AAT1281

SwitchReg™

2A Driver IC for High Intensity LED Camera Flash

General Description

The AAT1281 is a high efficiency, high current boost converter capable of 2A maximum output current using a Super Capacitor. It is an ideal power solution for LED photo flash applications in all single cell Li-ion powered products.

The AAT1281 maintains output current regulation by switching the internal high-side and low-side switch transistors. The transistor switches are pulse-width modulated at a fixed frequency of 2MHz. The high switching frequency allows the use of a small inductor and output capacitor, making the AAT1281 ideally suited for small battery-powered applications. A high-capacity Super Capacitor on the secondary side of the step-up converter provides the high-peak flash LED current, thereby reducing peak current demand from the Li-ion battery. To achieve this, the step-up converter features a fixed input current limiter. Also included are a "ready to flash" signal, indicating that the Super Capacitor is sufficiently charged, and a capacitor balancing pin.

AnalogicTech's AS²Cwire™ (Advanced Simple Serial Control™) serial digital input is used to enable, disable and set the movie mode current for each LED with 16 level settings. It includes a separate Flash Enable input to both initiate the Flash current and also start a default timer (also programmable) used either to terminate the Flash pulse at end of a predetermined time or as a safety feature.

The maximum flash and movie-mode current is set by one external resistor where the ratio of Flash to Movie Mode current is set at approximately 7.3:1. One or two LEDs can be connected to the AAT1281; in the case of two LEDs the output current is matched between each diode. The ratio of maximum flash current to movie mode current can also be adjusted via the AS²Cwire control.

The AAT1281 contains a thermal management system to protect the device in the event of an output short-circuit condition. Built-in circuitry prevents excessive inrush current during start-up. The shutdown feature reduces quiescent current to less than 1.0µA.

The AAT1281 is available in a Pb-free, thermally enhanced 14-pin 3x3mm TDFN package.

Features

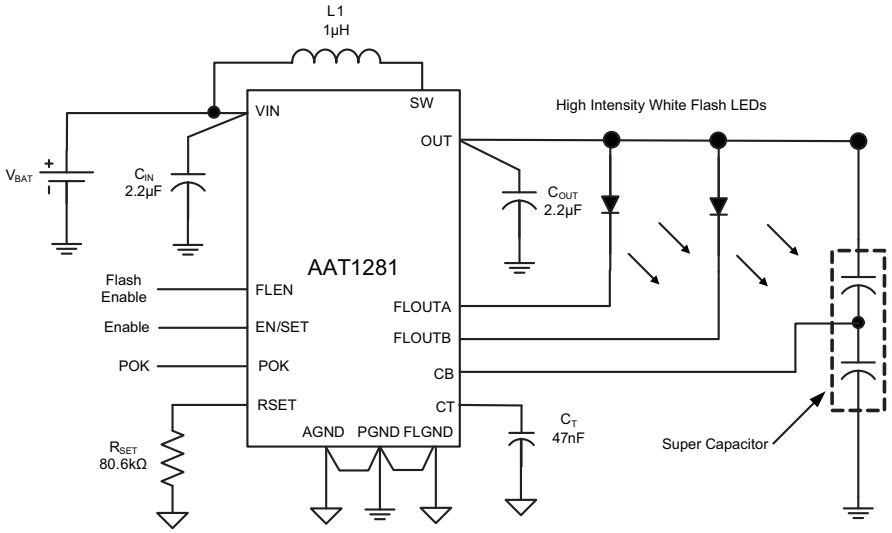
- V_{IN} Range: 2.7V to 5.5V
- Dual Channel Output
  - Up to 2A Regulated Output Current
    - 1A per channel
- Fixed Input Current Limit
  - 800mA*
  - Suited for Super Capacitor Applications
- Super Capacitor Balancing Pin
- POK: Ready to Flash Signal
- Internal Balancing Resistors
- Up to 90% Efficiency
- 2MHz Switching Frequency
- Separate Flash Enable
- Single Resistor sets Flash and Movie Mode Current
- AS²Cwire Single Wire Interface Sets:
  - 16 Level Movie Mode Current
  - Flash/Movie Current Ratio
  - Current Output Channel Control
  - Safety Timer
- Supply Current in Shutdown: <1.0µA
- True Load Disconnect
- Small Application Circuit
- Automatic Soft-Start
- 14-pin TDFN3x3 Package
- -40°C to +85°C Temperature Range

Applications

- Camcorder Video Light (Torch Light)
- Camera Phones/Smartphones
- Digital Still Cameras (DSCs)
- LED Photo Flash Light (Strobe Light)
- Mobile Handsets

* Contact Sales for alternative current limits.

Typical Application

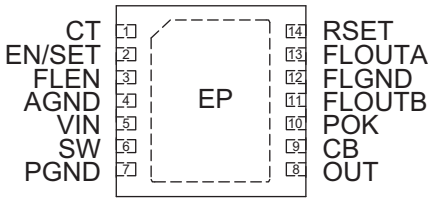


Pin Descriptions

Pin #	Symbol	Function	Description
1	CT	I	Flash timer control input. Connect a capacitor between CT and AGND to set default ON time for the flash output. A 47nF ceramic capacitor defaults the flash timer to 600ms. Alternative timeout periods can be programmed through AS²Cwire. To disable the flash timer, connect CT to AGND.
2	EN/SET	I	Movie mode enable pin. Can also interface with AS²Cwire to adjust movie mode current level, CT timing, A/B Output select and Flash/Movie mode current ratio. See programming tables for details.
3	FLEN	I	Flash enable pin. A low-to-high transition on the FLEN pin initiates a flash pulse and starts the flash timer.
4	AGND	P	Analog ground pin. Connect AGND to PGND and FLGND at a single point as close to the AAT1281 as possible.
5	VIN	PI	Power input. Connect IN to the input power supply voltage. Connect a 2.2µF or larger ceramic capacitor from IN to PGND as close as possible to the AAT1281.
6	SW	O	Step-up converter switching node. Connect a 1µH inductor between SW and IN.
7	PGND	P	Power ground pin. Connect PGND to AGND and FLGND at a single point as close to the AAT1281 as possible.
8	OUT	O	Power output of the step-up converter. Connect a 2.2µF or larger ceramic capacitor from OUT to PGND as close as possible to the AAT1281. Connect OUT to the super capacitor and the anode(s) of the Flash LED(s).
9	CB	I	Super Capacitor balancing pin. Connect the center tap of Super Capacitor here.
10	POK	O	POK output. Open drain, active low output. Connect pull-up resistor to V_{IN} to indicate when the Super Capacitor is charged and "Ready to Flash".
11	FLOUTB	O	Flash Output B. Connect cathode of Flash LED B to FLOUTB. For a single flash LED, connect FLOUTB and FLOUTA together. For two flash LEDs, each output will conduct 50% of the total flash output current. Can be turned on or off using AS²Cwire in Movie mode.
12	FLGND	P	Flash ground pin. Connect FLGND to PGND and AGND at a single point as close to the AAT1281 as possible.
13	FLOUTA	O	Flash Output A. Connect cathode of Flash LED A to FLOUTA. For a single flash LED, connect FLOUTA and FLOUTB together. For two flash LEDs, each output will conduct 50% of the total flash output current. Can be turned on or off using AS²Cwire in Movie mode.
14	RSET	I	Flash current setting input. A 80.6kΩ resistor from RSET to AGND sets the maximum flash current available at FLOUTA and FLOUTB to 2000mA. Each FLOUTA and FLOUTB channel will conduct 50% of the maximum programmed current (1000mA). This resistor also sets the maximum setting of the 16 programmable movie mode levels via AS²Cwire at EN/SET pin divided by 7.3.
	EP		Exposed paddle (bottom); Connect EP to PGND as close as possible to the AAT1281.

Pin Configuration

TDFN33-14
(TopView)



Absolute Maximum Ratings[1]

T_A = 25°C unless otherwise noted.

Symbol	Description	Value	Units
V_{IN}, V_{SW}, V_{OUT}	VIN, SW, OUT to GND or PGND	-0.3 to 6.0	V
$V_{EN/SET}$, V_{RSET}, V_{POK}, V_{FLEN}, V_{CB}	RSET, EN/SET, FLEN, POK, CT, FLOUTA, FLOUTB to GND, PGND, or FLGND	V_{IN} + 0.3	V
I_{OUT}	FLOUTA and FLOUTB[2]	2200	mA

Thermal Information[3]

Symbol	Description	Value	Units
θ_{JA}	Thermal Resistance	50	°C/W
P_D	Maximum Power Dissipation	2	W
T_J	Operating Temperature Range	-40 to 150	°C
T_S	Storage Temperature Range	-65 to 150	°C
T_{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	300	°C

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum rating should be applied at any one time.
2. Based on long-term current density limitation.
3. Mounted on an FR4 circuit board.

Electrical Characteristics[1]

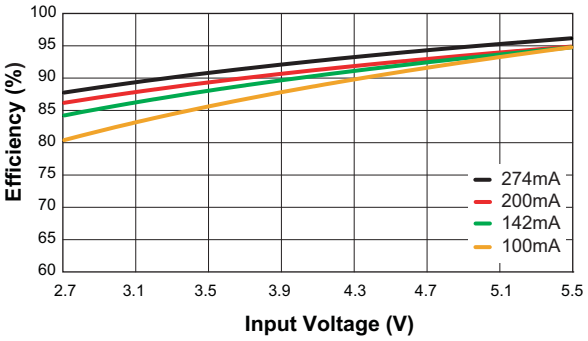
V_{IN} = 3.6V; C_{IN} = 2.2µF; C_{OUT} = 2.2µF; L = 1µH; R_{SET} = 80.6kΩ; T_A = -40°C to +85, unless otherwise noted. Typical values are T_A = 25°C.

Symbol	Description	Conditions	Min	Typ	Max	Units
Power Supply						
V_{IN}	Input Voltage Range		2.7		5.5	V
$I_{IN(Q)}$	Supply Current	EN = IN; FLEN = AGND; Set load = 2A; R_{SET} = 80.6kΩ		0.57	1	mA
$I_{SHDN(MAX)}$	Shutdown Current	EN/SET = FLEN = AGND			1.0	µA
$I_{FL(TOTAL)}$	Total Output Current, Flash Mode	R_{SET} = 80.6kΩ, FLOUTA + FLOUTB	1800	2000	2200	mA
$I_{FL(MATCH)}$	FLOUTA and FLOUTB Current Matching			10		%
$I_{MM(TOTAL)}$	Total Output Current, Movie Mode	R_{SET} = 80.6Ω , Movie Mode Current Set = 100%, FLOUTA + FLOUTB		274		mA
f_{osc}	Switching Frequency	T_A = 25°C	1.5	2.0	2.5	MHz
T_{SS}	Soft Start Time			200		µs
$t_{default}$	Default ON Time	C_T = 47µF		600		ms
T_{SD}	T_J Thermal Shutdown Threshold			140		°C
$T_{SD(HYS)}$	T_J Thermal Shutdown Hysteresis			15		°C
EN/SET/ FLEN/ Control						
$V_{EN(L)}$, $V_{FLEN(L)}$	EN/SET Threshold Low				0.4	V
$V_{EN(H)}$, $V_{FLEN(H)}$	Enable Threshold High		1.4			V
$T_{EN/SET(Low)}$	EN/SET Serial Interface Low Time		0.3		75	µs
$T_{EN/SET\ HI\ MIN}$	Minimum EN/SET High Time	$V_{EN/SET}$ > 1.4V		50		ns
$T_{EN/SET\ HI\ MAX}$	Maximum EN/SET High Time	$V_{EN/SET}$ > 1.4V			75	µs
$T_{EN/SET(OFF)}$	EN/SET Off Timeout	$V_{EN/SET}$ < 0.6V			500	µs
$T_{EN/SET(LAT)}$	EN/SET Latch Timeout	$V_{EN/SET}$ > 1.4V			500	µs
$I_{EN/SET}$, I_{FLEN}	EN/SET or FLEN Input Leakage	V_{FLEN} or $V_{EN/SET}$ = V_{IN} = 5V	-1		1	µA
$T_{FLEN\ OND}$	FLEN ON Delay Time	EN/SET = AGND		40		µs
$T_{FLEN\ OFFD}$	FLEN OFF Delay Time	EN/SET = AGND		10		µs
POK Output						
V_{POK}	Trip Threshold	V_{OUT} rising, T_A = 25°C		94		%
V_{POK_HYS}	POK Hysteresis			200		mV
$V_{POK(L)}$	System POK Voltage Low	I_{SINK} = 1mA			0.4	V
I_{POK}	POK Leakage Current	V_{POK} < V_{IN}, V_{OUT} < 94% of V_{OUT}			1.0	µA
Super Capacitor Balancing						
R_{CB}	Resistance from VOUT to center point or center point to GND	EN/SET = HIGH		25		kΩ
R_{CB_match}		EN/SET = HIGH		10		%

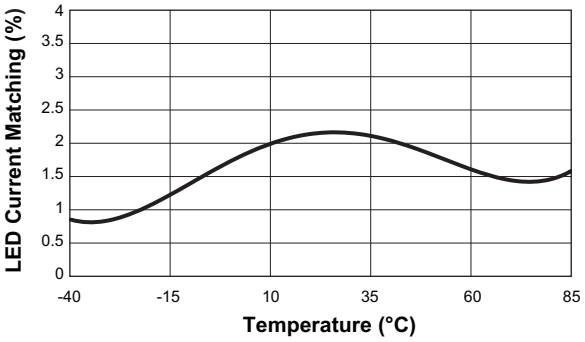
1. The AAT1281 is guaranteed to meet performance specifications over the -40°C to +85°C operating temperature range and is assured by design, characterization, and correlation with statistical process controls.

Typical Characteristics

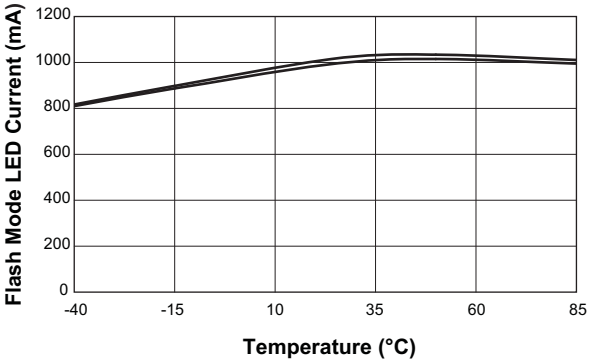
Boost Converter Efficiency (P_{OUT}/P_{IN}) without SuperCap
(L = 1µH)



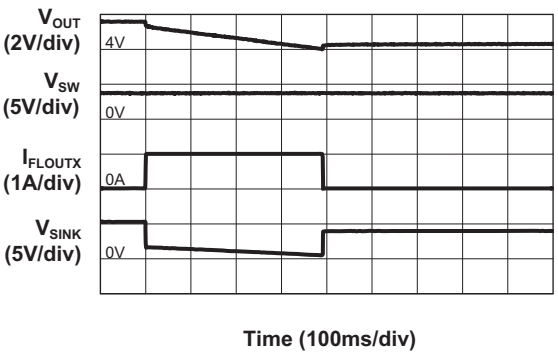
Flash Mode LED Current Matching vs. Temperature
(I_{FLOUTX} = 1A/Channel; V_{IN} = 3.6V; SuperCap [5.5V, 0.55F])



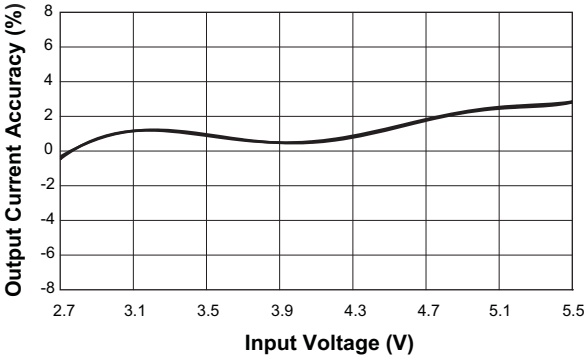
Flash Mode LED Current vs. Temperature
(I_{FLOUTX} = 1A/Channel; V_{IN} = 3.6V; SuperCap [5.5V, 0.55F])



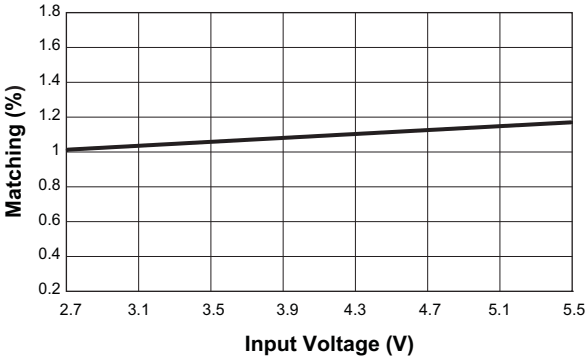
Flash Turn On Characteristic
(I_{FLOUTX} = 1A/Ch; V_{IN} = 3.6V; SuperCap [5.5V, 0.55F])



Movie Mode LED Current Accuracy
(I_{FLOUTX} = 100mA/Channel; L = 1µH)

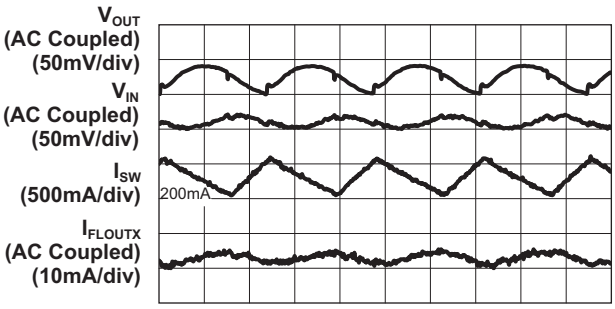


Movie Mode LED Current Matching
(I_{FLOUTX} = 100mA/Channel; L = 1µH)



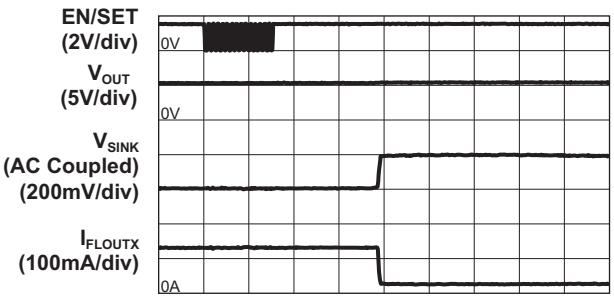
Typical Characteristics

Movie Mode Ripple
(V_{OUT} = 5.5V; V_{IN} = 3.6V; I_{FLOUTX} = 137mA/Ch; L = 1µH)



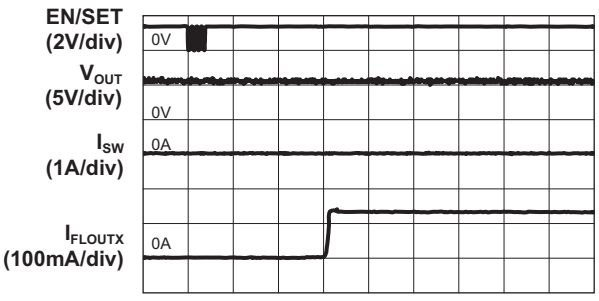
Time (200ns/div)

Movie Mode Transition Characteristic
(I_{FLOUTX} = 137mA/Ch to 27.4mA/Ch; SuperCap [5.5V, 0.55F])



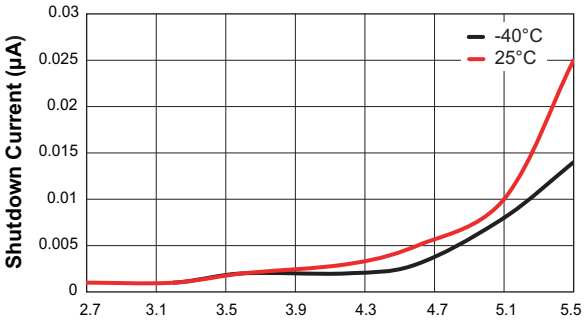
Time (100µs/div)

Movie Mode Turn On Characteristic
(I_{FLOUTX} = 137mA/Ch; V_{IN} = 3.6V; SuperCap [5.5V, 0.55F])

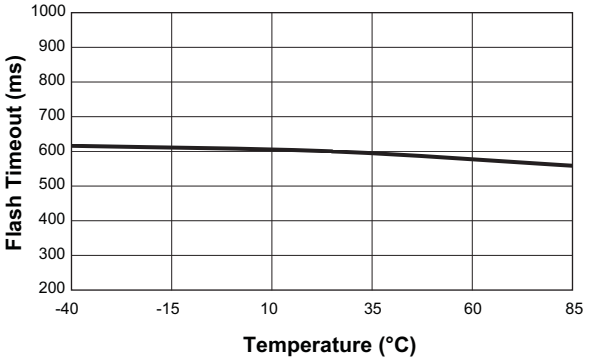


Time (100µs/div)

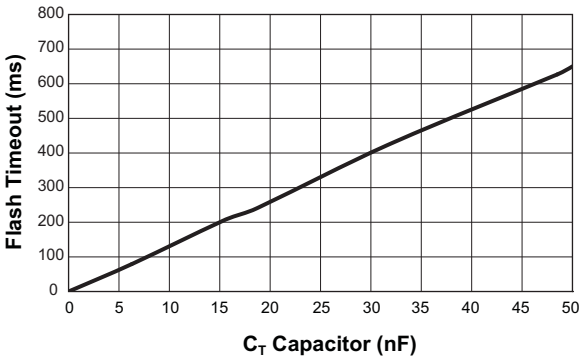
Shutdown Current vs. Input Voltage
(V_{EN} = V_{FLEN} = GND = AGND = FLGND)



Flash Timeout vs. Temperature
(V_{IN} = 3.6V; C_T = 47nF; I_{FLOUTX} = 1A/Ch)

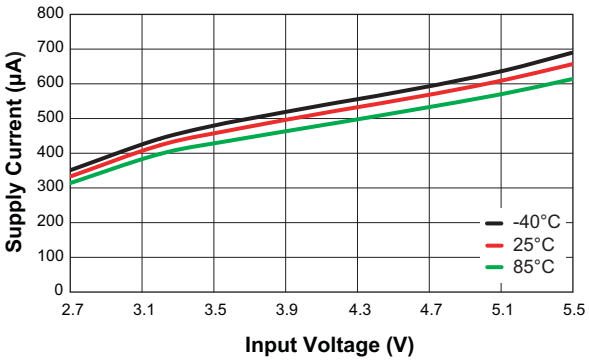


Flash Timeout vs. C_T Capacitor
(I_{FLOUTX} = 1A/Ch; SuperCap [5.5V, 0.55F])

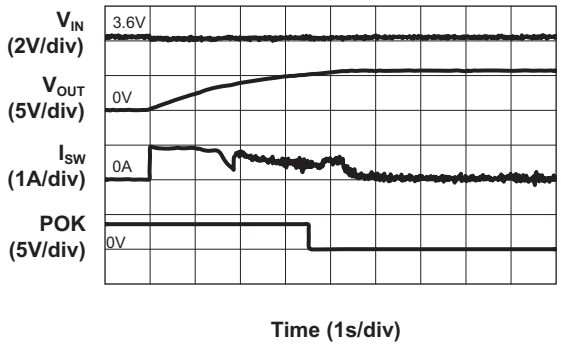


Typical Characteristics

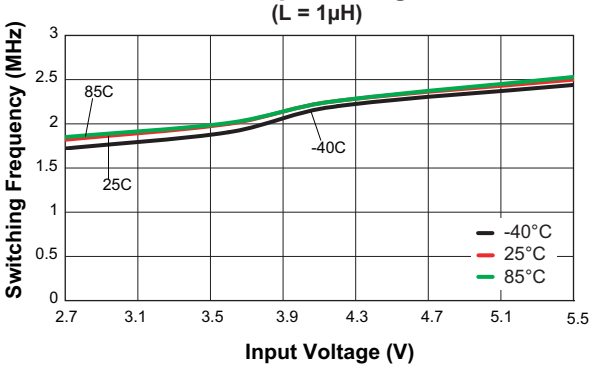
Supply Current vs. Input Voltage
(V_{EN} = 3.6V; V_{FLEN} = FLGND)



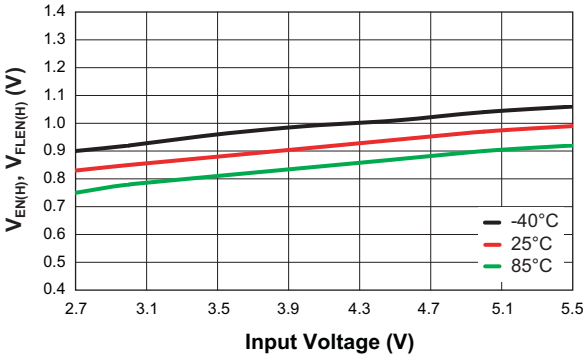
Super Capacitor Charging Characteristic
(I_{FLOUTX} = 1A/Ch; C_{OUT} = 0.55F; V_{IN} = 3.6V)



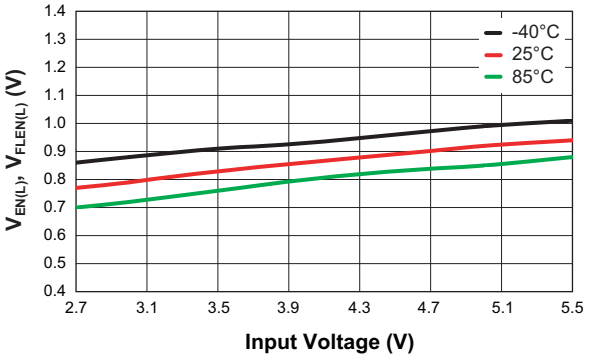
Movie Mode Switching Frequency vs. Input Voltage
(L = 1µH)



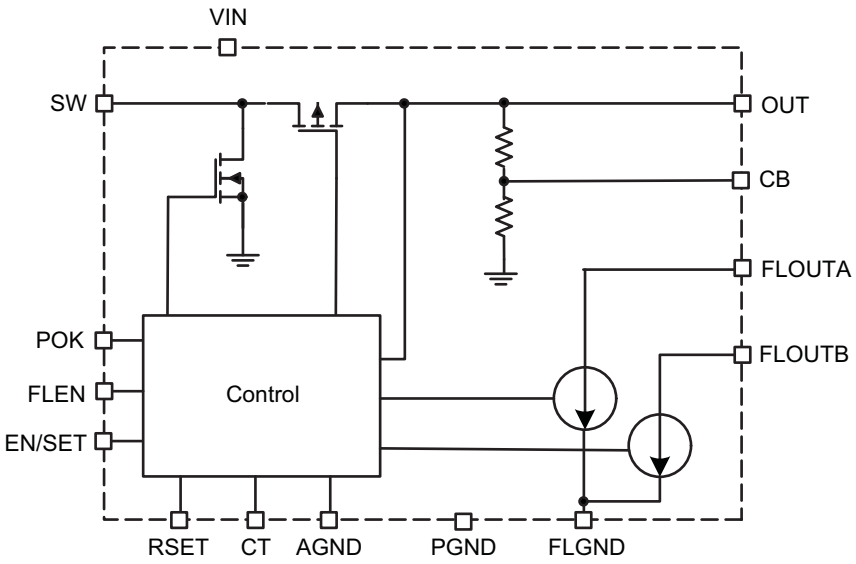
EN, FLEN High Threshold Voltage vs. Input Voltage



EN, FLEN Low Threshold Voltage vs. Input Voltage



Functional Block Diagram



Functional Description

The AAT1281 is a high power, 2A Flash LED driver. This device utilizes a highly efficient inductive step-up converter to achieve the desired output voltage (Super Capacitor voltage, 5.5V). The current of two output channels are regulated evenly and discharged from the output Super Capacitor, mainly for camera flash applications. The maximum flash current is set by an external resistor, R_{SET}, which also sets the maximum movie-mode current. The maximum movie-mode current is equal to the maximum programmed flash current reduced by the flash-to-movie-mode ratio with the default value set to 1:7.3. A flash pulse is initiated by strobing the FLEN input pin low-to-high, which initiates a flash pulse and also starts the internal safety timer. The maximum flash time is determined by an external timing capacitor connected to the CT pin. The flash duration can be set from 50ms up to a maximum of 1s. The flash timer will terminate the flash current regardless of the status of the FLEN pin. This can be either used as a simple flash timing pulse or can be used as a safety timer in the event of a control logic malfunction to prevent the LEDs from over-heating.

If the safety timer is not needed in the application, it can be disabled by connecting the CT pin directly to AGND. Further adjustments to the timeout period can be obtained by programming through the AS²Cwire interface.

When the AAT1281 is enabled, the step-up convertor operates at 2MHz switching and charged up the Super Capacitor to 5.5V in seconds. As soon as the Super Capacitor reaches 5.5V, the AAT1281 automatically changes to light load mode operation to maintain output regulation at light load or no load condition. This is discontinuous mode operation, and is normal behavior for a switching regulator. At this point, the LEDs are ready to be flashed.

During the flash, the boost engine is shut down, and the two LEDs connected to its corresponding current channel (FLOUTA or FLOUTB) share the output current supplied by the Super Capacitor equally. (The duration of the flash will be further discussed in the Applications Information section of this datasheet.) In applications where only one LED is connected to either FLOUTA or FLOUTB, the unused current channel must be directly connected to OUT, thereby disabling that channel. For the single ultra bright LED application which requires doubling the flash current, the two current channels can be connected together which allow this ultra bright single LED getting the full output current (please check with the LED specification from LED suppliers).

During movie mode operation, the safety timer is disabled. Enabling the output channels (FLOUTA and FLOUTB can be enabled or disabled individually or together) and the flash-to-movie-mode current ratio can be set using the AAT1281's AS²Cwire interface. The movie mode current level can be adjusted in 16 steps using a logarithmic scale. The maximum flash safety timer can be externally set by C_T, and the timer can be programmed from the maximum value in 16 linear steps through the AS²Cwire interface. The FLEN signal takes priority over movie mode operation.

To reduce the system component count, also included in the AAT1281 are the charge balancing resistors required to ensure that the two serially connected Super Capacitors (required due to the low capacitor breakdown voltage of one cell). As the Super Capacitor requires some time to fully charge, a POK output is included to inform the system that the AAT1281 is "Ready to Flash."

Over-Temperature Protection

Thermal protection disables the AAT1281 when internal power dissipation becomes excessive, as it disables both MOSFETs. The junction over-temperature threshold is 140°C with 15°C of temperature hysteresis. The output voltage automatically recovers when the over-temperature fault condition is removed.

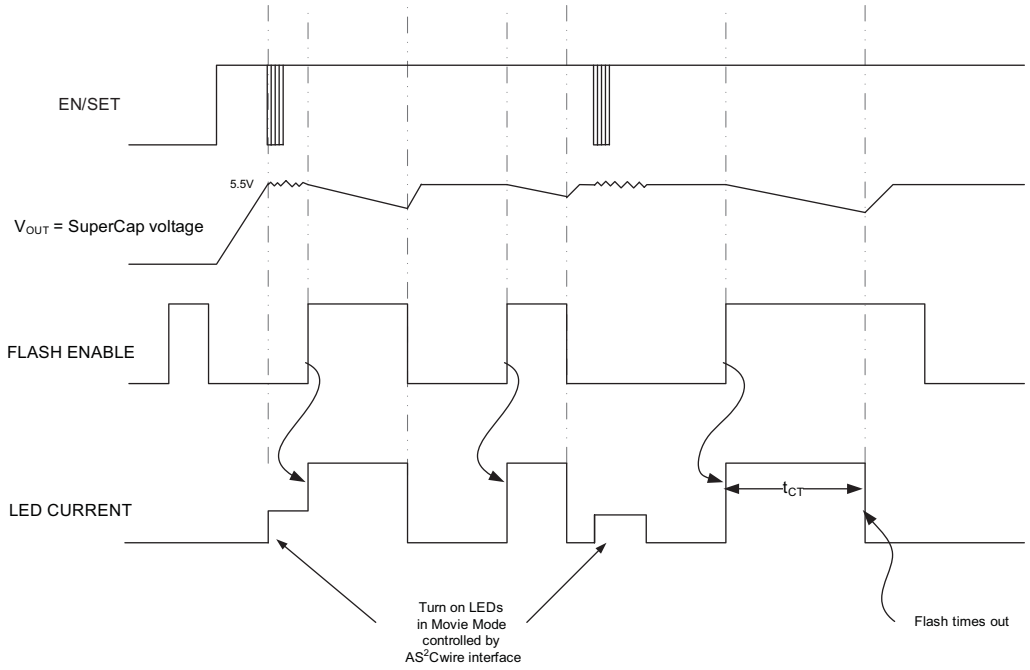
Over-Voltage Protection (Open LED, Open Super Capacitor)

The AAT1281's output voltage is limited by internal over-voltage protection circuitry, which prevents damage to the AAT1281 from an open super capacitor condition. During this condition, the output voltage rises and reaches 5.5V (typical), preventing the output voltage from rising higher. Once the open super capacitor condition is removed, charging of the super capacitor will resume. The controller will return to normal operation and maintain an average output voltage. If one LED channel accidently becomes open, the remaining LED channel of AAT1281 will still function, but may not be regulated to the desired current.

Device Startup and Shutdown

The AAT1281 is put into operation when EN/SET is set high. It is put into a shutdown mode when EN/SET is set to GND. In shutdown mode, the AAT1281 draws less than 1µA from the battery. All data and register contents are cleared (reset to the default value) during shutdown. During startup of this LED driver, the peak current is limited in order to avoid high peak current drawn from the battery.

Operating Diagram



Application Information

LED Selection

The AAT1281 is specifically designed to drive ultra bright flash LEDs with typical forward voltage of 2.5V to 4.0V within 1A forward current. Since the FLOUTA and FLOUTB pins have internal current-mirror circuitry which matches both channels with tight accuracy up to 1A per channel; the LED-to-LED brightness will be matched regardless of the individual LED forward voltage (V_F). Circuit designers should consult the LED supplier for LED specifications.

Flash Mode LED Current

The LED current is controlled by the RSET resistor. For maximum accuracy, a 1% tolerance resistor is recommended. FLOUTA and FLOUTB can be programmed up to a maximum total flash current of 2000mA or up to 1000mA per channel. FLOUTA and FLOUTB output current is matched across the programming range. A flash event is initiated by asserting the FLEN pin. A flash event is automatically terminated when FLEN is disabled or if the safety timer terminates before the FLEN pin is disabled. The maximum flash current in each FLOUTA and FLOUTB is set by the RSET resistor and can be calculated using the following equation:

$$I_{FLOUTA} = I_{FLOUTB} = \frac{81k\Omega \cdot A}{R_{SET}} = \frac{81k\Omega \cdot A}{80.6k\Omega} = \sim 1000mA \text{ per channel}$$

To prevent excessive power dissipation during higher flash current operation, R_{SET} values smaller than 80.6kΩ are not recommended. Since the super capacitor is the only source for the LED flash current, the duration of the flash is determined by the energy stored in the super capacitor. During flash, the energy of the super capacitor is discharged; at the same time, the voltage of the super capacitor is decreased. Once the super capacitor voltage is lowered to a level (the minimum sink pin voltage + the LED forward voltage), the flash is ended. With a fully charged super capacitor in place, the flash for two 1A LEDs can last for more than 500ms.

Movie Mode LED Current

The maximum movie-mode current level is set by the maximum, programmed flash current minus the programmed flash-to-movie-mode ratio in which the default value is 7.3:

$$I_{MOVIE\text{-}MODE[A/B]} = \frac{I_{FLOUT[A/B](MAX)}}{7.3} = \frac{1000mA}{7.3} = 137mA$$

To change the configuration or the settings, the AAT1281 can be programmed via the AS²Cwire interface.

Triggering FLEN low to high will enable a flash event with the maximum flash current set by the R_{SET} resistor or with programmed flash current set via the AS²Cwire interface. Concurrently, the flash timer is also initiated. All data and register contents are cleared (reset to the default value) after each flash event.

Flash Safety Timeout

The AAT1281 includes a timer circuit that enables the flash current for a programmed period of time. This feature eliminates the need for an external, housekeeping baseband controller to contain a safety delay routine. It also serves as a protection feature to minimize thermal issues with the flash LEDs in the event an external controller's flash software routine experiences hang-up or freeze. The flash safety timeout, T can be calculated by the following equation:

$$T = 13.5s/\mu F \bullet C_T$$

Where T is in seconds and C_T is the capacitance of the timer capacitor in µF.

For example, using a 47nF capacitor for C_T sets the flash timeout to:

$$\text{Flash Safety Timeout} = 13.5s/\mu F \bullet 0.047\mu F = 634ms$$

The relationship between the flash safety timeout and the capacitance of the timer capacitor is illustrated in Figure 1.

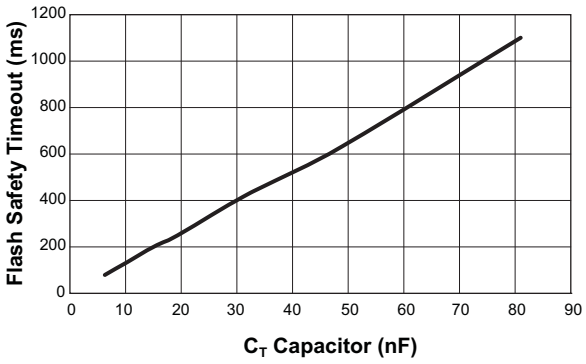


Figure 1: Flash Safety Timeout vs. Timer Capacitor.

AS²Cwire Serial Interface

Both current sinks on the AAT1281 are controlled by the Advanced Simple Serial Control (AS²Cwire). AS²Cwire relies on the number of rising edges of the EN/SET pin to address and load the registers. AS²Cwire latches data or address after the EN/SET pin has been held high for time T_{LAT}. Address or data is differentiated by the number of EN/SET rising edges. Since the data registers are 4 bits each, the differentiating number of pulses is 2^4 or 16, so that address 0 is signified by 17 rising edges, address 1 by 18 rising edges, address 2 by 19 rising edges, and so on. Data is set to any number of rising edges between 1 and including 16. A typical write protocol is a burst of EN/SET rising edges, signifying a particular address, followed by a pause with EN/SET held high for the T_{LAT} timeout period, a burst of rising edges signifying data, and a T_{LAT} timeout for the data registers. Once an address is set, then multiple writes to the corresponding data register are allowed. Address 0 is the default address on the first rising edge after the AAT1281 has been disabled.

When EN/SET is held low for an amount of time greater than T_{OFF}, the AAT1281 enters shutdown mode and draws less than 1µA from V_{IN}. Data and Address registers are reset to 0 during shutdown.

AS²Cwire addressing allows the control of the flash output current, the safety timer timeout, independent control of the A and B current sources and the ratio of the Movie Mode current to the Flash current.

If no programming takes place prior to a Flash EN signal, and the device is enabled, the registers will default to the values shown in the tables below. In the event that the clock data continues for fewer than 17 pulses, then the movie mode current will be programmed.

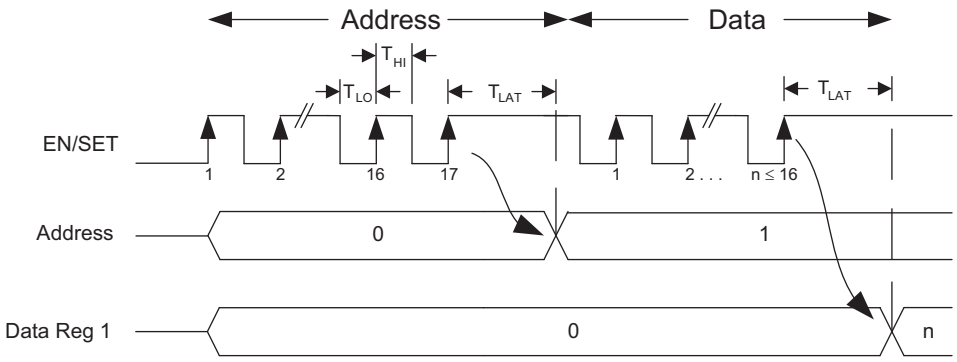


Figure 2: AS²Cwire Serial Interface Timing.

AS²C Serial Addressing

Movie Mode Current – Address 0

The AAT1281's movie mode current settings are controlled using the AS²Cwire interface. Movie mode current has a maximum value of 50% of the flash current. The maximum movie mode current is set by Address register 3 (discussed below). The default ratio between the flash current level and maximum movie mode current level is 1:7.3. The FLOUTA/FLOUTB movie mode current can be adjusted in logarithmic fashion to one of 16 steps represented as a fraction of the maximum movie mode current in Table 1. To adjust the movie mode current the user must first access Address 0 before writing the data to set the MM Current value.

Data	Percentage of Maximum MM Current
1*	100%
2	89%
3	79%
4	71%
5	63%
6	56%
7	50%
8	45%
9	40%
10	36%
11	32%
12	28%
13	25%
14	22%
15	20%
16	0%

Table 1: Address 0, Movie Mode Current Programming.

Flash/Safety Timer – Address 1

A timer function that enables the flash current sinks for a programmed amount of time is incorporated in the AAT1281. The on-time is programmed by loading the Timing Register at address 1 with a value from 1 to 16 and by choosing a value for the external timing capacitor, C_T (see Table 2).

Data	Ratio of MM Timeout
1*	16/16
2	15/16
3	14/16
4	13/16
5	12/16
6	11/16
7	10/16
8	9/16
9	8/16
10	7/16
11	6/16
12	5/16
13	4/16
14	3/16
15	2/16
16	1/16

Table 2: Address 1, Flash Safety Timer Programming; Maximum Value Programmed by C_T.

Output Enable Control – Address 2

In the case where two LEDs are used, each output can be enabled or disabled independently in movie mode as shown in Table 3. To enable or disable either or both FLOUTA and FLOUTB, a write instruction to Address 2 is applied to the AAT1281's EN/SET pin. If no write instruction is applied, the default value for Address 2 is FLOUTA, FLOUTB = OFF. During a flash event, both FLOUTA and FLOUTB will be enabled regardless of the movie-mode setting.

Data	Selection	
	FLOUTA	FLOUTB
1*	OFF	OFF
2	OFF**	ON
3	ON	OFF**
4	ON	ON

Table 3: Address 2, Movie Mode Output Configuration.

* Denotes the default value.
** A small current will flow due to the start-up test current.

Flash to Maximum Movie Mode Current Ratio – Address 3

The maximum movie-mode current is a fixed ratio of the flash current controlled by Address 3. The ratio may be varied from 1:2 to OFF in 16 linear steps as shown in Table 4. The default value for Address 3 is Data=4 and represents a flash to maximum movie mode current level of 1 to 7.3.

Data	FL to MM Ratio
1	1/2
2	1/3.8
3	1/5.5
4*	1/7.3
5	1/8.9
6	1/10.5
7	1/12.2
8	1/13.8
9	1/14.9
10	1/16.5
11	1/18
12	1/19.6
13	1/21.1
14	1/22.6
15	1/24
16	OFF

Table 4: Address 3, Flash/Movie Mode Current Ratio.

Selecting the Boost Inductor

The AAT1281 controller utilizes PWM control and the switching frequency is fixed. To maintain 2MHz maximum switching frequency and stable operation, a 1µH inductor is recommended. Manufacturer's specifications list both the inductor DC current rating, which is a thermal limitation, and peak inductor current rating, which is determined by the saturation characteristics. Measurements at full load and high ambient temperature should be performed to ensure that the inductor does not saturate or exhibit excessive temperature rise. The inductor (L) is selected to avoid saturation at minimum input voltage and maximum output load conditions. Worst-case peak current occurs at minimum input voltage (maximum duty cycle) and maximum load. Bench measurements are recommended to confirm actual I_{PEAK} and to ensure that the inductor does not saturate at maximum LED current and minimum input supply voltage.

The RMS current flowing through the boost inductor is equal to the DC plus AC ripple components. Under worst case RMS conditions, the current waveform is critically continuous. The resulting RMS calculation yields worst case inductor loss. The RMS current value should be compared against the inductor manufacturer's temperature rise, or thermal derating guidelines:

$$I_{RMS} = \frac{I_{PEAK}}{\sqrt{3}}$$

For a given inductor type, smaller inductor size leads to an increase in DCR winding resistance and, in most cases, increased thermal impedance. Winding resistance degrades boost converter efficiency and increases the inductor's operating temperature:

$$P_{LOSS(INDUCTOR)} = I^2_{RMS} \bullet DCR$$

Manufacturer	Part Number	Inductance (µH)	Saturated Rated Current (A)	DCR (mΩ)	Size (mm) LxWxH	Type
Cooper Bussmann	SD3812-1R0-R	1	2.69	48	4.0 x 4.0 x 1.2	Shielded Drum Core
Cooper Bussmann	SDH3812-1R0-R	1	3	45	3.8 x 3.8 x 1.2	Shielded Drum Core
Cooper Bussmann	SD10-1R0-R	1	2.25	44.8	5.2 x 5.2 x 1.0	Shielded Drum Core
Sumida	CDH38D11/S	1	2.69	48	4.0 x 4.0 x 1.2	Shielded Drum Core
Coilcraft	LPS4012-102NLC	1	2.5	60	4.1 x 4.1 x 1.2	Shielded Drum Core

Table 5: Typical Suggested Surface Mount Inductors.

* Denotes the default value.

Selecting the Boost Capacitors

In general, it is good design practice to place a decoupling capacitor (input capacitor) between the IN and GND pins. An input capacitor in the range of 2.2µF to 10µF is recommended. A larger input capacitor in this application may be required for stability, transient response, and/or ripple performance. The high output ripple inherent in the boost converter necessitates the use of low impedance output filtering. Multi-layer ceramic (MLC) capacitors provide small size and adequate capacitance, low parasitic equivalent series resistance (ESR) and equivalent series inductance (ESL), and are well suited for use with the AAT1281 boost regulator. MLC capacitors of type X7R or X5R are recommended to ensure good capacitance stability over the full operating temperature range. The output capacitor is selected to maintain the output load without significant voltage droop (ΔV_{OUT}) during the power switch ON interval. A 2.2µF ceramic output capacitor is recommended (see Table 6). Typically, 6.3V or 10V rated capacitors are required for this flash LED boost output. Ceramic capacitors selected as small as 0603 are available which meet these requirements. MLC capacitors exhibit significant capacitance reduction with applied voltage. Output ripple measurements should confirm that output voltage droop and operating stability are within acceptable limits. Voltage derating can minimize this factor, but results may vary with package size and among specific manufacturers. To maintain stable operation at full load, the output capacitor should be selected to maintain ΔV_{OUT} between 100mV and 200mV. The boost converter input current flows during both ON and OFF switching intervals. The input ripple current is less than the output ripple and, as a result, less input capacitance is required.

Super Capacitor

The AAT1281 requires a super capacitor connected to the output and the LEDs. After the super capacitor is fully charged, sufficient energy is stored and ready to provide large power surges such as flash peak current. When selecting a super capacitor, it is highly recommended to select a capacitor with an operating voltage of 5.5V and 550mF DC capacitance for the best results in AAT1281 camera flash applications. Low profile, low impedance (low ESR), and a wide environmental operating range (-40°C to +85°C) should also be considered when selecting a capacitor for portable power management systems. Please contact the super capacitor manufacturer for detailed information.

PCB Layout Guidelines

Boost converter performance can be adversely affected by poor layout. Possible impact includes high input and output voltage ripple, poor EMI performance, and reduced operating efficiency. Every attempt should be made to optimize the layout in order to minimize parasitic PCB effects (stray resistance, capacitance, and inductance) and EMI coupling from the high frequency SW node. A suggested PCB layout for the AAT1281 High Power 2A Flash LED Driver is shown in Figures 5 and 6. The following PCB layout guidelines should be considered:

1. Minimize the distance from capacitor C_{IN} and C_{OUT}'s negative terminals to the PGND pins. This is especially true with output capacitor C_{OUT}, which conducts high ripple current from the output to the PGND pins.
2. Minimize the distance between IN and switching pin SW; minimize the size of the PCB area connected to the SW pin.
3. Maintain a ground plane and connect to the IC PGND pin(s) as well as the PGND connections of C_{IN} and C_{OUT}.
4. Consider additional PCB exposed area for the flash LEDs to maximize heatsinking capability. This may be necessary when using high current application and long flash duration application.
5. Connect the exposed paddle (bottom of the die) to either PGND or GND. Connect AGND, FLGND to GND as close as possible to the package.

Manufacturer	Part Number	Capacitance (µF)	Voltage Rating (V)	Temp Co.	Case Size
Murata	GRM185R60J225KE26	2.2	6.3	X5R	0603
Murata	GRM188R71A225KE15	2.2	10	X7R	0603
Murata	GRM21BR70J225KA01	2.2	6.3	X7R	0805
Murata	GRM21BR71A225KA01	2.2	10	X7R	0805
Murata	GRM219R61A475KE19	4.7	10	X5R	0805
Murata	GRM21BR71A106KE51	10	10	X7R	0805

Table 6: Typical Suggested Surface Mount Capacitors.

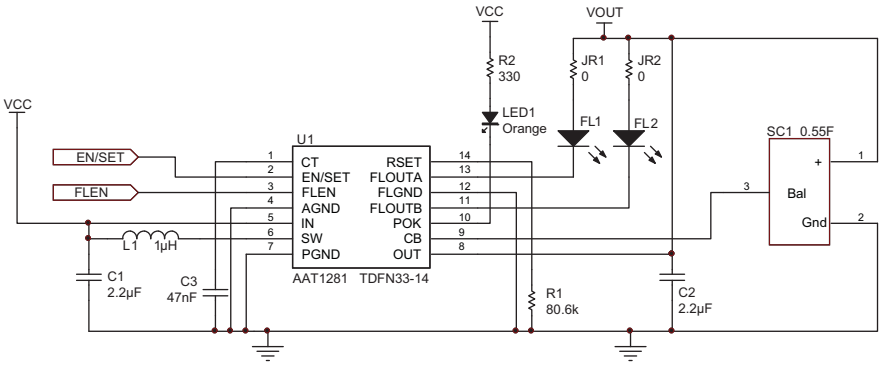


Figure 3: AAT1281 Evaluation Board Schematic.

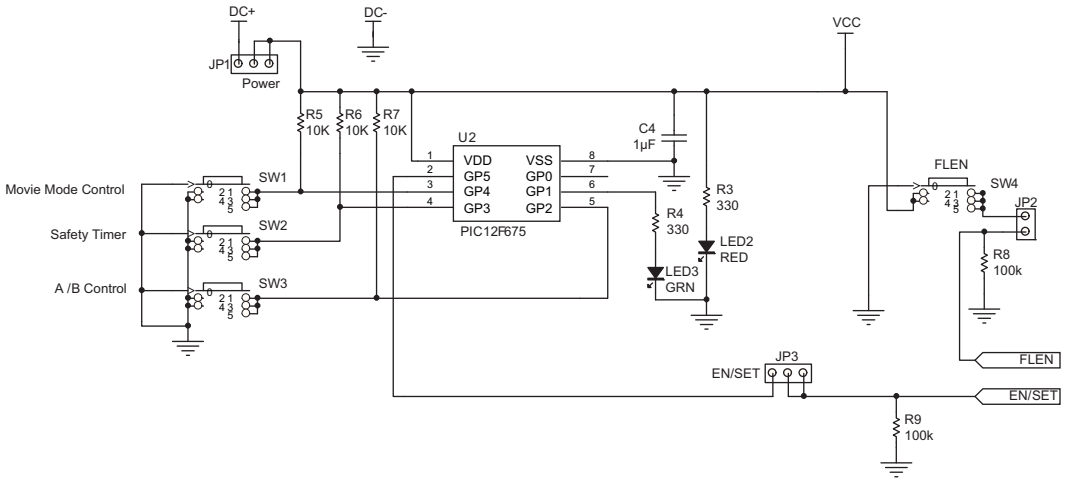


Figure 4: AAT1281 Evaluation Board MCU Section Schematic.

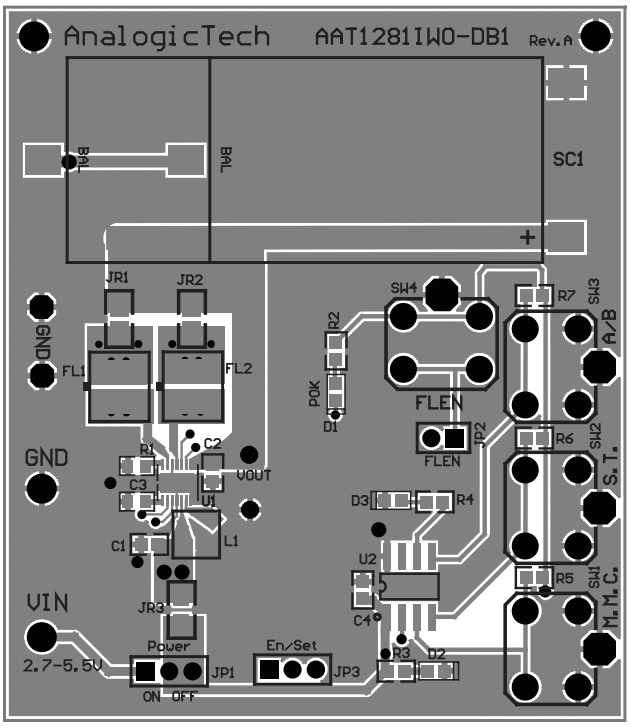


Figure 5: AAT1281 Evaluation Board Top Side Layout.

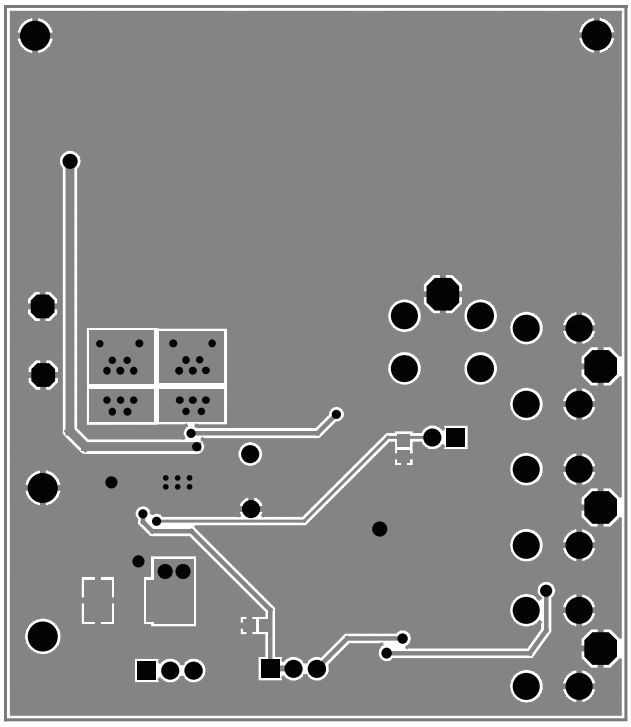


Figure 6: AAT1281 Evaluation Board Bottom Side Layout.

Component	Part Number	Description	Manufacturer
U1	AAT1281IWO	High Power 2A Flash Driver; TDFN33-14 package	AnalogicTech
U2	PIC12F675	8-bit CMOS, FLASH-based µC; 8-pin SOIC package	Microchip
SW1 – SW4	PTS645TL50	Switch Tact, SPST, 5mm	ITT Industries
R1	Chip Resistor	80.6kΩ, 1%, 1/4W; 0402	Vishay
R8, R9	Chip Resistor	100kΩ, 1%, 1/4W; 0603	Vishay
R5, R6, R7,	Chip Resistor	10kΩ, 5%, 1/4W; 0603	Vishay
R2, R3, R4	Chip Resistor	330Ω, 5%, 1/4W; 0603	Vishay
JR1, JR2, JR3	Chip Resistor	0Ω, 5%	Vishay
C1, C2	GRM188R71A225KE15	2.2µF, 10V, X7R, 0603	MuRata
C3	GRM155R71A473KA01	47nF, 10V, X7R, 0402	MuRata
C4	GRM185R61A105KE36	1uF, 10V, X5R, 0603	MuRata
L1	SD3812-1R0-R	Drum Core, 1µH, 2.69A, 48mΩ	Cooper Bussmann
FL1-FL2	*	White Flash LED	*
D1	LTST-C190EKT	Red Orange LED; 0603	Lite-On Inc.
D2	LTST-C190CKT	Red LED; 0603	Lite-On Inc.
D3	LTST-C190GKT	Green LED; 0603	Lite-On Inc.
SC1	**	5.5V, 0.55F, Low ESR	**
JP1, JP2, JP3	PRPN401PAEN	Conn. Header, 2mm zip	Sullins Electronics

Table 7: AAT1281 Evaluation Board Bill of Materials.

* Seoul Semiconductor FCW401ZD, Lumileds LXCL-PWM1 or LXCL-PWF4, or OSRAM LW F65G based on availability from the manufacturer.
** CAP-XX HS206F or TDK EDLC152344-551-2F-30 supercap based on availability from the manufacturer.

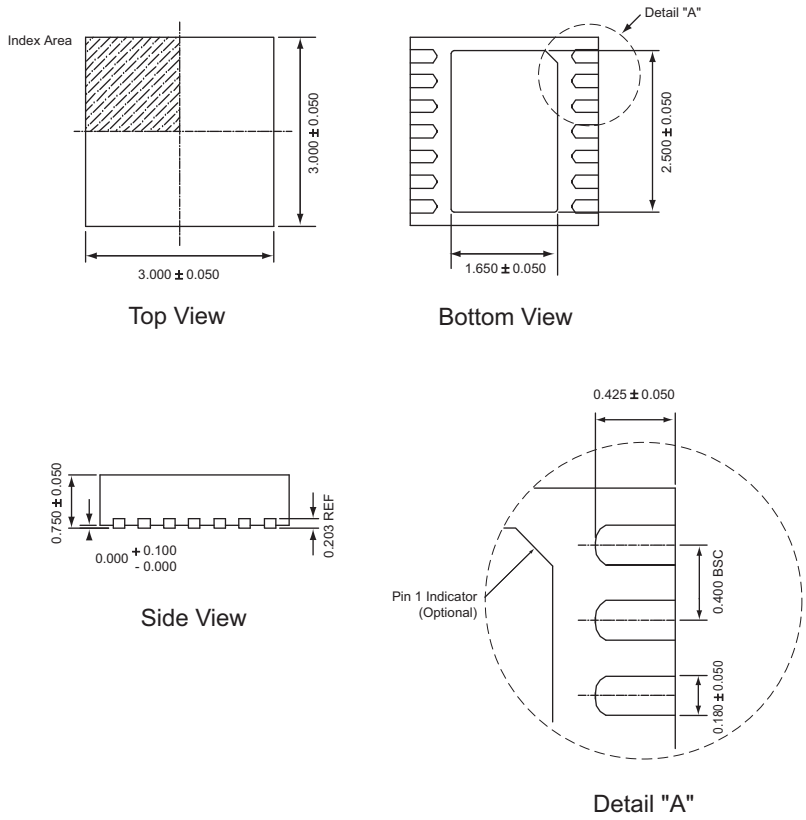
Ordering Information

Package	Marking[1]	Part Number (Tape and Reel)[2]
TDFN33-14	3HXXY	**AAT1281IWO-T1**

All AnalogicTech products are offered in Pb-free packaging. The term "Pb-free" means semiconductor products that are in compliance with current RoHS standards, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. For more information, please visit our website at http://www.analogictech.com/about/quality.aspx.

Package Information

TDFN33-14[3]



1. XYY = assembly and date code.
2. Sample stock is generally held on part numbers listed in **BOLD**.
3. The leadless package family, which includes QFN, TQFN, DFN, TDFN and STDFN, has exposed copper (unplated) at the end of the lead terminals due to the manufacturing process. A solder fillet at the exposed copper edge cannot be guaranteed and is not required to ensure a proper bottom solder connection.

Advanced Analogic Technologies, Inc.
3230 Scott Boulevard, Santa Clara, CA 95054
Phone (408) 737-4600
Fax (408) 737-4611