ChargePump™

General Description

The AAT2807A is a member of AnalogicTech's Total Power Management IC™ product family. It is a dual charge pump designed to support both white LED backlight and flash applications for systems operating with Lithium-Ion batteries. The backlight charge pump is capable of driving up to three LEDs at a total of 60mA. The current sinks may be operated individually or in parallel for driving higher current LEDs. To maximize power efficiency, the charge pump operates in 1X, 1.5X, or 2X mode, where the mode of operation is automatically selected by comparing the forward voltage of each LED with the input voltage. AnalogicTech's S²Cwire™ (Simple Serial Control™) serial digital input is used to enable, disable, and set current for each LED with eight settings. The charge pump consumes extremely low current internally (80µA typical) at light load for optimized efficiency.

The flash charge pump is a charge pump doubler with a regulated output voltage. It is designed to deliver 150mA of continuous current and up to 300mA of pulsed current. It has an independent enable pin for improved power savings.

Built-in soft-start circuitry prevents excessive inrush current during start-up. In shutdown mode, the device disconnects the load from V_{IN} and consumes less than 1µA.

The AAT2807A is available in a space-saving, thermally-enhanced 16-pin 4x4mm DFN package and is rated over the -40°C to +85°C temperature range.

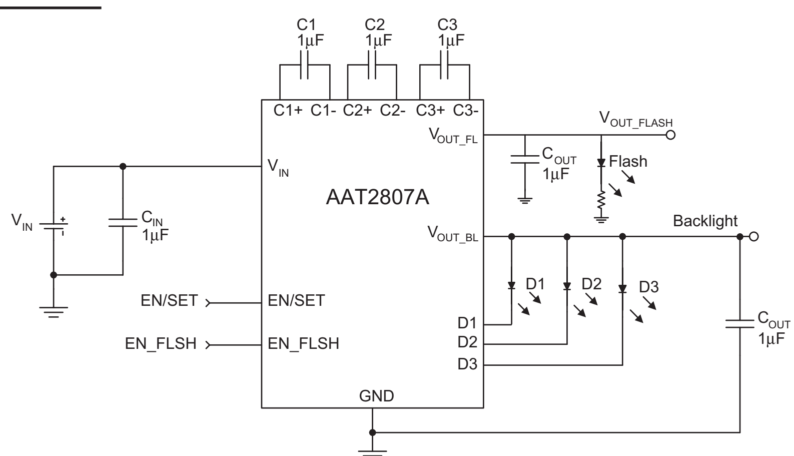
Features

- V_{IN} Range: 2.7V to 5.5V
- Dual Charge Pump to Support Backlight and Flash LEDs
- Backlight Charge Pump:
  - Regulated Current
  - Three Current Sink Inputs
  - Brightness Control via Single GPIO
  - Tri-Mode Charge Pump
  - 20mA of Current Per Input Current Sink
- Flash Charge Pump:
  - Regulated Output Voltage
  - 300mA of Pulsed Current
- Independent Enable Pins
- Low Noise Constant Frequency Operation
- 1MHz Switching Frequency
- Automatic Soft Start
- No Inductors
- Available in DFN44-16 Package

Applications

- Color (RGB) Lighting
- White LED Backlighting
- White LED Photo Flash

Typical Application

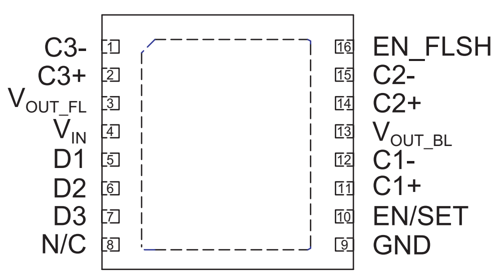


Pin Descriptions

Pin #	Symbol	Function
1	C3-	Flying capacitor 3 positive terminal. Connect a 1µF capacitor between C1+ and C1-.
2	C3+	Flying capacitor 3 negative terminal.
3	V_{OUT_FL}	Regulated output voltage for flash LED. Requires 1µF capacitor connected between this pin and ground.
4	V_{IN}	Input power supply. Requires 1µF capacitor connected between this pin and ground.
5	D1	Current sink input 1.
6	D2	Current sink input 2.
7	D3	Current sink input 3.
8	N/C	Not internally connected.
9	GND	Ground.
10	EN/SET	S^2Cwire serial interface control pin. It is used to enable/disable the backlight charge pump and to control the brightness of the white LEDs.
11	C1+	Flying capacitor 1 + terminal. Connect a 1µF capacitor between C1+ and C1-.
12	C1-	Flying capacitor 1 - terminal.
13	V_{OUT_BL}	Charge pump output for backlight. Requires 1µF capacitor connected between this pin and ground.
14	C2+	Flying capacitor 2 + terminal. Connect a 1µF capacitor between C1+ and C1-.
15	C2-	Flying capacitor 2 - terminal.
16	EN_FLSH	Enable/disable pin for the flash charge pump.
EP		Exposed paddle (bottom); connect to GND directly beneath package.

Pin Configuration

DFN44-16
(Top View)



Absolute Maximum Ratings[1]

Symbol	Description	Value	Units
V_{IN}	Input Voltage	-0.3 to 6.0	V
$V_{EN/SET}$; EN_FL	EN/SET; EN_FL to GND Voltage	-0.3 to V_{IN} + 0.3	V
T_{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	300	°C

Note 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.

Thermal Information

Symbol	Description	Value	Units
P_D	Maximum Power Dissipation[1, 2]	2.0	W
θ_{JA}	Maximum Thermal Resistance[1]	50	°C/W

Notes:
1. Mounted on an FR4 board.
2. Derate 6.25mW/°C above 25°C.

Electrical Characteristics[1]

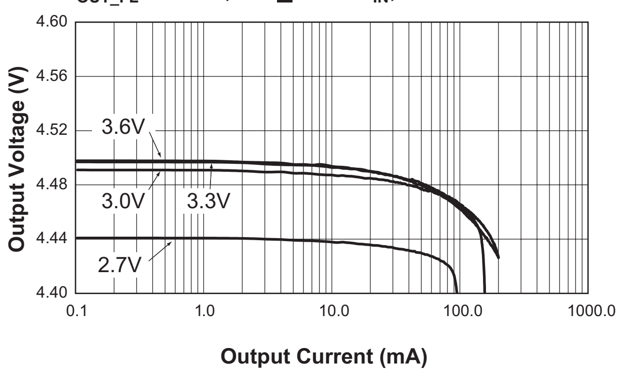
V_{IN} = 3.5V; $C_{IN} = C_{OUT} = C_1 = C_2 = C_3$ = 1.0µF; T_A = -40°C to 85°C, unless otherwise noted. Typical values are at T_A = 25°C.

Symbol	Description	Conditions	Min	Typ	Max	Units
Input Power Supply						
V_{IN}	Operation Range		2.7		5.5	V
I_{CC}	Operating Current	1X Mode, 3.0 ≤ V_{IN} ≤ 5.5, Active, No Load Current; EN_FLSH = GND, EN/SET = V_{IN}		0.3	1	mA
		1.5X Mode, 3.0 ≤ V_{IN} ≤ 5.5, Active, No Load Current; EN_FLSH = GND, EN/SET = V_{IN}		1.0	3.0	
		2X Mode, 3.0 ≤ V_{IN} ≤ 5.5, Active, No Load Current; EN_FLSH = GND, EN/SET = V_{IN}		1.0	3.0	
		3.0 ≤ V_{IN} ≤ 5.5, No Load Current; EN_FLSH = V_{IN}, EN/SET= GND		2.0	4.5	
I_{SHDN}	Shutdown Current	EN_FLSH = EN/SET=0			1.0	µA
I_{DX}	Input Current Accuracy [2, 4]	I_{SET} = 20mA; T_A = 25°C	-12		12	%
$I_{(D-Match)}$	Current Matching Between Any Two Current Sink Inputs [2,5]	VD1:D3 = 3.6, V_{IN} = 3.5V		0.5		%
R_{SINK}	Sink Switch Impedance (each) [2]			7		Ω
V_{OUT_FL}	Flash Charge Pump Output Voltage	3.0V < V_{IN} < 5V, I_{OUT} = 100mA; EN_FLSH = V_{IN}	4.3	4.5	4.8	V
I_{DX_FLSH}	Continuous Maximum Output Current Flash Charge Pump [3]	EN_FLSH = V_{IN}	150			mA
	Pulsed Maximum Output Current Flash Charge Pump [3]	T_{PULSE} = 250ms; V_{IN} = 3.6V; EN_FLSH = V_{IN}		300		
η_{CP}	Charge Pump Section Efficiency	V_{IN} = 3.5V, $I_{OUT(TOTAL)}$ = 120mA, Measured from IN to CP		93		%
T_{SS}	Soft-Start Time			100		µs
F_{CLK}	Clock Frequency			1.0		MHz
$V_{EN(L)}$	Enable Threshold Low				0.4	V
$V_{EN(H)}$	Enable Threshold High		1.4			V
$T_{EN/SET\ LO}$	EN/SET Low Time	$V_{EN/SET}$ < 0.6V	0.3		75	µs
$T_{EN/SET\ HI}$	Minimum EN/SET High Time	$V_{EN/SET}$> 1.4V		50		ns
T_{OFF}	EN/SET Off Timeout	$V_{EN/SET}$< 0.6V			500	µs
T_{LAT}	EN/SET Latch Timeout	$V_{EN/SET}$> 1.4V			500	µs
I_I	Enable and EN/SET Input Leakage	$V_{EN/SET}$= V_{EN_FLSH} = V_{IN}	-1.0		1.0	µA

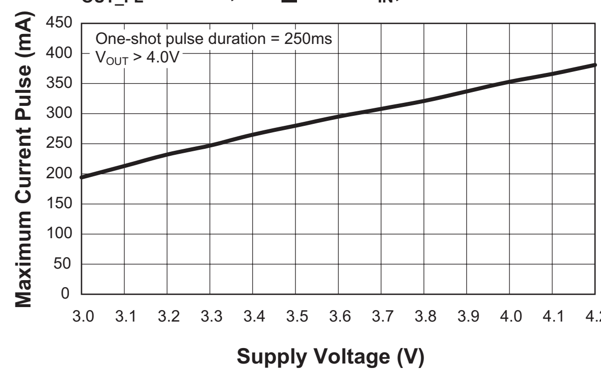
Notes:
1. The AAT2807A is guaranteed to meet performance specifications over the -40°C to 85°C operating temperature range and is assured by design, characterization, and correlation with statistical process controls.
2. Specification applies only to the tri-mode charge pump.
3. Specification applies only to the charge pump doubler.
4. Determined by the sum of all active channels.
5. Current matching is defined as the deviation of any sink current from the average of all active channels.

Typical Characteristics

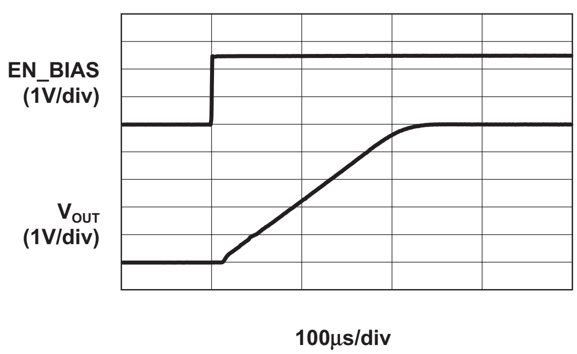
Output Voltage vs. Output Current
V_{OUT_FL} = 4.5V; EN_FL = V_{IN}; EN/SET = GND



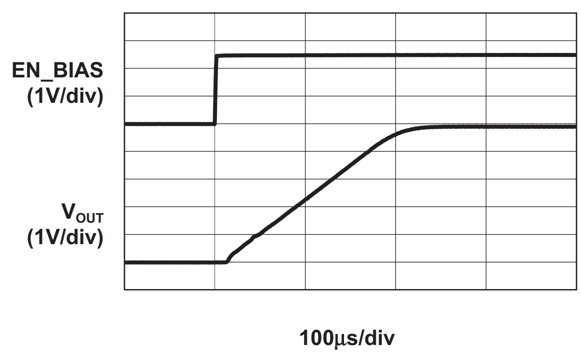
Maximum Current Pulse vs. Supply Voltage
V_{OUT_FL} = 4.5V; EN_FL = V_{IN}; EN/SET = GND



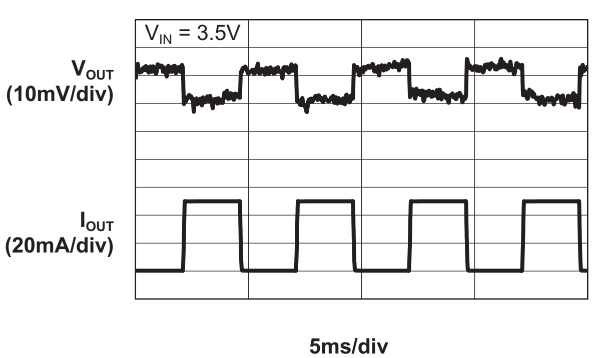
Startup Time with 50mA Load
Flash Charge Pump



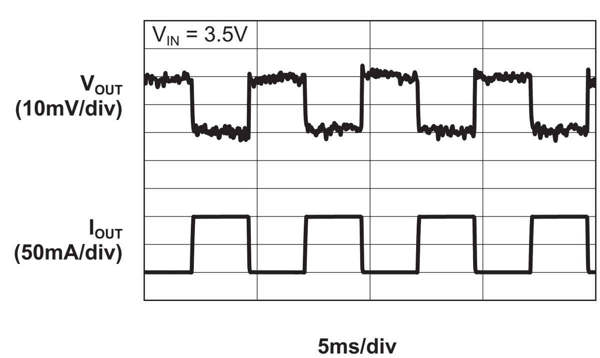
Startup Time with 100mA Load
Flash Charge Pump



Load Response vs. Time
50mA Load; Flash Charge Pump

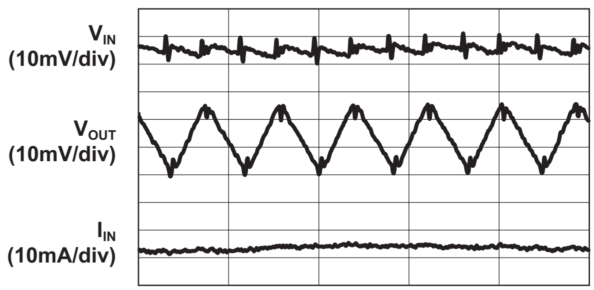


Load Response vs. Time
100mA Load; Flash Charge Pump

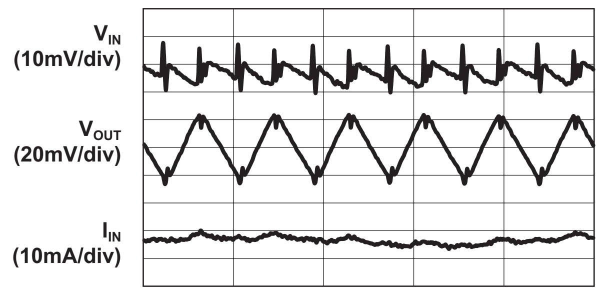


Typical Characteristics

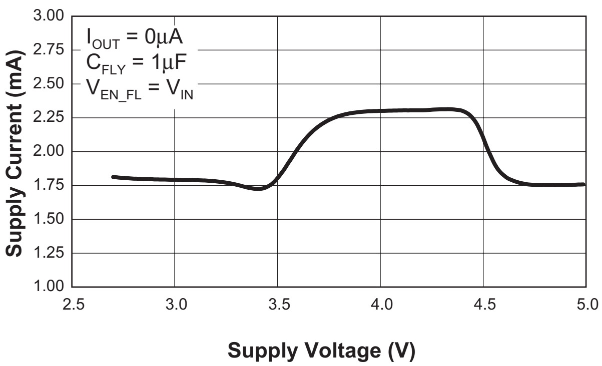
Output Ripple Voltage vs. Time
I_{OUT} = 50mA @ V_{IN} = 3.5V; Flash Charge Pump



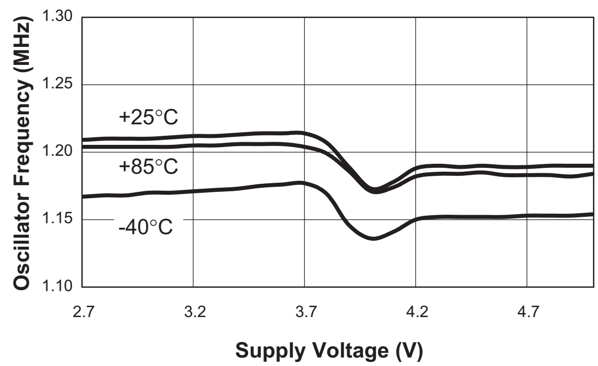
Output Ripple Voltage vs. Time
I_{OUT} = 100mA @ V_{IN} = 3.5V; Flash Charge Pump



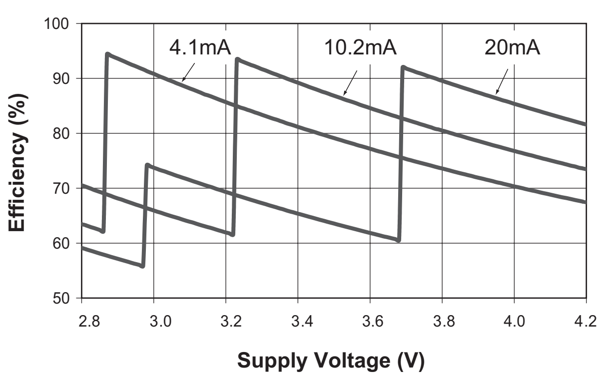
Supply Current vs. Supply Voltage
Flash Charge Pump



Oscillator Frequency vs. Supply Voltage
Flash Charge Pump

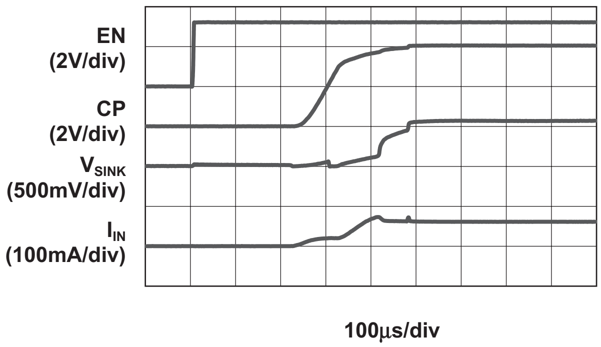


Efficiency vs. Supply Voltage

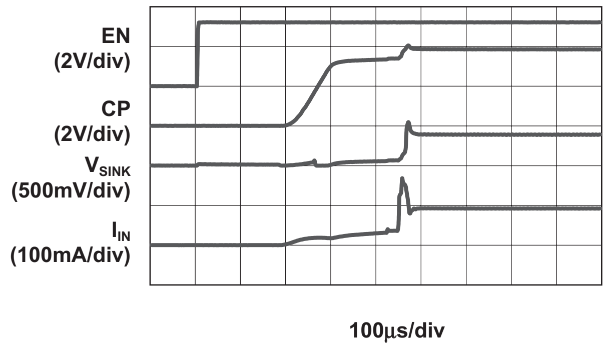


Typical Characteristics

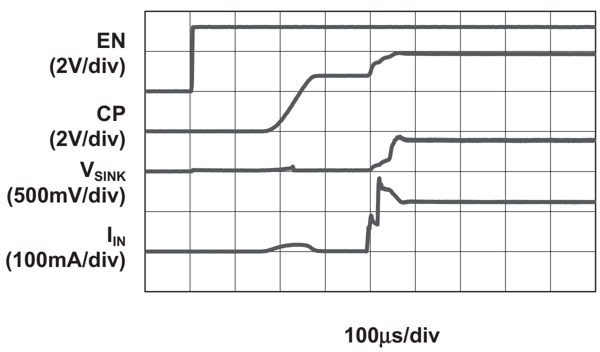
Turn On to 1X Mode
V_{IN} = 4.2V, D_X = 20mA



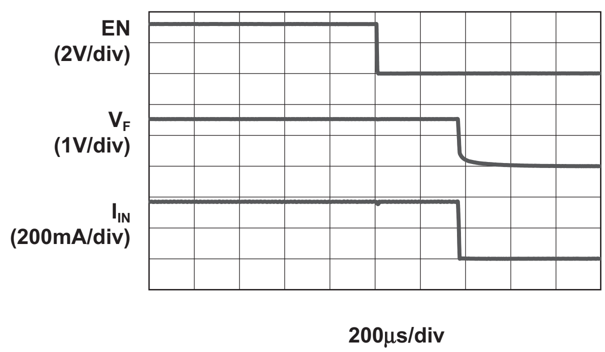
Turn On to 1.5X Mode
V_{IN} = 3.5V, D_X = 20mA



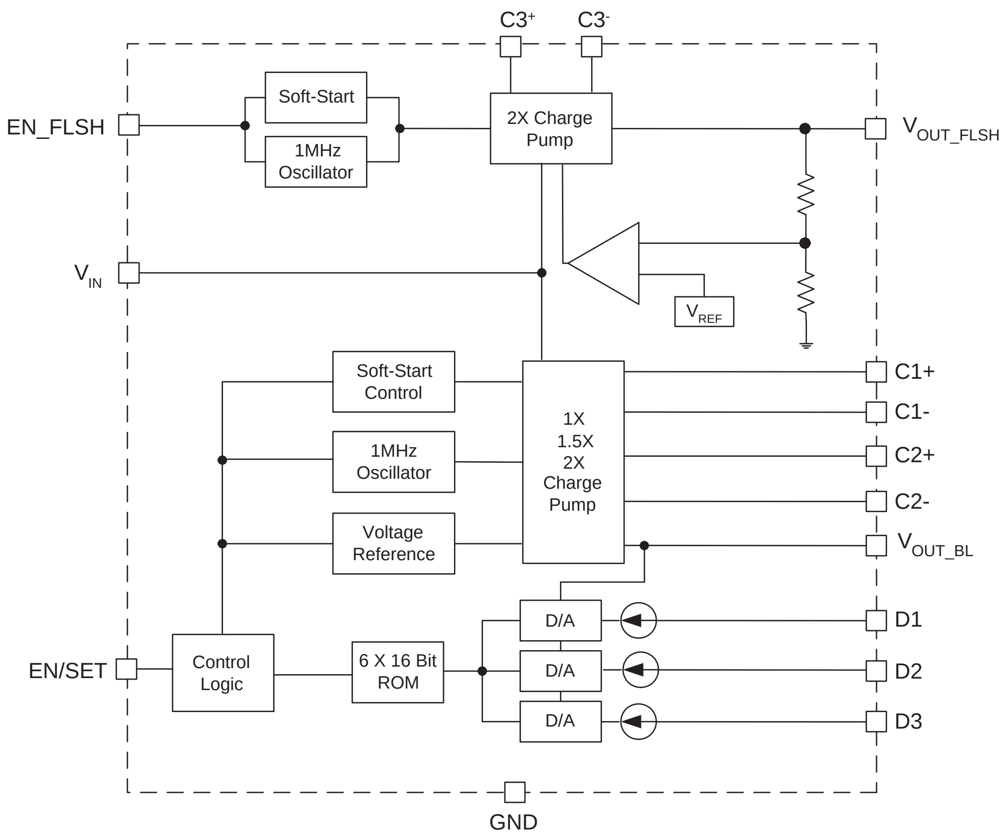
Turn On to 2X Mode
V_{IN} = 2.8V, D_X = 20mA



Turn Off from 1.5X Mode
V_{IN} = 3.5V, D_X = 20mA



Functional Block Diagram



Functional Description

The AAT2807A is a dual charge pump designed for flash and white LED applications. The backlight charge pump is tri-mode load switch (1X) and high efficiency (1.5X or 2X) charge pump device. To maximize power conversion efficiency, an internal sensing circuit monitors the voltage required on each constant current sink input and sets the load switch and charge pump modes based on the input battery voltage and the current sink input voltage. As the battery voltage discharges over time, the white LED charge pump is enabled when any of the three current sink inputs near dropout. The charge pump initially starts in 1.5X mode. If the charge pump output drops enough for any current source output to become close to dropout, the charge pump will automatically transition to 2X mode. The three constant current sink inputs D1 to D3 can drive three individual LEDs with a maximum current of 20mA per LED. The S^2Cwire serial interface enables and sets the constant current sink magnitudes. The flash charge pump is a charge pump doubler with regulated output voltage. It is designed to deliver 150mA of continuous current and 300mA of pulsed current.

The AAT2807A requires six external components: three 1µF ceramic capacitors for the charge pump flying capacitors (C1, C2 and C3), one 1µF ceramic input capacitor (C_{IN}), one 0.33µF to 1µF ceramic for backlight charge pump output capacitor (C_{OUT}), and one 1µF ceramic capacitor for flash charge pump output capacitor (C_{OUT}).

Constant Current Output Level Settings

The constant current sink levels for D1 to D3 are set via the serial interface. No PWM (pulse width modulation) or additional control circuitry is needed to control LED brightness. This feature greatly reduces the burden on a microcontroller or system IC to manage LED or display brightness, allowing the user to "set it and forget it." With its high-speed serial interface (up to 1MHz data rate), the input sink current can be changed successively to brighten or dim LEDs, giving the users real-time control of LED brightness. Because the inputs D1 to D3 are true independent constant current sinks, the voltage observed on any single given input will be determined by the actual forward voltage (V_F) for the LED being driven.

Data	I_{OUT} (mA)
1	20
2	14
3	10
4	7
5	20
6	14
7	10
8	7
9	0
10	0
11	0
12	0
13	0.05
14	0.5
15	1
16	2

Table 1: Constant Current Programming Levels.

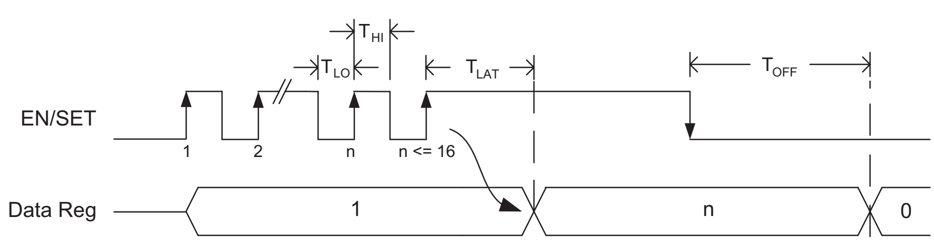
S²Cwire Serial Interface

The current sink input magnitude on the backlight charge pump is controlled by AnalogicTech's S²Cwire serial digital input. The interface relies on the number of rising edges of the EN/SET pin to load the registers. S²Cwire latches data after the EN/SET pin has been held high for time T_{LAT}. The interface records rising edges of the EN/SET pin and decodes them into 16 different states, as indicated in Table 1. There are four brightness levels. To further optimize power efficiency, the device also offers four low-current levels for dim LED operation (Data 13-16). At the lowest current setting, the internal supply current reduces to only 80µA typical.

The interface can be clocked at speeds up to 1MHz, such that intermediate states are not visible. The first rising edge of EN/SET enables the IC and initially sets the output LED current to 20mA. Once the final clock cycle is input for the desired brightness level, the EN/SET pin is held high to maintain the device output current at the programmed level. The device is disabled 500µs (T_{OFF}) after the EN/SET pin transitions to a logic low state.

The EN/SET timing is designed to accommodate a wide range of data rates. After the first rising edge of EN/SET, the charge pump is enabled and reaches full capacity after the soft-start time (T_{SS}). During the soft-start time, multiple clock pulses may be entered on the EN/SET pin to set the final output current level with a single burst of clocks. The current outputs remain constant as long as EN/SET remains in a logic high state. The current outputs are switched off after EN/SET has remained in a low state for at least the T_{OFF} timeout period; then, the backlight charge pump enters shutdown mode and draws less than 1µA from V_{IN}. Data are reset to 0 during shutdown.

S²Cwire Serial Interface Timing Diagram



Applications Information

LED Selection

The AAT2807A is specifically intended for driving white LEDs. However, the device design will allow the AAT2807A to drive most types of LEDs with forward voltage specifications ranging from 2.0V to 4.3V. LED applications may include main display backlighting, camera photo-flash applications, color (RGB) LEDs, infrared (IR) diodes for remotes, and other loads benefiting from a controlled output current generated from a varying input voltage. Since the D1 to D3 input current sinks are matched with negligible voltage dependence, LED brightness will be matched regardless of the specific LED forward voltage (V_F) levels.

In some instances (e.g., in high-luminous-output applications such as photo flash), it may be necessary to drive high-V_F type LEDs. The low-dropout current sinks in the AAT2807A make it capable of driving LEDs with forward voltages as high as 4.3V at full current from an input supply as low as 3.0V. Outputs can be paralleled to drive high-current LEDs without complication.

Device Switching Noise Performance

The AAT2807A has two independent fixed frequencies of approximately 1MHz to control noise and limit harmonics that can interfere with the RF operation of cellular telephone handsets or other communication devices. Back-injected noise appearing on the input pin of the charge pump is 20mV peak-to-peak, typically ten times less than inductor-based DC/DC boost converter white LED backlight solutions. The AAT2807A soft-start feature prevents noise transient effects associated with in-rush currents during start up of the charge pump circuit.

Capacitor Selection

Careful selection of the six external capacitors C_{IN}, C1, C2, C3 and C_{OUT} (for backlight and flash) is important because they will affect turn-on time, output ripple, and transient performance. Optimum performance will be obtained when low Equivalent Series Resistance (ESR) ceramic capacitors are used. In general, low ESR may be defined as less than 100mΩ. A value of 1µF for all six capacitors is a good starting point when choosing capacitors.

Capacitor Characteristics

Ceramic composition capacitors are highly recommended over all other types of capacitors for use with the AAT2807A. Ceramic capacitors offer many advantages over their tantalum and aluminum electrolytic counterparts. A ceramic capacitor typically has very low ESR, is lowest cost, has a smaller PCB footprint, and is non-polarized. Low ESR ceramic capacitors help to maximize charge pump transient response. Since ceramic capacitors are non-polarized, they are not prone to incorrect connection damage.

Equivalent Series Resistance

ESR is an important characteristic to consider when selecting a capacitor. ESR is a resistance internal to a capacitor that is caused by the leads, internal connections, size or area, material composition, and ambient temperature. Capacitor ESR is typically measured in milliohms for ceramic capacitors and can range to more than several ohms for tantalum or aluminum electrolytic capacitors.

Ceramic Capacitor Materials

Ceramic capacitors less than 0.1µF are typically made from NPO or COG materials. NPO and COG materials typically have tight tolerance and are stable over temperature. Larger capacitor values are typically composed of X7R, X5R, Z5U, or Y5V dielectric materials. Large ceramic capacitors, typically greater than 2.2µF, are often available in low-cost Y5V and Z5U dielectrics, but capacitors greater than 1µF are typically not required for AAT2807A applications.

Capacitor area is another contributor to ESR. Capacitors that are physically large will have a lower ESR when compared to an equivalent material smaller capacitor. These larger devices can improve circuit transient response when compared to an equal value capacitor in a smaller package size.

Thermal Protection

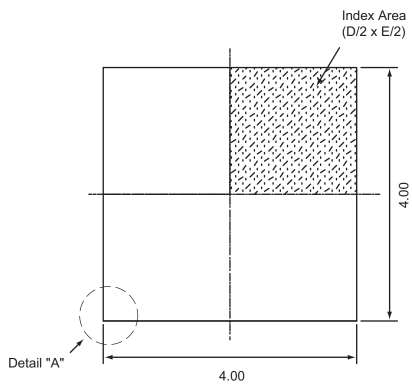
The AAT2807A has a thermal protection circuit that will shut down both charge pumps if the die temperature rises above the thermal limit, as is the case during a short circuit of the charge pump outputs.

Ordering Information

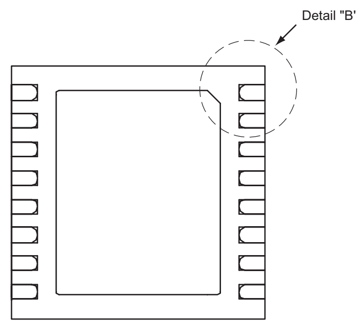
Package	Marking[1]	Part Number (Tape and Reel)
DFN44-16	NWXYY	**AAT2807AIXN-4.5-T1**

Note: sample stock is held on part numbers listed in **BOLD**.
Note 1: XYY= assembly and date code.

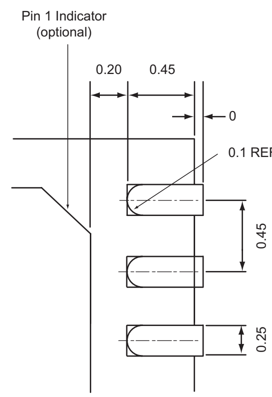
Package Information



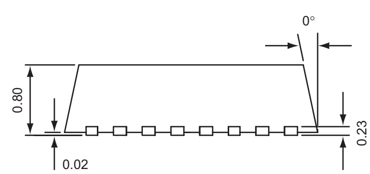
Top View
(Saw Type)



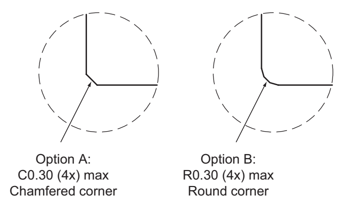
Bottom View



Detail "B"



Side View
(Saw Type)



Detail "A"

Package dimensions subject to change.
All dimensions in millimeters.

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