AAT4282B

Slew Rate Controlled Load Switch

General Description

The AAT4282B SmartSwitch™ is a member of Skyworks' Application Specific Power MOSFET™ (ASPM™) product family. The AAT4282B is a dual P-channel MOSFET power switch designed for high-side load-switching applications. Each MOSFET has a typical $R_{DS(ON)}$ of 67mΩ, allowing increased load switch current handling capacity with a low forward voltage drop. The AAT4282B offers a shutdown load discharge circuit to rapidly turn off a load circuit when the switch is disabled. A slew-rate selector pin can switch between fast and slow slew rate.

The AAT4282B load switch operates from 1.5V up to 6.5V, making it ideal for both 3V and 5V systems. Input logic levels are TTL and 2.5V to 5V CMOS compatible. The quiescent supply current is a very low, less than 1µA.

The AAT4282B is available in a Pb-free, low profile 2.0 × 2.0mm TDFN22-8 package and is specified over the -40°C to 85°C temperature range.

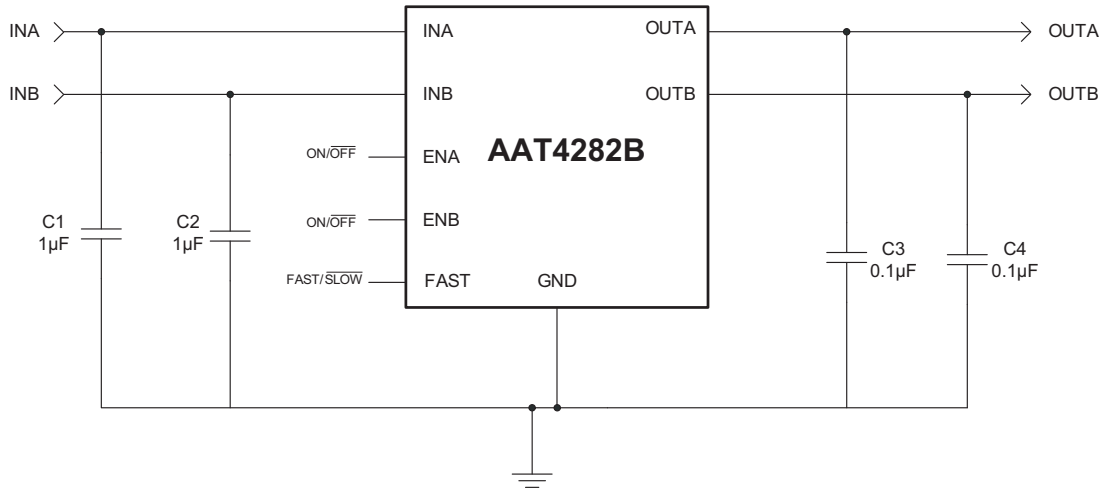
Features

- V_{IN} Range: 1.5V to 6.5V
- Low $R_{DS(ON)}$
  - 67mΩ Typical @ 5V
  - 125mΩ Typical @ 1.8V
- Slew Rate Turn-On Time
  - 750µs - Slow (FAST = Low)
  - 65µs - Fast (FAST = High)
- Fast Shutdown Load Discharge Option
- Low Quiescent Current
  - 40nA Typical
- TTL/CMOS Input Logic Level
- Temperature Range -40°C to 85°C
- TDFN22-8 Package

Applications

- Cellular Telephones
- Digital Still Cameras
- Hotswap Supplies
- Notebook Computers
- PDA Phones
- PDAs
- PMPs
- Smartphones

Typical Application

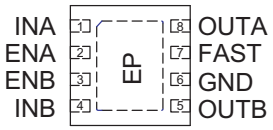


Pin Descriptions

Pin #	Symbol	Function
1	INA	This is the pin to the P-channel MOSFET source for Switch A. Bypass to ground through a 1µF capacitor. INA is independent of INB
2	ENA	Active-High Enable Input A. A logic low turns the switch off and the device consumes less than 1µA of current. Logic high resumes normal operation.
3	ENB	Active-High Enable Input B. A logic low turns the switch off and the device consumes less than 1µA of current. Logic high resumes normal operation.
4	INB	This is the pin to the P-channel MOSFET source for Switch B. Bypass to ground through a 1µF capacitor. INB is independent of INA.
5	OUTB	This is the pin to the P-channel MOSFET drain connection. Bypass to ground through a 0.1µF capacitor.
6	GND	Ground connection
7	FAST	Active-high input Switches between FAST (Logic H) and SLOW (Logic L) Slew rate
8	OUTA	This is the pin to the P-channel MOSFET drain connection. Bypass to ground through a 0.1µF capacitor.
EP	-	Exposed Paddle. May be connected to ground. A large copper pad under the package is helpful for thermal dissipation.

Pin Configuration

TDFN22-8
(Top View)



Absolute Maximum Ratings[1]

Symbol	Description	Value	Units
V_{IN}	IN to GND	-0.3 to 6.5	V
V_{EN}, FAST	EN, FAST to GND	-0.3 to 6.5	
V_{OUT}	OUT to GND	-0.3 to V_{IN} + 0.3	
I_{MAX}	Maximum Continuous Switch Current	3	A
I_{DM}	Maximum Pulsed Current (Duty Cycle ≤ 10%)	5.5	
T_J	Junction Temperature Range	-40 to 150	°C
T_{LEAD}	Maximum Soldering Temperature (at leads)	300	
V_{ESD}	ESD Rating[2] – HBM	4	kV

Thermal Characteristics[3]

Symbol	Description	Value	Units
θ_{JA}	Thermal Resistance	74	°C/W
P_D	Maximum Power Dissipation[4]	1.35	W

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.
2. Human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.
3. Mounted on a AAT4282B demo board in still 25°C air.
4. Refer to the section of "Thermal Considerations and High Output Current Applications" for the details.

Electrical Characteristics[1]

V_{IN} = 5V, T_A = -40 to 85°C unless otherwise noted. Typical values are at T_A = 25°C.

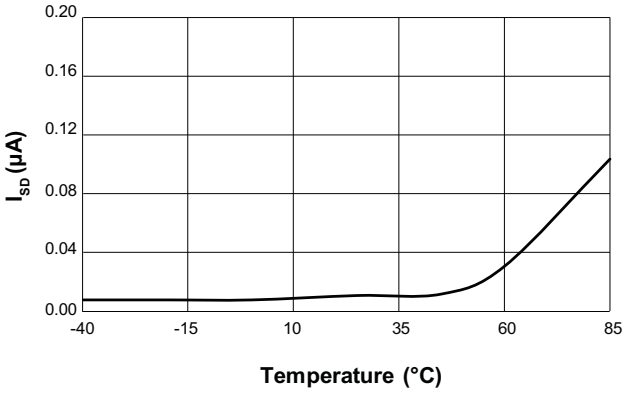
Symbol	Description	Conditions	Min	Typ	Max	Units
V_{IN}	Operation Voltage		1.5		6.5	V
I_Q	Quiescent Current	ON/OFF = ACTIVE, FAST = V_{IN}, I_{OUT} = 0			1.0	µA
$I_{Q(OFF)}$	Off Supply Current	ON/OFF = INACTIVE, OUT = OPEN			1.0	
$I_{SD(OFF)}$	Off Switch Current	ON/OFF = GND, V_{OUT} = 0			1.0	
$R_{DS(ON)}$	On-Resistance A or B	V_{IN} = 6.5V, I_{LOAD} = 300mA		63		mΩ
		V_{IN} = 5.0V, I_{LOAD} = 300mA		67	130	
		V_{IN} = 4.2V, I_{LOAD} = 300mA		71	140	
		V_{IN} = 3.0V, I_{LOAD} = 300mA		82	160	
		V_{IN} = 1.8V, I_{LOAD} = 300mA		125	230	
TCR_{RDS}	On Resistance Temperature Coefficient			2800		ppm/°C
V_{IL}	ON/OFF Input Logic Low Voltage	V_{IN} = 1.5V			0.4	V
V_{IH}	ON/OFF Input Logic High Voltage	V_{IN} = 5V	1.4			
I_{SINK}	ON/OFF Input Leakage	$V_{ON/OFF}$ = 5.5V			1.0	µA
$t_{D(ON)}$	Output Turn-On Delay Time	V_{IN} = 5V, R_{LOAD} =10Ω, T_A =25°C		13	40	µs
t_{ON}	Turn-On Rise Time	V_{IN} = 5V, R_{LOAD} =10Ω, FAST = 5V, T_A =25°C		65	150	
t_{ON}	Turn-On Rise Time	V_{IN} = 5V, R_{LOAD} =10Ω, FAST = 0V, T_A =25°C		750	1500	
$t_{D(OFF)}$	Output Turn-OFF Delay Time	V_{IN} = 5V, R_{LOAD} =10Ω, T_A =25°C		1	10	
R_{PD}	Output Pull-Down Resistance During OFF	ON/OFF = Inactive, T_A =25°C		150	250	Ω

1. The AAT4282B 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.

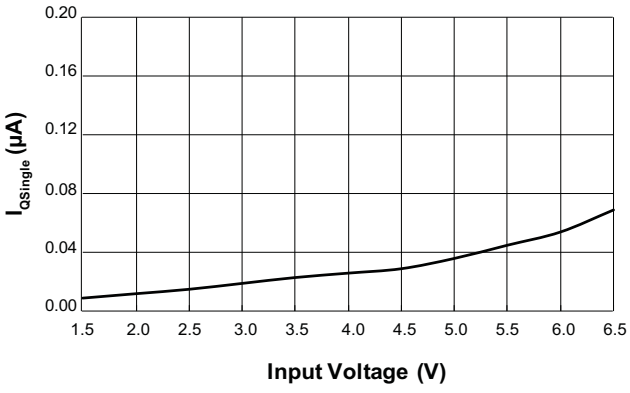
Typical Characteristics

Unless otherwise noted, V_{IN} = 5V, T_A = 25°C.

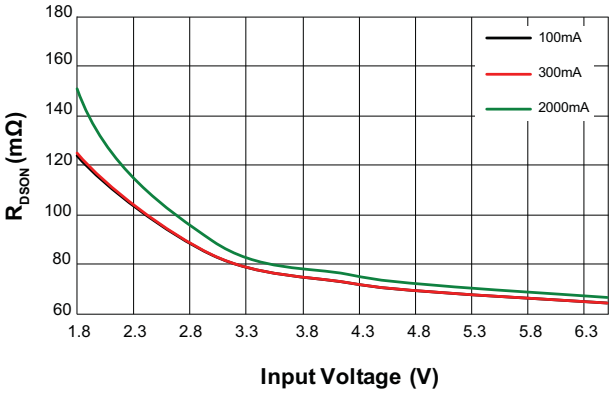
Off Supply Current vs. Temperature
(V_{IN} = 5.0V, EN = 0V; No Load)



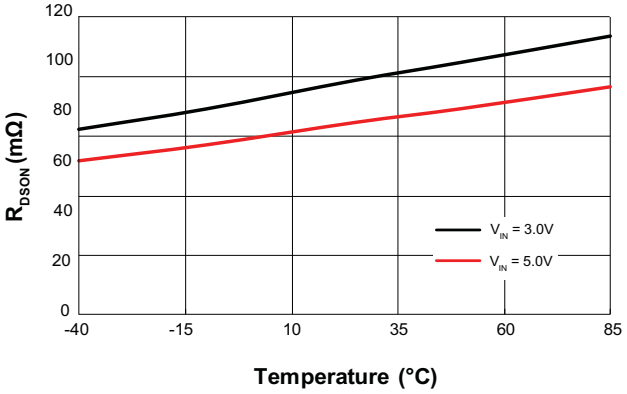
Quiescent Current vs. Input Voltage
(No Load; Single Switch)



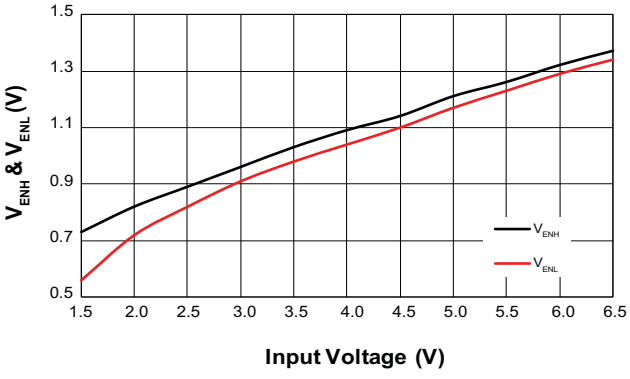
On-Resistance vs. Input Voltage



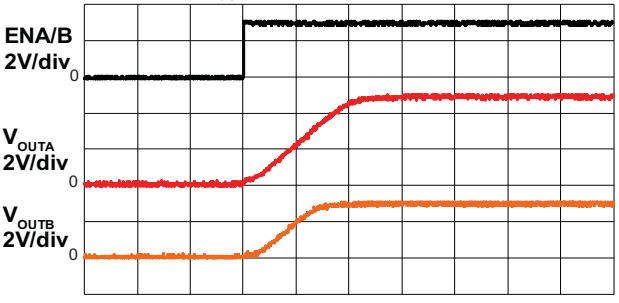
On-Resistance vs. Temperature
(I_{LOAD} = 300mA)



EN Input ON/OFF Threshold vs. Input Voltage



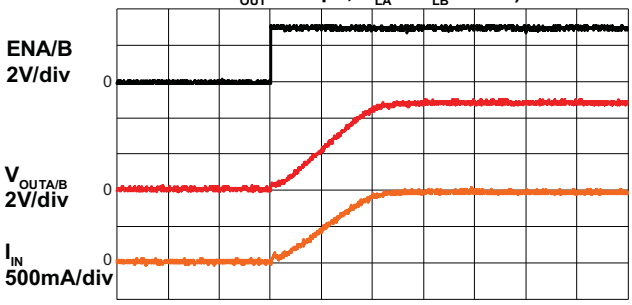
Output Turn On Delay Time
(V_{INA} = 5.0V, V_{INB} = 3.0V, FAST = 3.0V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{LA} = R_{LB} = 10Ω)



Typical Characteristics

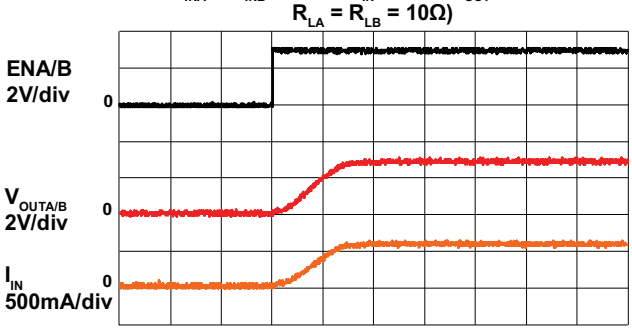
Unless otherwise noted, V_{IN} = 5V, T_A = 25°C.

Output Turn On Delay Time
(V_{INA} = V_{INB} = FAST = 5.0V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{LA} = R_{LB} = 10Ω)



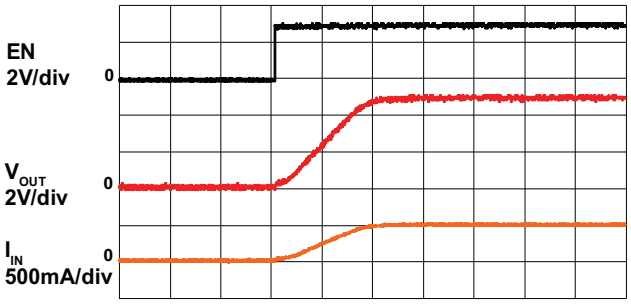
Time (40µs/div)

Output Turn On Delay Time
(V_{INA} = V_{INB} = 3.0V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{LA} = R_{LB} = 10Ω)



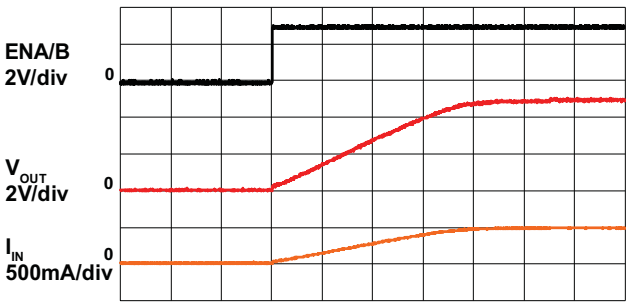
Time (40µs/div)

Output Turn On Time (Single Switch)
(V_{IN} = FAST = 5.0V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω)



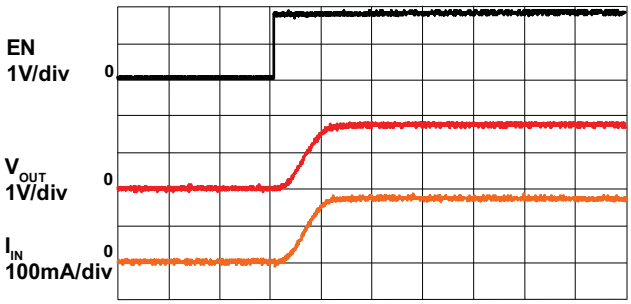
Time (40µs/div)

Output Turn On Time (Single Switch)
(V_{IN} = 5.0V, FAST = 0V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω)



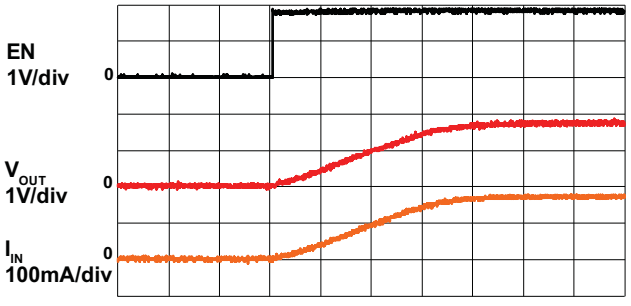
Time (200µs/div)

Output Turn On Time (Single Switch)
(V_{IN} = FAST = 1.8V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω)



Time (40µs/div)

Output Turn On Time (Single Switch)
(V_{IN} = 1.8V, FAST = 0V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω)

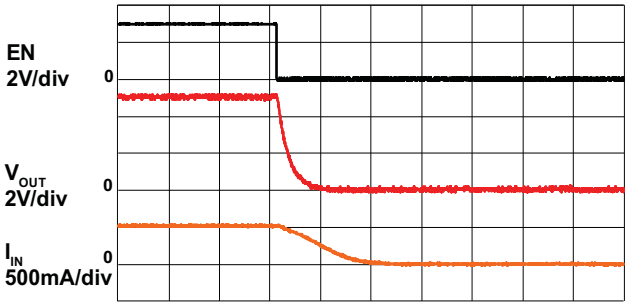


Time (100µs/div)

Typical Characteristics

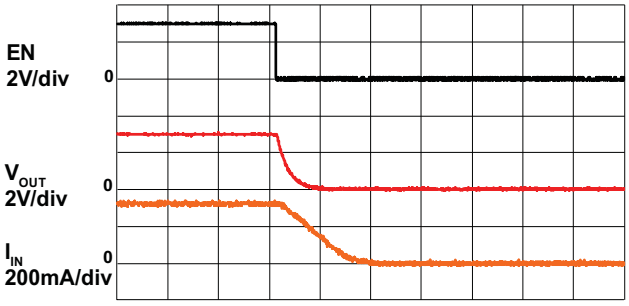
Unless otherwise noted, V_{IN} = 5V, T_A = 25°C.

Output Turn Off Delay Time (Single Switch)
(V_{IN} = 5.0V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω)



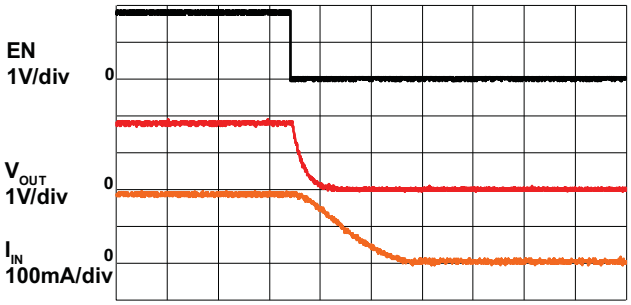
Time (4µs/div)

Output Turn Off Delay Time (Single Switch)
(V_{IN} = 3.0V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω)



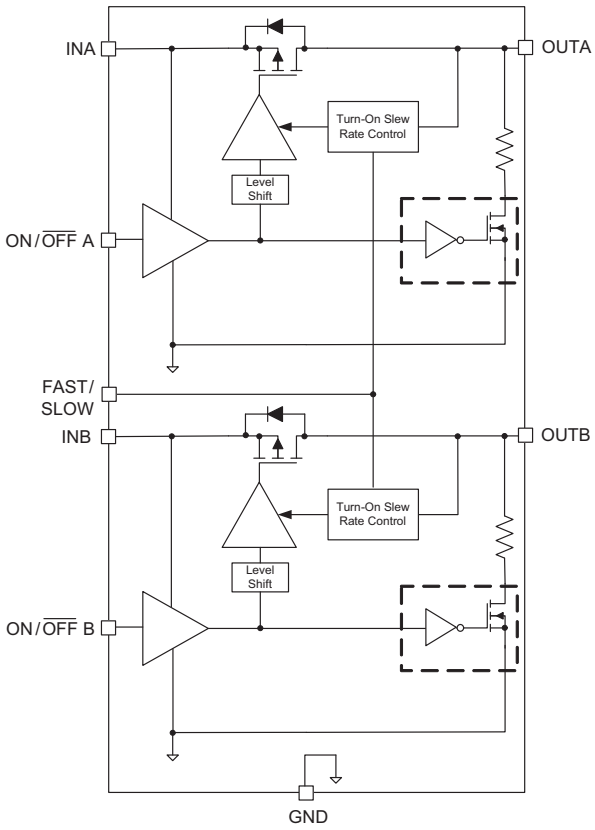
Time (4µs/div)

Output Turn Off Delay Time (Single Switch)
(V_{IN} = 1.8V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω)



Time (4µs/div)

Functional Block Diagram



Functional Description

The AAT4282B is a flexible dual P-channel MOSFET power switch designed for high-side load switching applications. During turn-on slewing, the current ramps linearly until it reaches the level required for the output load condition. The proprietary turn-on current control method works by careful control and monitoring of the MOSFET gate voltage. When the device is switched ON, the gate voltage is quickly increased to the threshold level of the MOSFET. Once at this level, the current begins to slew as the gate voltage is slowly increased until the MOSFET becomes fully enhanced. Once it has reached this point, the gate is quickly increased to the full input voltage and the $R_{DS(ON)}$ is minimized.

The AAT4282B has a minimized slew rate limited turn-on function and a shutdown output discharge circuit to rapidly turn off a load when the load switch is disabled through the ON/OFF pin. Using the FAST input pin on the AAT4282B, the device can be manually switched to a slower slew rate.

The AAT4282B operates with input voltages ranging from 1.5V to 6.5V. This device has an extremely low operating current, making it ideal for battery-powered applications.

The ON/OFF control pin is TTL compatible and will also function with 2.5V to 5V logic systems, making the AAT4282B an ideal level-shifting load switch.

Applications Information

Input Capacitor

A 1µF or larger capacitor is typically recommended for C_{IN} in most applications. A C_{IN} capacitor is not required for basic operation; however, it is useful in preventing load transients from affecting upstream circuits. C_{IN} should be located as close to the device VIN pin as practically possible. Ceramic, tantalum, or aluminum electrolytic capacitors may be selected for C_{IN}. There is no specific capacitor equivalent series resistance (ESR) requirement for C_{IN}. However, for higher current operation, ceramic capacitors are recommended for C_{IN} due to their inherent capability over tantalum capacitors to withstand input current surges from low-impedance sources, such as batteries in portable devices.

Output Capacitor

For proper slew operation, a 0.1µF capacitor or greater is required between VOUT and GND. Likewise, with the output capacitor, there is no specific capacitor ESR requirement. If desired, C_{OUT} may be increased without limit to accommodate any load transient condition without adversely affecting the slew rate.

Enable Function

The AAT4282B features an enable / disable function. This pin (EN*x*) is active high and is compatible with TTL or CMOS logic. To assure the load switch will turn on, the signal level must be greater than 1.4V. The load switch will go into shutdown mode when the voltage on the EN*x* pin falls below 0.4V. When the load switch is in shutdown mode, the OUT pin is tri-stated, and the quiescent current drops to leakage levels below 1µA.

Reverse Output-to-Input Voltage Conditions and Protection

Under normal operating conditions, a parasitic diode exists between the output and input of the load switch. The input voltage should always remain greater than the output load voltage, maintaining a reverse bias on the internal parasitic diode. Conditions where V_{OUT} might exceed V_{IN} should be avoided since this would forward bias the internal parasitic diode and allow excessive current flow into the VOUT pin, possibly damaging the load switch. In applications where there is a possibility of V_{OUT} exceeding V_{IN} for brief periods of time during normal operation, the use of a larger value C_{IN} capacitor is highly recommended. A larger value of C_{IN} with respect to C_{OUT} will effect a slower C_{IN} decay rate during shutdown, thus preventing V_{OUT} from exceeding V_{IN}. In applications where there is a greater danger of V_{OUT} exceeding V_{IN} for extended periods of time, it is recommended to place a Schottky diode from V_{IN} to V_{OUT} (connecting the cathode to V_{IN} and anode to V_{OUT}). The Schottky diode forward voltage should be less than 0.45V.

Thermal Considerations and High Output Current Applications

The AAT4282B is designed to deliver a continuous output load current. The limiting characteristic for maximum safe operating output load current is package power dissipation. In order to obtain high operating currents, careful device layout and circuit operating conditions must be taken into account.

The following discussions will assume the load switch is mounted on a printed circuit board utilizing the minimum recommended footprint as stated in the Printed Circuit Board Layout Recommendations section of this datasheet.

At any given ambient temperature (T_A), the maximum package power dissipation can be determined by the following equation:

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{\theta_{JA}}$$

Constants for the AAT4282B are maximum junction temperature ($T_{J(MAX)}$ = 125°C)[1] and package thermal resistance (θ_{JA} = 74°C/W). Worst case conditions are calculated at the maximum operating temperature, T_A = 85°C. Typical conditions are calculated under normal ambient conditions where T_A = 25°C. At T_A = 85°C, $P_{D(MAX)}$ = 541mW. At T_A = 25°C, $P_{D(MAX)}$ = 1351mW.

The maximum continuous output current for the AAT4282B is a function of the package power dissipation and the R_{DS} of the MOSFET at $T_{J(MAX)}$. The maximum R_{DS} of the MOSFET at $T_{J(MAX)}$ is calculated by increasing the

1. The actual maximum junction temperature of AAT4282B is 150°C. However, good design practice is to derate the maximum die temperature to 125°C to prevent the possibility of over-temperature damage.

maximum room temperature R_{DS} by the R_{DS} temperature coefficient. The temperature coefficient (TC) is 2800ppm/°C. Therefore, at 125°C:

$R_{DS(MAX)} = R_{DS(25°C)} \cdot (1 + TC \cdot \Delta T)$

$R_{DS(MAX)} = 130m\Omega \cdot (1 + 0.002800 \cdot (125°C - 25°C))$

$R_{DS(MAX)} = 166.4m\Omega$

For maximum current, refer to the following equation:

$$I_{OUT(MAX)} < \sqrt{\frac{P_{D(MAX)}}{R_{DS}}}$$

For example, if V_{IN} = 5V, $R_{DS(MAX)}$ = 166.4mΩ, and T_A = 25°C, $I_{OUT(MAX)}$ = 2.93A. If the output load current were to exceed 2.93A or if the ambient temperature were to increase, the internal die temperature would increase and the device would be damaged. Higher peak currents can be obtained with the AAT4282B. To accomplish this, the device thermal resistance must be reduced by increasing the heat sink area or by operating the load switch in a duty cycle manner. Duty cycles with peaks less than 2ms in duration can be considered using the method described in the High Peak Current Applications section of this datasheet.

High Peak Output Current Applications

Some applications require the load switch to operate at a continuous nominal current level with short duration, high-current peaks. Refer to the I_{DM} specification in the Absolute Maximum Ratings table to ensure the AAT4282B's maximum pulsed current rating is not exceeded. The duty cycle for both output current levels must be taken into account. To do so, first calculate the power dissipation at the nominal continuous current level, and then add the additional power dissipation due to the short duration, high-current peak scaled by the duty factor. For example, a 4V system using an AAT4282B which has channel A operates at a continuous 1A load current level, and channel B operates at a continuous 100mA load current level and has short 3A current peaks, as in a GSM application. The current peak occurs for 576µs out of a 4.61ms period. First, the current duty cycle is calculated:

$$\% \text{ Peak Duty Cycle} = \frac{x}{100} = \frac{576\mu s}{4.61ms}$$

$$\% \text{ Peak Duty Cycle} = 12.5\%$$

The load current is 100mA for 87.5% of the 4.61ms period and 3A for 12.5% of the period. Since the Electrical Characteristics do not report $R_{DS(MAX)}$ for 4V operation, it must be approximated by consulting the chart of $R_{DS(ON)}$ vs. V_{IN}. The R_{DS} reported for 5V at 100mA and 3A can be scaled by the ratio seen in the chart to derive the R_{DS} for 4V V_{IN} at 25°C: 130mΩ · 72mΩ/67mΩ = 139.7mΩ. De-rated for temperature: 139.7mΩ · (1 + 0.002800 · (125°C - 25°C)) = 178.8mΩ.

For channel A, the power dissipation for a continuous 1A load is calculated as follows:

$P_{D(CHA)} = I_{OUT}^2 \cdot R_{DS} = (1A)^2 \cdot 178.8m\Omega = 178.8mW$

For channel B, the power dissipation for 100mA load is calculated as follows:

$P_{D(MAX)} = I_{OUT}^2 \cdot R_{DS}$

$P_{D(100mA)} = (100mA)^2 \cdot 178.8m\Omega$

$P_{D(100mA)} = 1.79mW$

$P_{D(87.5\%D/C)} = \%DC \cdot P_{D(100mA)}$

$P_{D(87.5\%D/C)} = 0.875 \cdot 1.79mW$

$P_{D(87.5\%D/C)} = 1.57mW$

The power dissipation for 100mA load at 87.5% duty cycle is 1.57mW. Now the power dissipation for the remaining 12.5% of the duty cycle at 3A is calculated:

$P_{D(MAX)} = I_{OUT}^2 \cdot R_{DS}$

$P_{D(3A)} = (3A)^2 \cdot 178.8m\Omega$

$P_{D(3A)} = 1609mW$

$P_{D(12.5\%D/C)} = \%DC \cdot P_{D(3A)}$

$P_{D(12.5\%D/C)} = 0.125 \cdot 1609mW$

$P_{D(12.5\%D/C)} = 201.1mW$

Finally, the total power dissipation for channels A and B is determined as follows:

$P_{D(total)} = P_{D(CHA)} + P_{D(100mA)} + P_{D(3A)}$

$P_{D(total)} = 178.8mW + 1.57mW + 201.1mW$

$P_{D(total)} = 381mW$

The maximum power dissipation for the AAT4282B operating at an ambient temperature of 85°C is 381mW. The device in this example will have a total power dissipation of 541mW. This is well within the thermal limits for safe operation of the device; in fact, at 85°C, the AAT4282B will handle a 3A pulse for up to 22 duty cycle. At lower ambient temperatures, the duty cycle can be further increased.

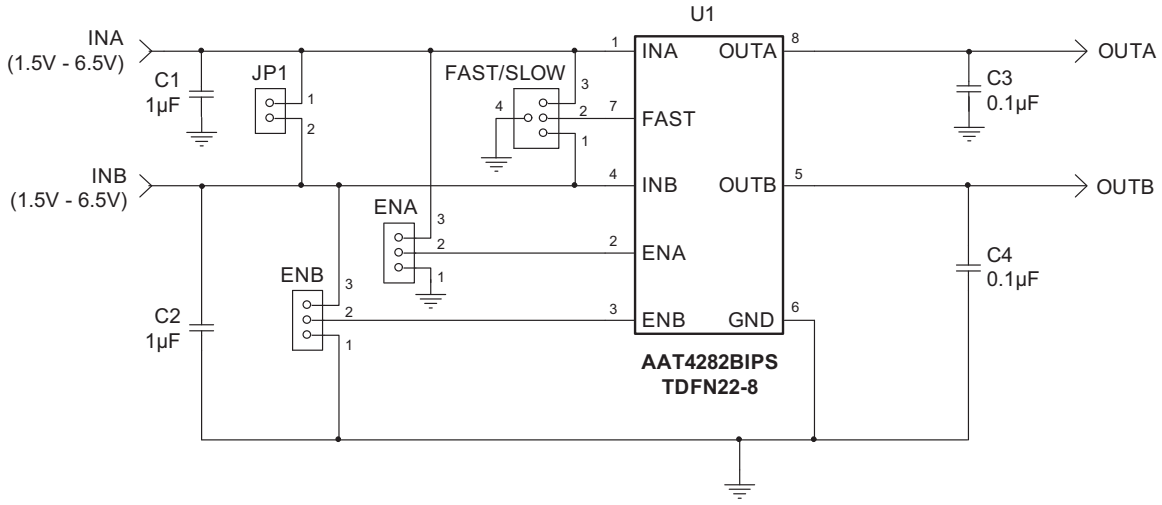
Printed Circuit Board Layout Recommendations

For proper thermal management, and to take advantage of the low $R_{DS(ON)}$ of the AAT4282B, a few circuit board layout rules should be followed: V_{IN} and V_{OUT} should be routed using wider than normal traces, and GND should be connected to a ground plane. For best performance, C_{IN} and C_{OUT} should be placed close to the package pins.

Evaluation Board Layout

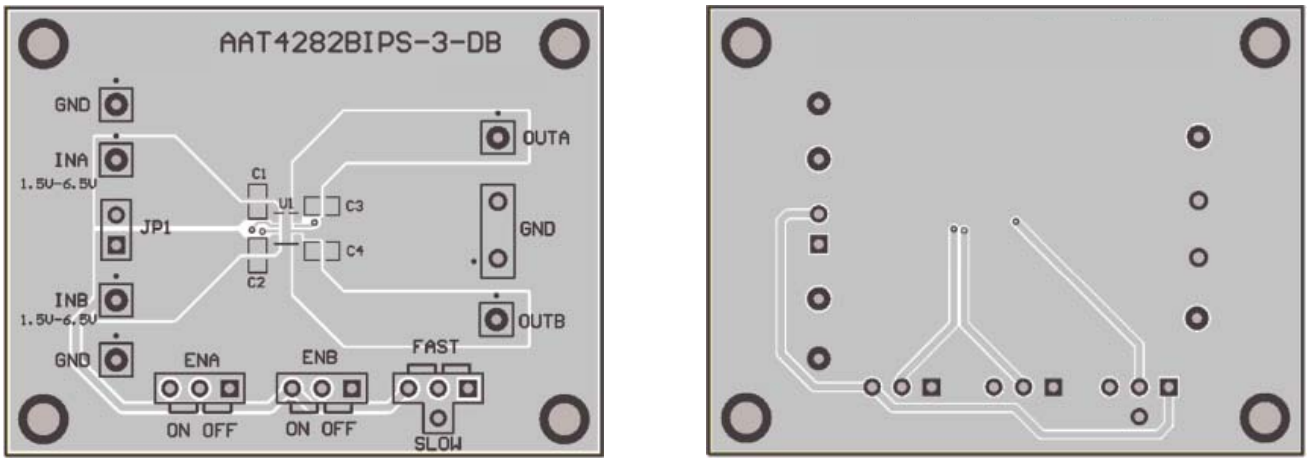
The AAT4282B evaluation layout follows the printed circuit board layout recommendations and can be used for good applications layout. Refer to Figures 1 and Firgure 2.

Note: Board layout shown is not to scale.



C1, C2 1µF 0603 X5R 10V (P/N: GRM188R61A105KA61D)
C3, C4 0.1µF 0603 X5R 10V (P/N: GRM188R71C104KA01D)

Figure 1: AAT4282BIPS Evaluation Board Schematic.



(a) Top Side **(b) Bottom Side**

Figure 2: AAT4282BIPS Evaluation Board Layout.

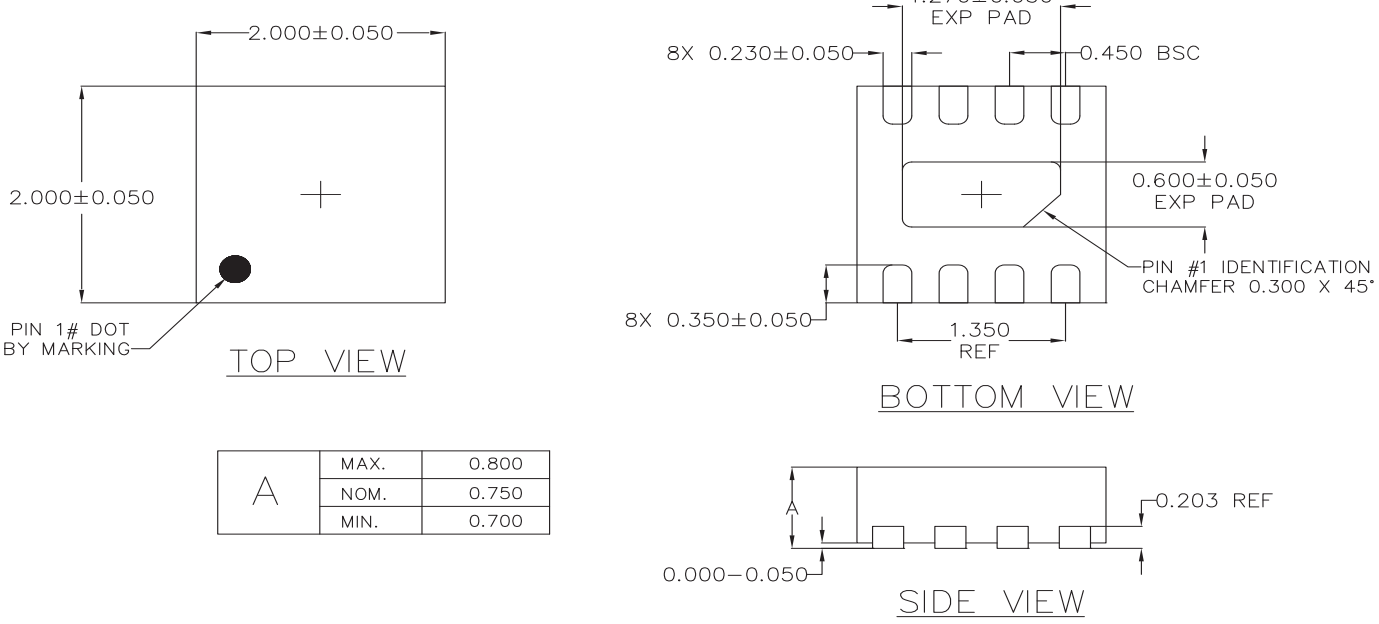
Ordering Information

Package	Marking[1]	Part Number (Tape and Reel)[2]
TDFN22-8	W9XYY	**AAT4282BIPS-3-T1**

Skyworks Green™ products are compliant with all applicable legislation and are halogen-free. For additional information, refer to *Skyworks Definition of Green™*, document number SQ04-0074.

Package Information[3]

TDFN22-8



A	MAX.	0.800
	NOM.	0.750
	MIN.	0.700

NOTES:
1. PLATING REQUIREMENT PER SOURCE CONTROL DRAWING (SCD) 2504.

OUTLINE: DFN
8 LEADS, 2 X 2 X 0.75 MM
1.27 X 0.6 MM EXPOSED PADDLE
0.450 MM PITCH

All dimensions in millimeters.

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, FTDFN, 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.

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