEDF2	LEDF1	LEDF0	FLASH (mA) (1ch)	FLASH (mA) (total)
0	0	0	150	300
0	0	1	250	500
0	1	0	350	700
0	1	1	450	900
1	0	0	550	1100
1	0	1	650	1300
1	1	0	800	1600
1	1	1	1000	2000

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

LEDT0, LEDT1, LEDT2: The current setting for LEDs that connect to LED1, LED2.

DIM: Small torching current setting

0: normal setting

1: torching current= torching setting current / 5

LEDT2	LEDT1	LEDT0	TORCH (mA) (1ch)		TORCH (mA) (2ch)	
			DIM= "0"	DIM= "1"	DIM= "0"	DIM= "1"
0	0	0	30	6	60	12
0	0	1	50	10	100	20
0	1	0	70	14	140	28
0	1	1	90	18	180	36
1	0	0	110	22	220	44
1	0	1	130	26	260	52
1	1	0	160	32	320	64
1	1	1	200	40	400	80

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

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
04H	Others	VINDET	VIN1	VIN0	DET2	DET1	DET0	LIMIT1	LIMIT0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
	Default	0	0	0	0	0	0	1	0

LIMIT1, LIMIT0: Inductor limit current setting

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

Table 5. inductor current limit setting

DET2, DET1, DET0: NTC pin voltage detection setting (NTC pin= 35 μ A)

DET2	DET1	DET0	NTC pin voltage
0	0	0	off
0	0	1	0.60V
0	1	0	0.67V
0	1	1	0.74V
1	0	0	0.81V
1	0	1	0.88V
1	1	0	0.95V
1	1	1	1.02V

Table 6. NTC pin voltage detection

VIN1, VIN0: Input voltage detection

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

Table 7. Input voltage detection

VINDET: The status after input voltage be detected

0: change to torch mode.

1: Power-down

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

FLASH: Drive LED with flashing current

TORCH: Drive LED with torching current

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

Table 8. LED Control Status (LED1=LED2 bits= “01” or “10” or “11”)

Addr	Register Name	D7	D6	D5	D4	D3	D2	D1	D0
06H	Fault/Status	LIGHT_ NG	EN_ NG	TSD	NTC	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

NTC: NTC protection is working or not.

0: not working 1: working

TSD: Thermal shut down is detected or not.

0: not in the status of TSD 1: TSD

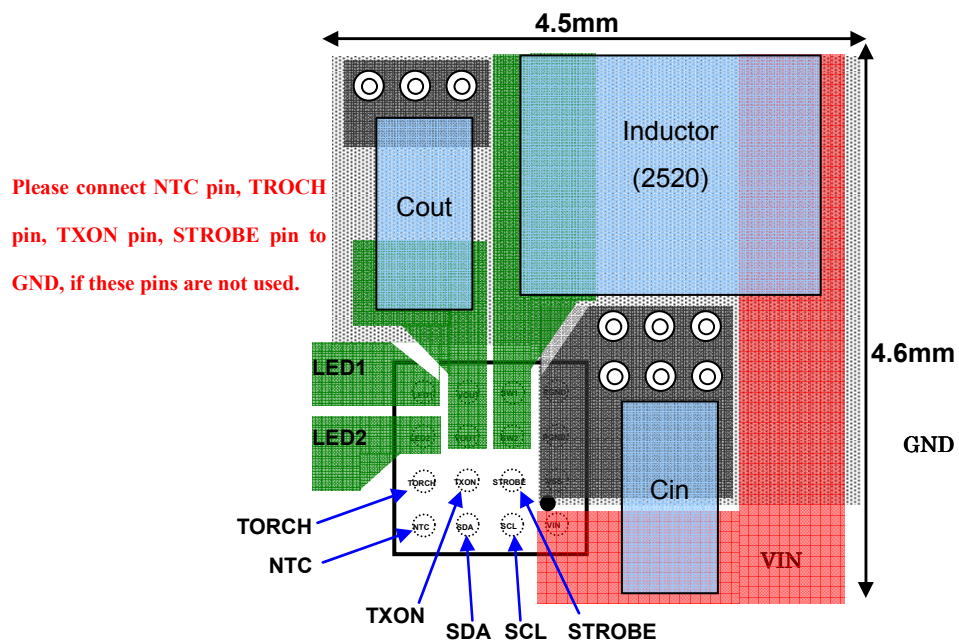
EN_ NG: for Start-up Stand-by

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)

SYSTEM DESIGN



The example of recommended external parts (LED1=LED2=800mA, VIN=3.0~4.5V, VOUT<4.5V)

項目	記号	定数	Type(例)	寸法	メーカー
Inductor	L	1uH	DFE252010C DC RES=45mohm	2.5 x 2.0 x 1.2 mm	TOKO
			LQH44PN1R0NP0 DC=30mohm	3.7 x 4.0 x 1.8mm	Murata
			VLF4014ST-1R0N2R3 DC=50mohm	3.8 x 3.6 x 1.4mm	TDK
Condenser	Cin Cout	4.7uF	GRM188B30J475KE18 (6.3V)	1.6 x 0.8 mm	Murata
			C1608JB0J475K, C1608JB0J475M C1608X5R0J475K, C1608X5R0J475M 3.5uF @3.7V, 2.8uF @5V	1.6 x 0.8 mm	TDK
NTC抵抗		150k 220k 470k	NCP15WM154 (B constant=4614) NCP15WM224 (B constant=4614) NCP15WM474 (B constant=4614)	1.0 x 0.5 mm	Murata

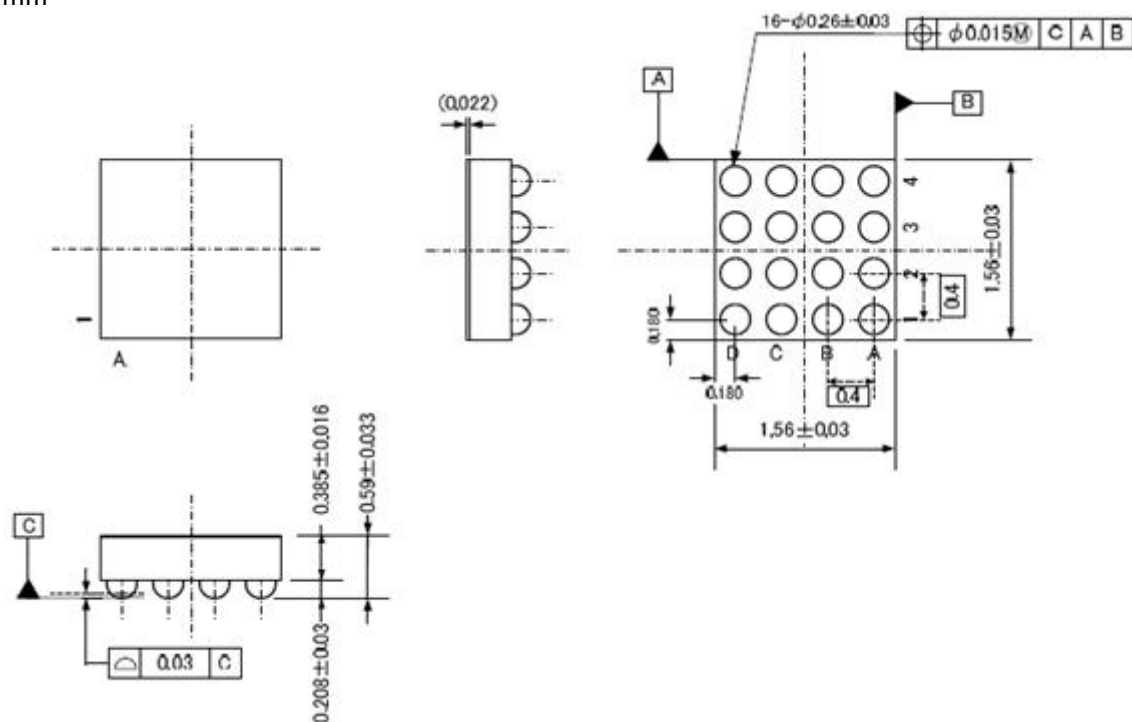
Table 9. Recommend external parts example

Note:

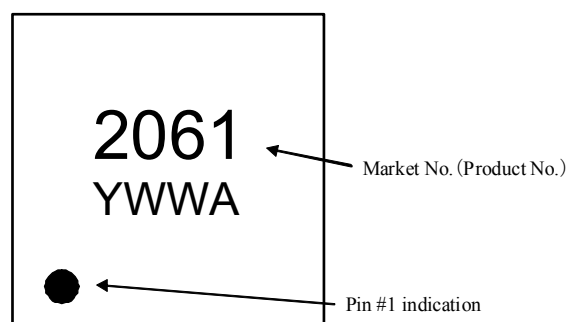
- PGND and VSS shall be connected to the same ground plane.
- Inductor shall be placed as close as possible to the chip.
- Capacitors shall be placed as close as possible to the chip.
- Low ESR (Equivalent Series Resistance) capacitors are recommended.

PACKAGE

Unit: mm



MARKING



YWWA : Date code (4 digit)

A: manage number

WW: producing week

Y: producing year (Ex: 2012-> "2")

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