ChargePump™

General Description

The AAT3112 is a member of Analogic Tech™'s Power Management IC™ family. It is a dual charge pump voltage doubler that provides a regulated output voltage. It operates with input voltage range of 2.7 - 5.0 Volts. The device can deliver up to 500 mA of pulsed current making it ideal for white LED flash applications. Low external parts counts (two 1μF flying capacitors and two small capacitors at V_{IN} and V_{OUT}) make AAT3112 ideally suited for small battery powered applications.

The AAT3112 has a thermal management system to protect the device in the event of a short circuit condition at the output pin. Built-in soft-start circuitry prevents excessive inrush current during start-up. A high charge pump switching frequency enables the use of very small external capacitors. A low current shutdown feature disconnects the load from V_{IN} and reduces quiescent current to less than 1μA. The AAT3112 is available in 16 pin 3x3mm QFN package.

Features

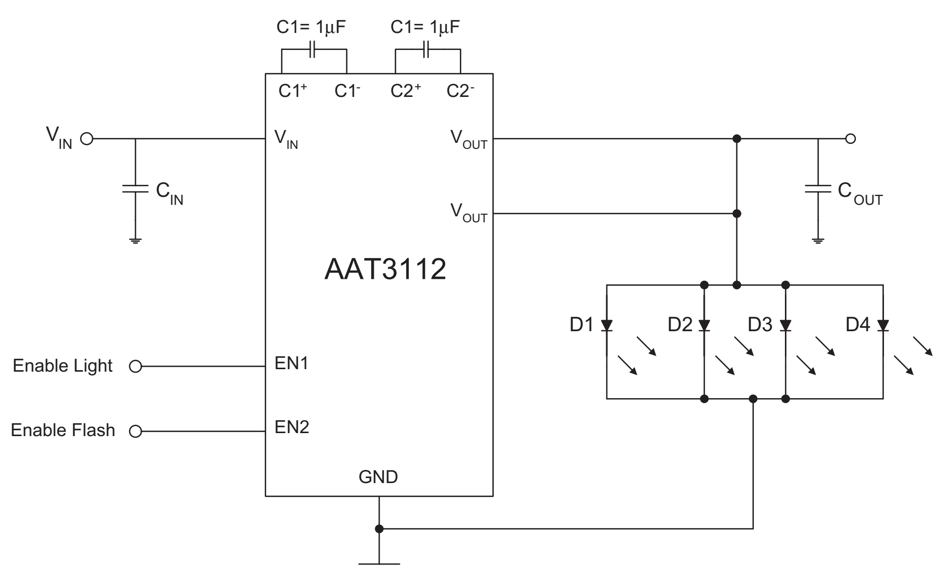
- V_{IN} Range: 2.7V to 5.5V
- I_Q < 1μA in Shutdown
- Up to 500mA of output current
- Regulated 4.5V output
- 26μA of Quiescent Current
- Small Application Circuit
- Automatic Soft-Start
- No Inductors
- Short circuit/over temperature protection
- 16 pin 3x3 QFN package

Applications

- White LED Backlighting
- White Photo-Flash

Preliminary Information

Typical Application

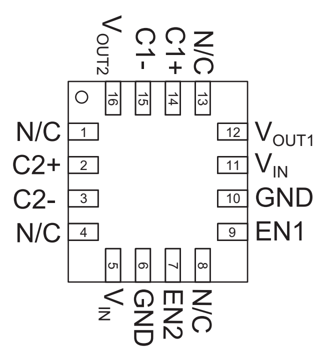


Pin Descriptions

Pin #	Symbol	Function
1	N/C	No connect.
2	C2+	Flying Capacitor 2 positive terminal. Connect 1μF Capacitor between C2+ and C2-.
3	C2-	Flying Capacitor 2 negative terminal.
4	N/C	No connect.
5	V_{IN}	Input Voltage. Connect to pin 11.
6	GND	Ground connection
7	EN2	Enable pin. When connected high, charge pump 2 is enabled. When connected low, it disables the charge pump.
8	N/C	No connect.
9	EN1	Enable pin. When connected high, charge pump 1 is enabled. When connected low, it disables the charge pump.
10	GND	Ground connection
11	V_{IN}	Input Voltage. Connect to pin 5.
12	V_{OUT1}	Output pin for regulated output Voltage. Bypass this pin to ground with a low ESR capacitor.
13	N/C	No connect.
14	C1+	Flying Capacitor 1 positive terminal. Connect 1 μF Capacitor between C1+ and C1-.
15	C1-	Flying Capacitor 1 negative terminal.
16	V_{OUT2}	Regulated output Voltage 2. Must be connected to V_{OUT1} for higher current applications. If used separately, bypass this pin to ground with a low ESR capacitor.

Pin Configuration

QFN33-16
(Top View)



Absolute Maximum Ratings[1]

Symbol	Description	Value	Units
V_{IN}	Input Voltage	-0.3 to 6	V
V_{OUT}	Charge Pump Output	-0.3 to 6	V
V_{EN}	EN to GND Voltage	-0.3 to 6	V
T_J	Operating Junction Temperature Range	-40 to 150	°C
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	2.0	W
θ_{JA}	Maximum Thermal Resistance[1]	50	°C/W

Note 1: Mounted on an FR4 board.

Electrical Characteristics

V_{IN} = 3.3V, V_{OUT} = 5.0V, $C_{IN} = C_{OUT}$ = 10 µF, C1 = C2 = 1.0µF; T_A = -40 to 85 °C. Unless otherwise noted, typical values are T_A = 25°C

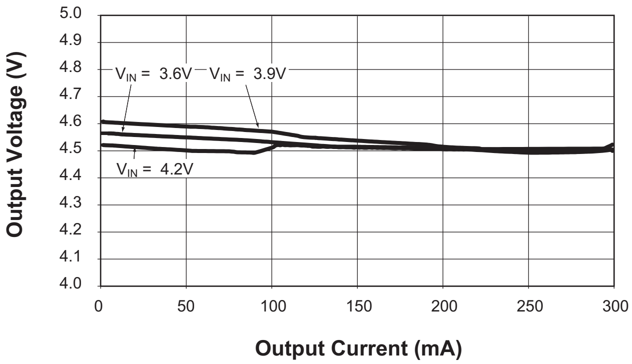
Symbol	Description	Conditions	Min	Typ	Max	Units
Input Power Supply						
V_{IN}	Operation Range		2.7		5.5	V
I_Q	Quiescent Current	$2.7 \leq V_{IN} \leq 5.0$, I_{OUT} = 0 mA; EN1 = EN2 = V_{IN}		26	60	µA
I_{SHDN}	Shutdown Current	EN1 = EN2 = 0			1.0	µA
I_{OUT}	Pulsed Output Current	V_{IN} = 3.6V; V_{OUT} = 4.0V; T_{PULSE} = 50mS		590		mA
		V_{IN} = 3.6V; V_{OUT} =4.0V; T_{PULSE} = 500mS		500		
V_{OUT}	Output Voltage	$2.7 \leq V_{IN} \leq 5.0$, I_{OUT} = 100mA	4.32	4.5	4.68	V
		$3.0 \leq V_{IN} \leq 5.0$, I_{OUT} = 200mA	4.32	4.5	4.68	
Charge Pump Section						
F_{CLK}	Clock Frequency			750		KHz
η_{CP}	Charge Pump Efficiency	V_{IN} = 2.7V; I_{OUT} = 100mA		80		%
EN						
$V_{EN(L)}$	Enable Threshold Low				0.3	V
$V_{EN(H)}$	Enable Threshold High		1.4			V
I_{EN}	EN Input leakage		-1.0		1.0	µA

Note 1: The AAT3112 is guaranteed to meet performance specification over the -40 to +85°C operating temperature range, and are assured by design, characterization and correlation with statistical process controls.

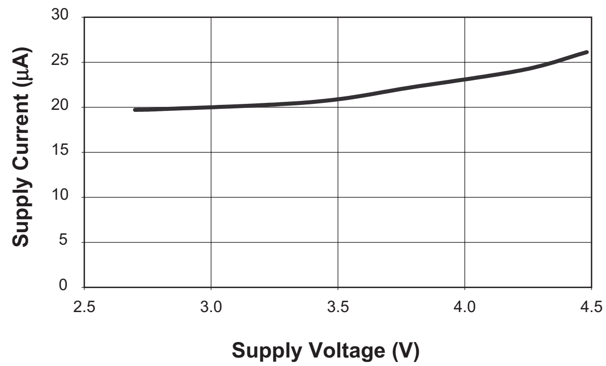
Typical Characteristics

(unless otherwise noted: V_{IN}=3.5V, C_{IN}=C_{OUT}=10µF, C1=C2=1µF, T_A=25°C)

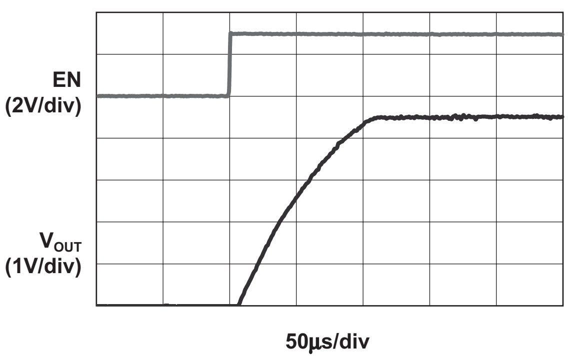
Output Voltage vs. Output Current



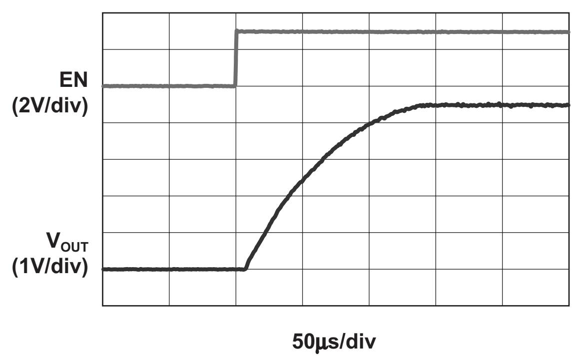
Supply Current vs. Supply Voltage
No load, No switching



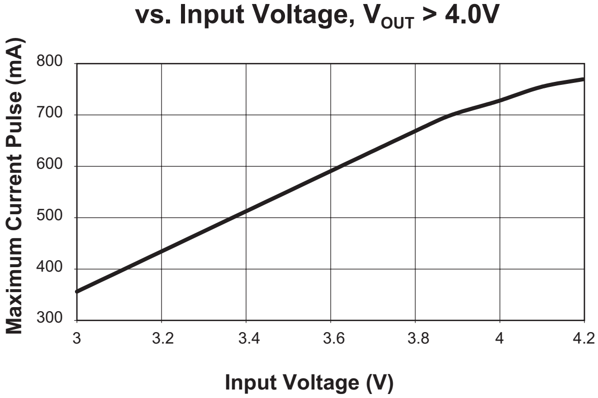
Startup Time with 100mA Load



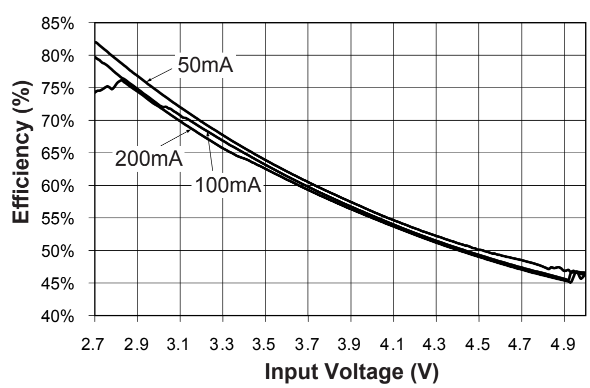
Startup Time with 200mA Load



Maximum Current Pulse (50ms pulse) vs. Input Voltage, V_{OUT} > 4.0V



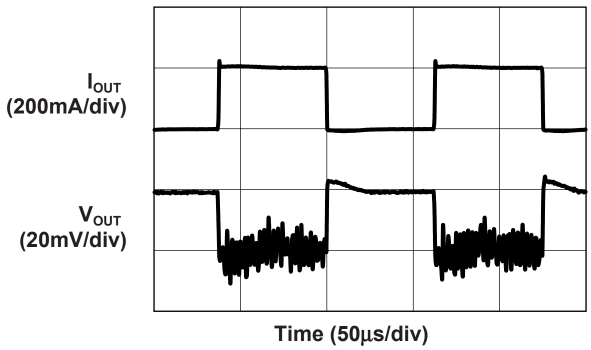
Efficiency vs. Supply Voltage



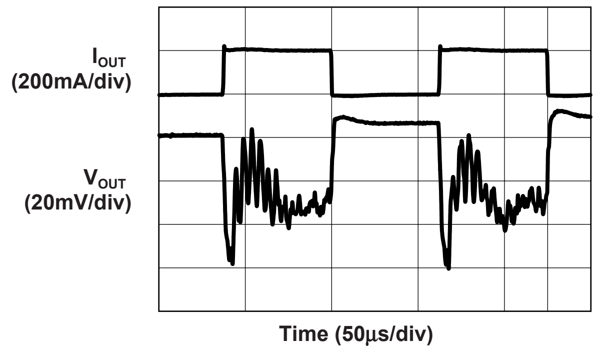
Typical Characteristics

(unless otherwise noted: V_{IN}=3.5V, C_{IN}=C_{OUT}=10µF, C1=C2=1µF, T_A=25°C)

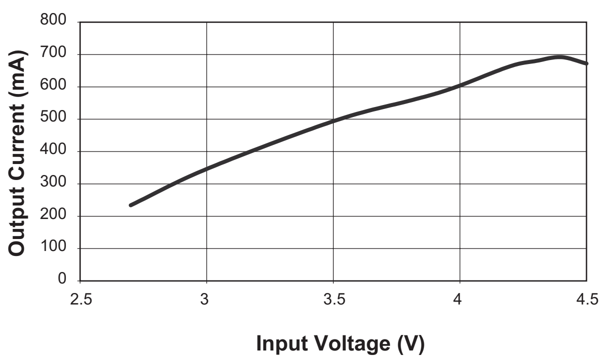
Load Transient Response (V_{IN} = 3.0V)



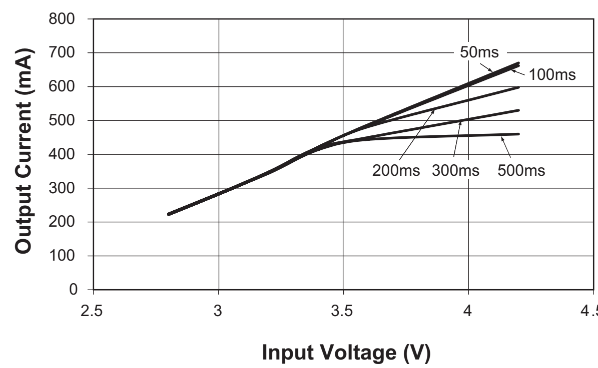
Load Transient Response (V_{IN} = 4.2V)



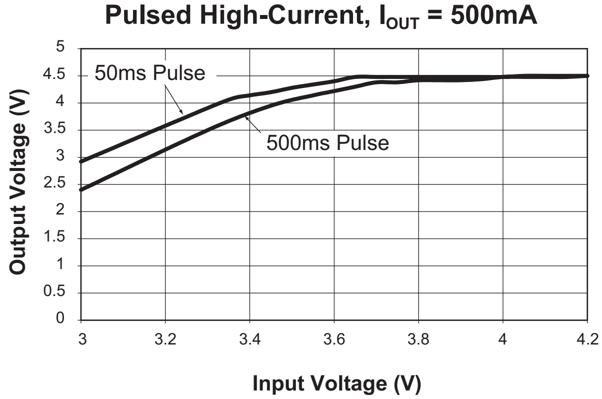
Output Current vs. Input Voltage 500ms Pulse Time, V_{OUT} > 4.0V



Output Current vs. Input Voltage (70°C) V_{OUT} > 4.0V

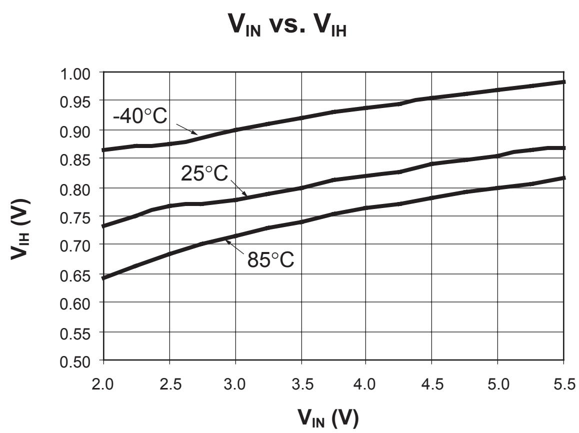


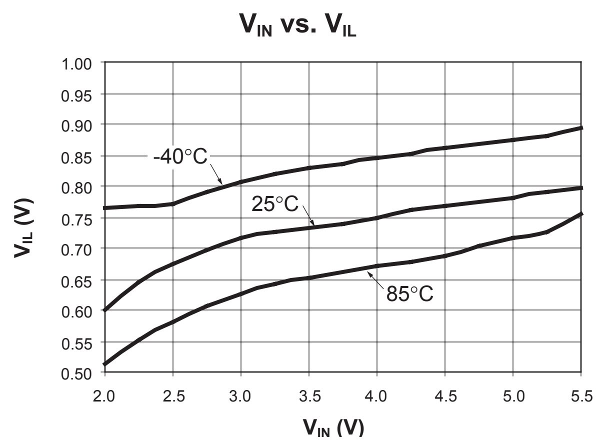
Output Voltage vs. Input Voltage for Pulsed High-Current, I_{OUT} = 500mA

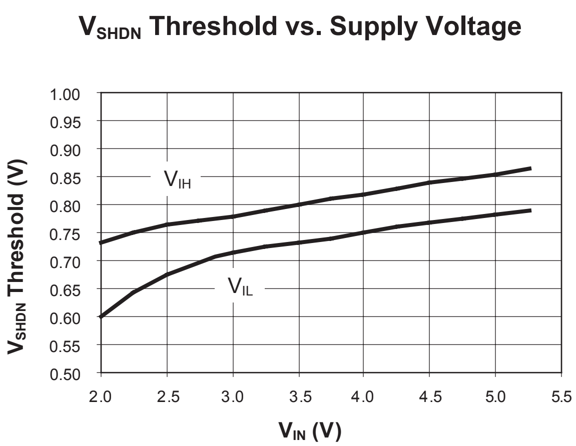


Typical Characteristics

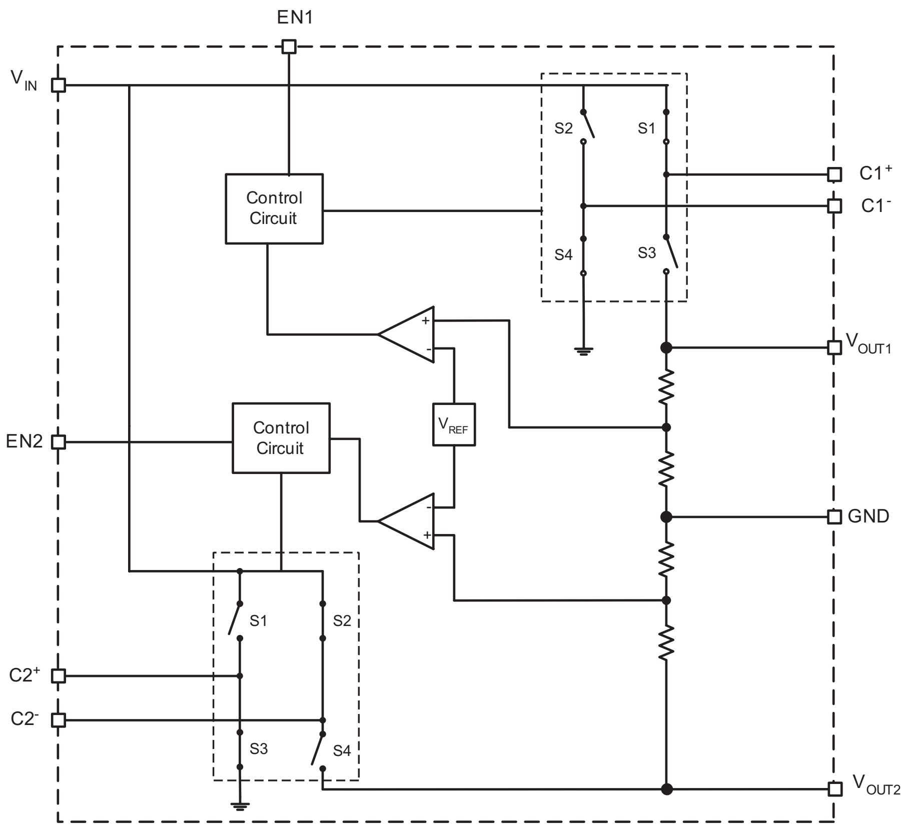
(unless otherwise noted: V_{IN}=3.5V, C_{IN}=C_{OUT}=10µF, C1=C2=1µF, T_A=25°C)







Functional Block Diagram



Functional Description

The AAT3112 is a dual charge pump intended for high current applications. It boosts the input voltage to a regulated output voltage. Regulation is achieved by sensing the output voltage through an internal resistor divider network. The AAT3112 requires only four external components: two 1.0µF ceramic capacitors for the charge pump (C1 and C2), one 10µF ceramic capacitor for C_{IN} and one 10µF ceramic capacitor for C_{OUT}.

The AAT3112 is designed to deliver 200 mA of continuous current, and up to 500 mA of pulsed current. Each charge pump engine has an independent enable pin for longer battery life. The charge pump switching frequency is approximately 750 KHz enabling the use of small external flying capacitors.

The AAT3112 has complete output short circuit and thermal protection to safeguard the device under extreme operating conditions. An internal thermal protection circuit senses die temperature and will shut down the device if the internal junction temperature exceeds approximately 145°C.

Applications Information

Charge Pump Efficiency

The AAT3112 is a regulated output voltage doubling charge pump. The efficiency (η) can simply be defined as a linear voltage regulator with an effective output voltage that is equal to two times the input voltage. Efficiency (η) for an ideal voltage doubler can typically be expressed as the output power divided by the input power:

$$\eta = \frac{P_{OUT}}{P_{IN}}$$

In addition, with an ideal voltage doubling charge pump, the output current may be expressed as half the input current. The expression to define the ideal efficiency (η) can be rewritten as:

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times 2I_{OUT}} = \frac{V_{OUT}}{2V_{IN}}$$

$$\eta(\%) = 100\left(\frac{V_{OUT}}{2V_{IN}}\right)$$

For a charge pump with an output of 5 volts and a nominal input of 3.0 volts, the theoretical efficiency is 83.3%. Due to internal switching losses and IC quiescent current consumption, the actual efficiency can be measured at 82.7%. These figures are in close agreement for output load conditions from 1mA to 400mA. Efficiency will decrease as load current drops below 0.05mA or when the level of V_{IN} approaches V_{OUT}.

Capacitor Selection

Careful selection of the four external capacitors C_{IN}, C1, C2, C_{OUT} is important because they will affect turn on time, output ripple and transient performance. Optimum performance will be obtained when low ESR (<100mΩ) ceramic capacitors are used. In general, low ESR may be defined as less than 100mΩ.

Capacitor Characteristics

Ceramic composition capacitors are highly recommended over all other types of capacitors for use with the AAT3112. 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 maximize charge pump transient response. Since ceramic capacitors are non-polarized, they are not prone to incorrect connection damage.

Equivalent Series Resistance (ESR): ESR is an important characteristic to consider when selecting a capacitor. ESR is a resistance internal to a capacitor, which 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. Large 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 large capacitors are not required in the AAT3112 application.

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.

Layout Considerations

High charge pump switching frequencies and large peak transient currents mandate careful printed circuit board layout. As a general rule for charge pump boost converters, all external capacitors should be located as close as possible to the device package with minimum length trace connections.

Maximize the ground plane around the AAT3112 charge pump and make sure all external capacitors are connected to the immediate ground plane. A local component side ground plane is recommended.

Application Circuits

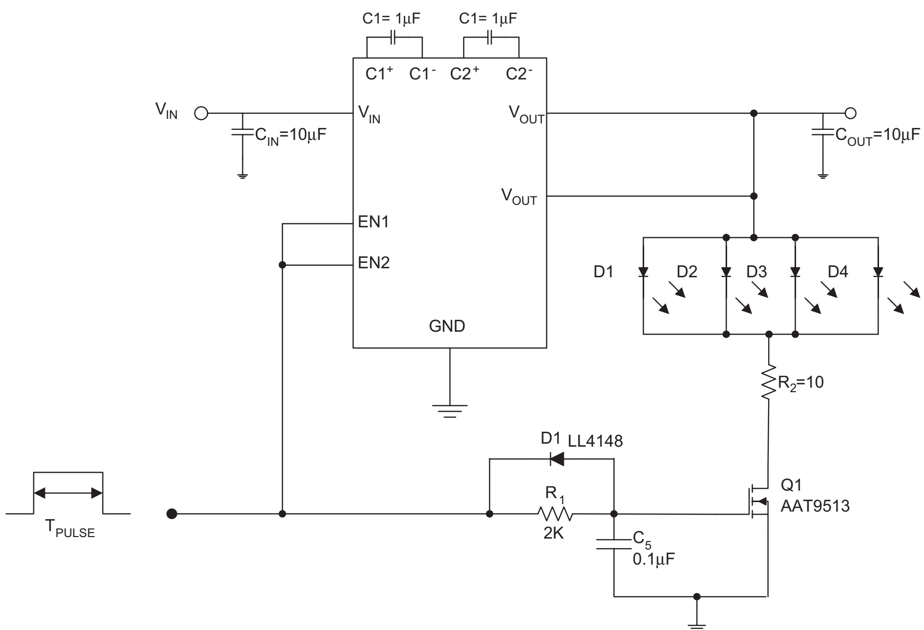


Figure 1: Flash Application

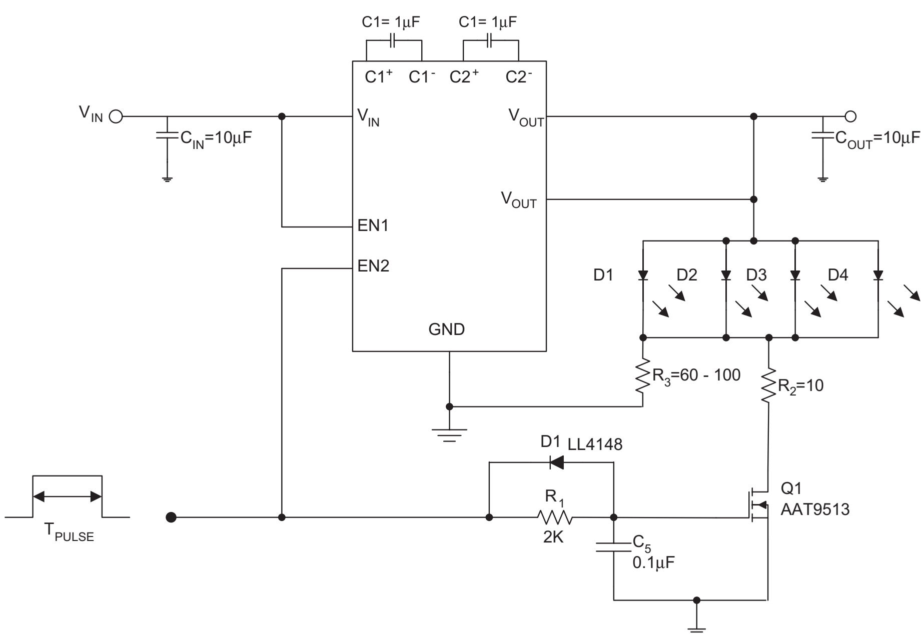


Figure 2: Movie Mode Light

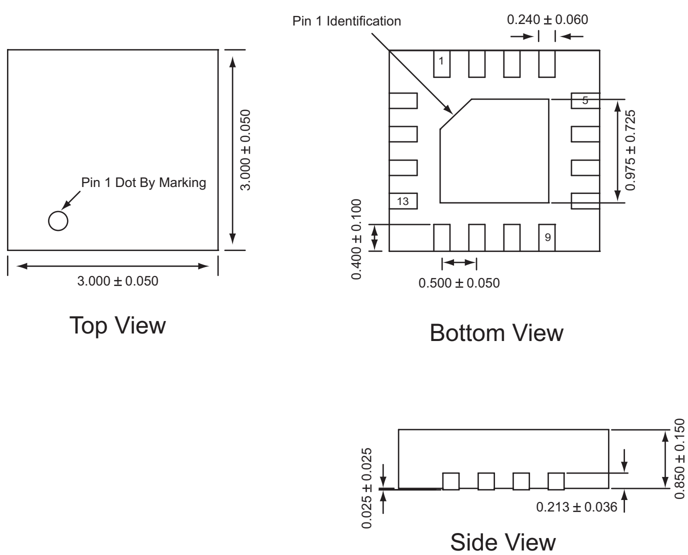
Ordering Information

Package	Marking[1]	Part Number (Tape and Reel)
QFN33-16	LGXYY	**AAT3112IVN-4.5-T1**
QFN33-16	MNXYY	**AAT3112IVN-5.0-T1**

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

Package Information

QFN33-16



All dimensions in millimeters.

Advanced Analogic Technologies, Inc.
830 E. Arques Avenue, Sunnyvale, CA 94085
Phone (408) 737-4600
Fax (408) 737-4611