DATA SHEET

AAT4282A: Slew Rate Controlled Load Switch

Applications

- Cellular telephones
- Digital still cameras
- Hot-swap supplies
- Notebook computers
- PDA phones
- PDAs
- PMPs
- Smartphones

Features

- V_{IN} range: 1.5 V to 6.5 V
- Low $R_{DS(ON)}$:
  - 60 mΩ typical @ 5 V
  - 140 mΩ typical @ 1.5 V
- Slew rate turn-on time options:
  - 1 ms
  - 0.5 μs
  - 100 μs
- Fast shutdown load discharge option
- Low quiescent current:
  - Typical 1 μA
- TTL/CMOS input logic level
- Temperature range: –40 °C to 85 °C
- FTDFN (8-pin, 2.0 mm × 2.0 mm) package (MSL1, 260 ºC per JEDEC J-STD-020)

Description

The AAT4282A SmartSwitch™ is a member of the Skyworks Application Specific Power MOSFET (ASPM™) product family. The AAT4282A is a dual P-channel MOSFET power switch designed for high-side load-switching applications. Each MOSFET has a typical $R_{DS(ON)}$ of 60 mΩ, allowing increased load switch current handling capacity with a low forward voltage drop. The device is available in three different versions with flexible turn-on and turn-off characteristics – from very fast to slew-rate limited. The standard 4282A (-1) version has a slew-rate limited turn-on load switch. The AAT4282A (-2) version features fast turn-on capability, typically less than 500 ns turn-on and 3 μs turn-off times. The AAT4282A (-3) variation offers a shutdown load discharge circuit to rapidly turn off a load circuit when the switch is disabled. An additional feature is a slew-rate selector pin which can switch between fast and slow slew rate.

All the AAT4282A load switch versions are designed to operate from 1.5 V up to 6.5 V, making them ideal for both 3 V and 5 V systems. Input logic levels are TTL and 2.5 V to 5 V CMOS compatible. The quiescent supply current is a very low 1 μA.

The AAT4282A is available in the Pb-free, low profile, 8-pin 2.0 mm × 2.0 mm FTDFN package and is specified over the –40 °C to 85 °C ambient temperature range.

A typical application circuit is shown in Figure 1. The pin configurations are shown in Figure 2. Signal pin assignments and selector guide are provided in Tables 1 and 2.

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.

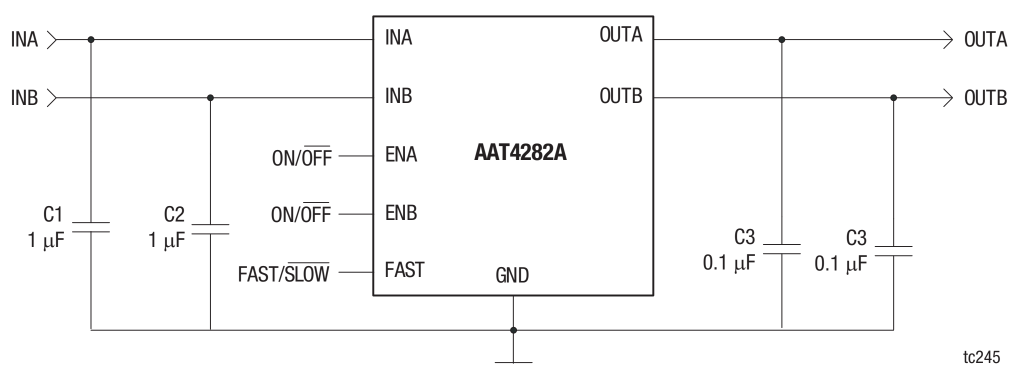

Figure 1. AAT4282A Typical Application Circuit

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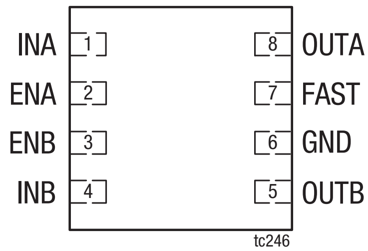


Figure 2. AAT4282A Pinout – 8-Pin, 2.0 mm × 2.0 mm FTDFN (Top View)

Table 1. AAT4282A Signal Descriptions

Pin Number	Name	Description
1	INA	This is the pin to the P-channel MOSFET source for Switch A. Bypass to ground through a 1 μF 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 1 μA 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 1 μA 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 1 μF capacitor. INB is independent of INA.
5	OUTB	This is the pin to the P-channel MOSFET drain connection. Bypass to ground through a 0.1 μF 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 0.1 μF capacitor.

Table 2. AAT4282A Selector Guide

Part Number	Slew Rate (Typ)		Active Pull-Down	Enable
	FAST (H)	*SLOW (L)*		
AAT4282A-1 (Note 1)	1 ms		NO	Active High
AAT4282A-2 (Note 1)	0.5 μs		NO	Active High
AAT4282A-3	100 μs	1 ms	YES	Active High

Note 1: Parts not available in stock, but can be ordered.

Electrical and Mechanical Specifications

The absolute maximum ratings of the AAT4282A are provided in Table 3, the thermal information is listed in Table 4, and electrical specifications are provided in Table 5.

Table 3. AAT4282A Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Minimum	Maximum	Units
IN to GND	V_{IN}	–0.3	+7	V
EN, FAST to GND	V_{EN}, V_{FAST}	–0.3	+7	V
OUT to GND	V_{OUT}	–0.3	V_{IN} + 0.3	V
Maximum continuous switch current	I_{MAX}		3	A
Maximum pulsed current (duty cycle ≤ 10%)	I_{DM}		5.5	A
Operating junction temperature range	T_J	–40	150	°C
Maximum soldering temperature (at leads)	T_{LEAD}		300	°C
Electrostatic discharge: Human Body Model (HBM), Class 3A (Note 2)	ESD		4000	V

Note 1: Exposure to maximum rating conditions for extended periods may reduce device reliability. There is no damage to device with only one parameter set at the limit and all other parameters set at or below their nominal value. Exceeding any of the limits listed may result in permanent damage to the device.

Note 2: Human Body Model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin.

Table 4. AAT4282A Thermal Information (Note 1)

Parameter	Symbol	Value	Units
Maximum thermal resistance	θ_{JA}	70	°C/W
Maximum power dissipation	P_D	1.78	W

Note 1: Mounted on a AAT4282A demo board in still 25 °C air.

CAUTION: *Although this device is designed to be as robust as possible, electrostatic discharge (ESD) can damage this device. This device must be protected at all times from ESD. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD precautions should be used at all times.*

Table 5. AAT4282A Electrical Specifications (Note 1)
(V_{IN} = 5 V, T_A = –40 °C to +85°C, Unless Otherwise Noted, Typical Values are T_A = 25 °C, Per Channel)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Operation voltage	V_{IN}		1.5		6.5	V
Quiescent current	I_Q	ON/OFF = Active, V_{FAST} = V_{IN}, I_{OUT} = 0 A			1.0	μA
Off supply current	$I_{Q(OFF)}$	ON/OFF = Inactive, OUT = Open			1.0	μA
Off switch current	$I_{SD(OFF)}$	ON/OFF = GND, V_{OUT} = 0 V			1.0	μA
On-resistance A or B	$R_{DS(ON)}$	V_{IN} = 6.5 V		56		Ω
		V_{IN} = 5 V		60	130	Ω
		V_{IN} = 4.2 V		65	140	Ω
		V_{IN} = 3.0 V		76	160	Ω
		V_{IN} = 1.80 V		110	230	Ω
		V_{IN} = 1.5 V		140	280	Ω
On resistance temperature coefficient	TCR_{RDS}			2800		ppm/°C
ON/OFF input logic low voltage	V_{IL}	V_{IN} = 1.5 V			0.4	V
ON/OFF input logic high voltage	V_{IH}	V_{IN} = 5 V	1.4			V
ON/OFF input leakage	I_{SINK}	$V_{SD/OFF}$ = 5.5 V			1.0	μA
AAT4282A-1 (Note 2)						
Output turn-on delay time	$t_{D(ON)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C		20	40	μs
Turn-on rise time	t_{ON}	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C		1000	1500	μs
Output turn-off delay time	$t_{D(OFF)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C		4.0	10	μs
AAT4282A-2 (Note 2)						
Output turn-on delay time	$t_{D(ON)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C		0.5	2	μs
Turn-on rise time	t_{ON}	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C		0.5	1.0	μs
Output turn-off delay time	$t_{D(OFF)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C		4.0	10	μs
AAT4282A-3						
Output turn-on delay time	$t_{D(ON)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C		20	40	μs
Turn-on rise time	t_{ON}	V_{IN} = 5 V, R_{LOAD} = 10 Ω, V_{FAST} = 5 V, T_A = 25 °C		100	150	μs
Turn-on rise time	t_{ON}	V_{IN} = 5 V, R_{LOAD} = 10 Ω, V_{FAST} = 0 V, T_A = 25 °C		1000	1500	μs
Output turn-off delay time	$t_{D(OFF)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C		4.0	10	μs
Output pull-down resistance during OFF	R_{PD}	ON/OFF = Inactive, T_A = 25 °C		150	250	Ω

Note 1: Performance is guaranteed only under the conditions listed in this table.

Note 2: Contact factory for other turn on and delay options.

Typical Performance Characteristics

(V_{IN} = 5 V, T_A = –40 °C to +85 °C, Unless Otherwise Noted, Typical Values are T_A = 25 °C, Per Channel)

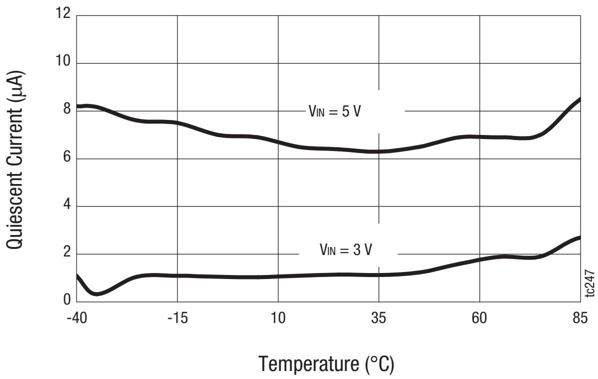


Figure 3. Quiescent Current vs Temperature (No Load; Single Switch)

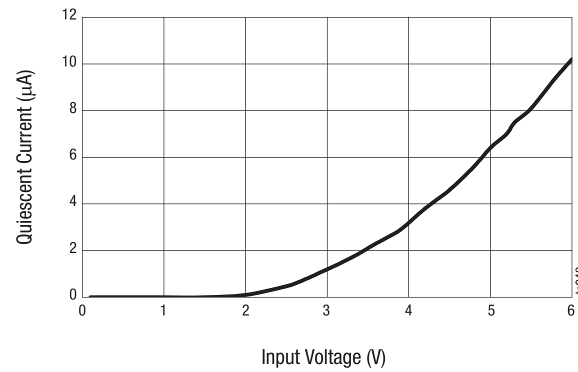


Figure 4. Quiescent Current vs Input Voltage (No Load; Single Switch)

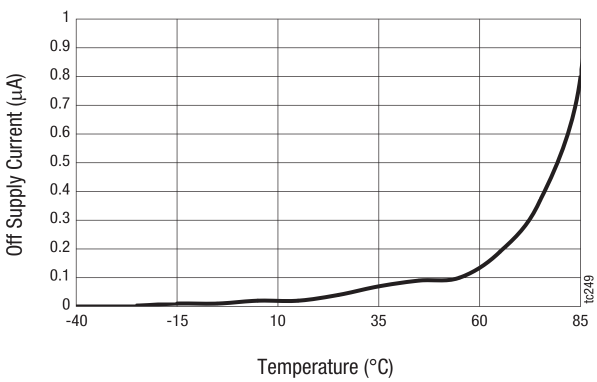


Figure 5. Off Supply Current vs Temperature (No Load; EN = GND; V_{IN} = 5.0 V)

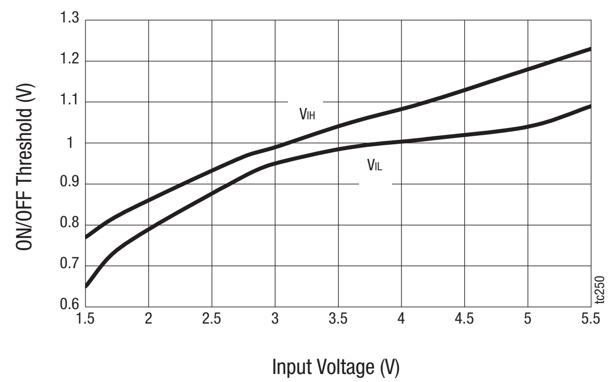


Figure 6. Typical ON/OFF Threshold vs Input Voltage

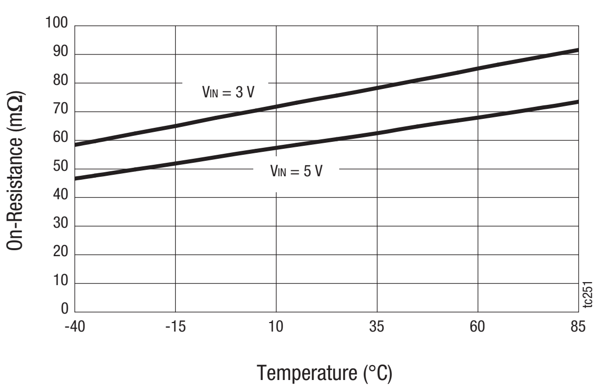


Figure 7. On-Resistance vs Temperature

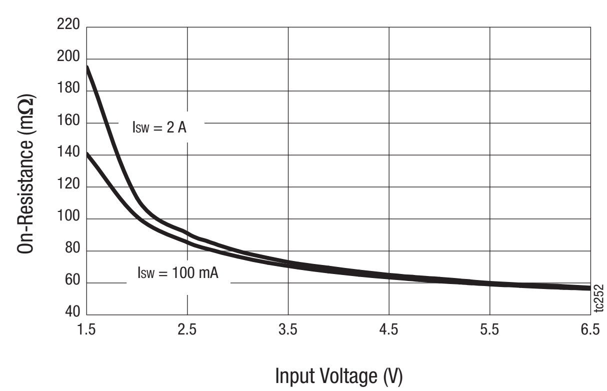


Figure 8. On-Resistance vs Input Voltage

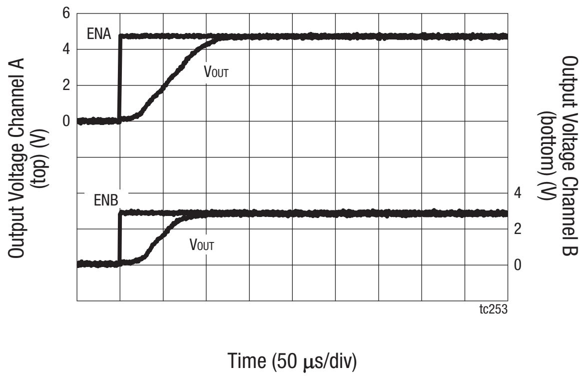


Figure 9. Output Turn-On Delay Time (V_{INA}/V_{ENA} = 5 V, V_{INB}/V_{ENB} = 3 V, R_{LA} = 10 Ω, R_{LB} = 20 Ω)

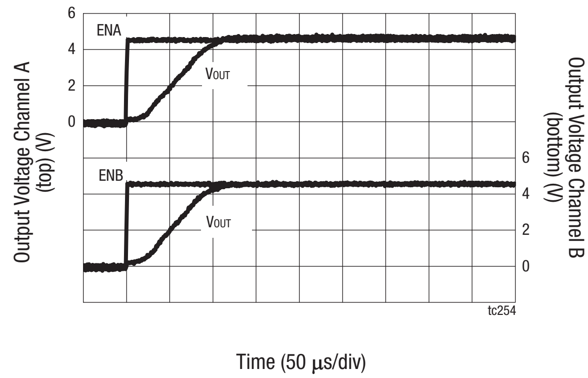


Figure 10. Output Turn-On Delay Time ($V_{INA}/V_{INB}/V_{EN}$ = 5 V, R_L = 10 Ω)

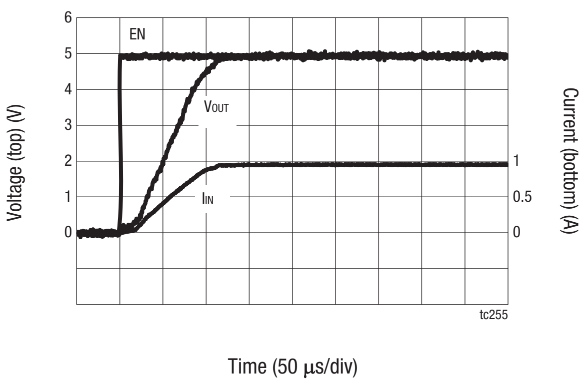


Figure 11. Output Turn-On Delay Time (V_{IN} = 5 V, R_L = 10 Ω)

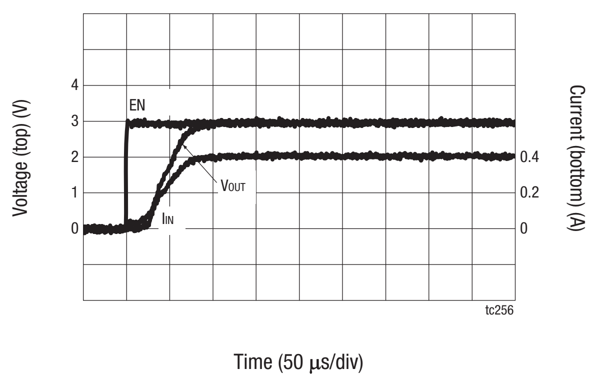


Figure 12. Output Turn-On Delay Time (V_{IN} = 3 V, R_L = 20 Ω)

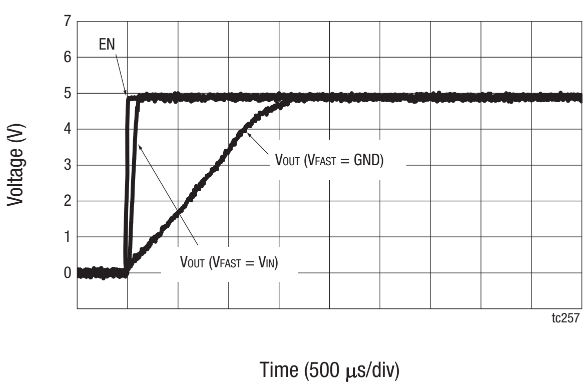


Figure 13. Output Turn-On (R_L = 10 Ω)

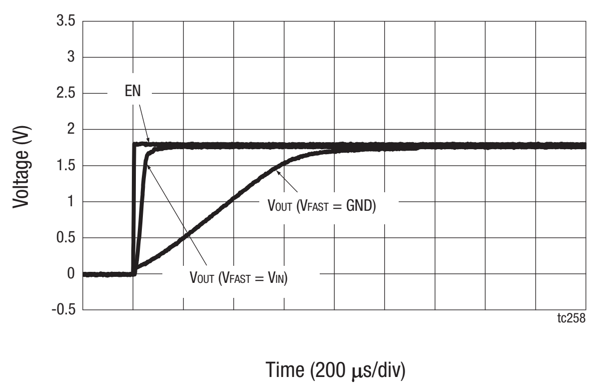


Figure 14. Output Turn-On (V_{IN} = 1.8 V, R_L = 10 Ω)

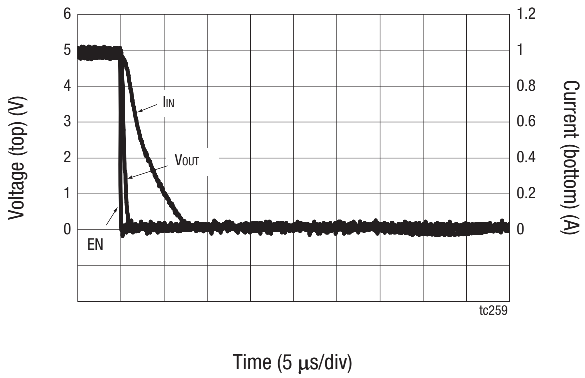


Figure 15. Output Turn-Off Delay Time (V_{IN} = 5 V, R_L = 10 Ω)

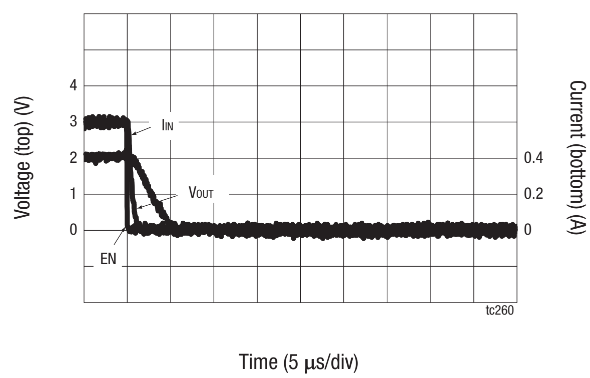


Figure 16. Output Turn-Off Delay Time (V_{IN} = 3 V, R_L = 20 Ω)

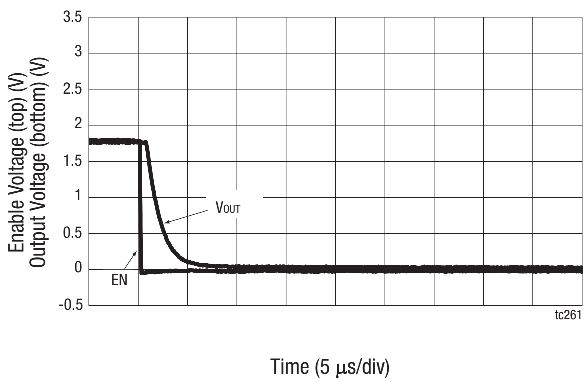


Figure 17. Output Turn-Off Delay Time (V_{IN} = 1.8 V, R_L = 10 Ω)

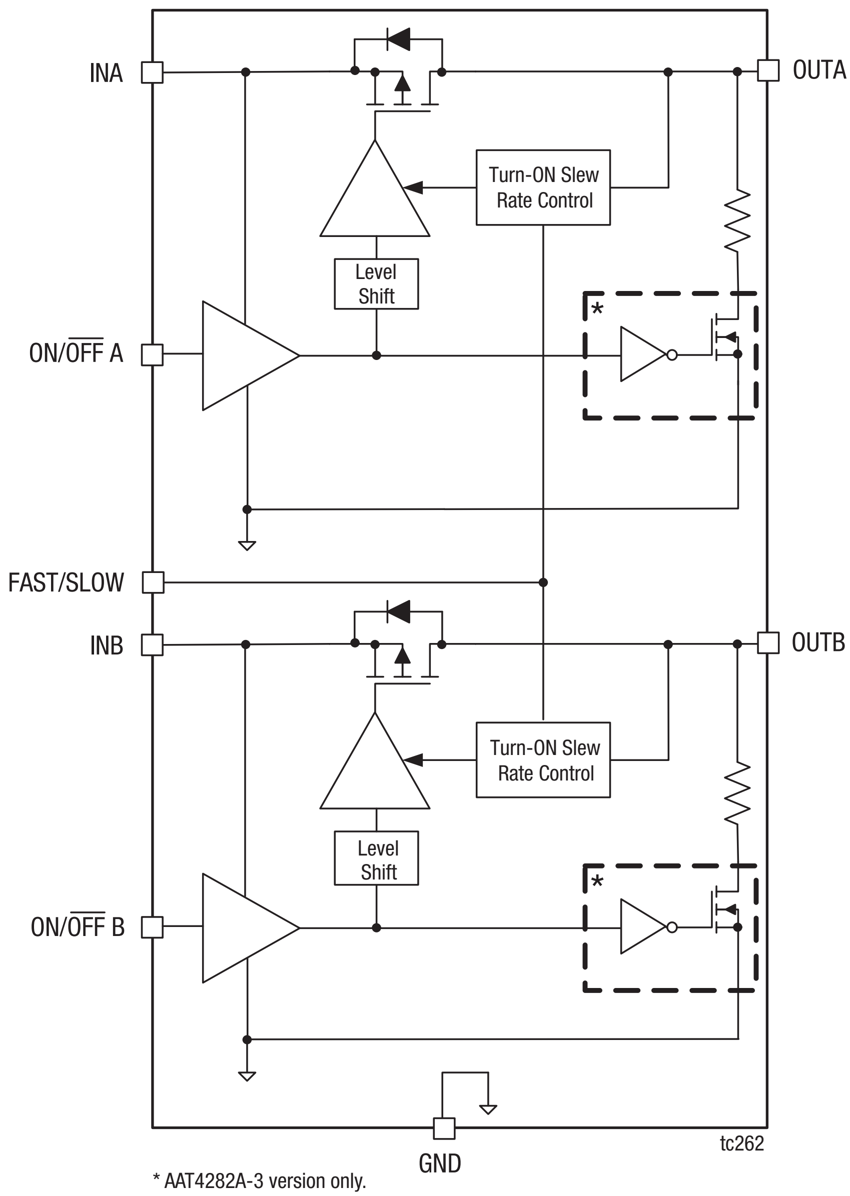


Figure 18. AAT4282A Functional Block Diagram

Functional Description

The AAT4282A is a family of flexible dual P-channel MOSFET power switches designed for high-side load switching applications. There are three versions of the AAT4282A with different turn-on and turn-off characteristics to choose from, depending upon the specific requirements of an application. The first version, the AAT4282A-1, has a moderate turn-on slew rate feature, which reduces in-rush current when the MOSFET is turned on. This function allows the load switch to be implemented with either a small input capacitor or no input capacitor at all. 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 second version, AAT4282A-2, is a very fast switch intended for high-speed switching applications. This version has no turn-on slew rate control and no special output discharge features.

The final switch version, AAT4282A-3, has the addition of 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 AAT4282A-3, the device can be manually switched to a slower slew rate.

All versions of the AAT4282A operate with input voltages ranging from 1.5 V to 6.5 V. All versions of this device have extremely low operating current, making them ideal for battery-powered applications.

The ON/OFF control pin is TTL compatible and also functions with 2.5 V to 5 V logic systems, making the AAT4282A an ideal level-shifting load switch.

A functional block diagram is shown in Figure 18.

Application Information

Input Capacitor

A 1 μF or larger capacitor is 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 0.1 μF or greater capacitor is required between OUT 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 AAT4282A features an enable/disable function. This pin (EN) is active high and is compatible with TTL or CMOS logic. To assure the load switch turns on, the EN control level must be greater than 1.4 V. The load switch goes into shutdown mode when the voltage on the EN pin falls below 0.4 V. When the load switch is in shutdown mode, the OUT pin is tri-stated, and quiescent current drops to leakage levels below 1 μF.

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 OUT 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 0.45 V.

Thermal Considerations and High Output Current Applications

The AAT4282A 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 assumes 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 AAT4282A are maximum junction temperature ($T_{J(MAX)}$ = 125 °C, please note that the actual maximum junction temperature of AAT4282A 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) and package thermal resistance (θ_{JA} = 70 °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, $P_{D(MAX)}$ = 571 mW.
At T_A = 25 °C, $P_{D(MAX)}$ = 1429 mW.

The maximum continuous output current for the AAT4282A 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 maximum room temperature R_{DS} by the R_{DS} temperature coefficient. The temperature coefficient (T_C) is 2800 ppm/°C. Therefore, at 125°C:

$$R_{DS(MAX)} = R_{DS(25\,°C)} \times (1 + T_C \times \Delta T)\ (\Omega)$$

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

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

For maximum current, refer to the following equation:

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

For example, if V_{IN} = 5 V, $R_{DS(MAX)}$ = 166.4 mΩ, and T_A = 25 °C, $I_{OUT(MAX)}$ = 2.93 A. If the output load current were to exceed 2.93 A 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 AAT4282A. 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 2 ms in duration can be considered using the method described in the High Peak Output 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 Table 3 to ensure that the AAT4282A'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 4 V system using an AAT4282A which has channel A operates at a continuous 1 A load current level, and channel B operates at a continuous 100 mA load current level and has short 3 A current peaks, as in a GSM application. The current peak occurs for 576 µs out of a 4.61 ms period. First, the current duty cycle is calculated:

$$\%Peak\ Duty\ Cycle = \left(\frac{x}{100}\right) = \left(\frac{576\mu s}{4.61ms}\right)$$

$$\%Peak\ Duty\ Cycle = 12.5\%$$

The load current is 100 mA for 87.5% of the 4.61 ms period and 3 A for 12.5% of the period. Since the Electrical Characteristics do not report $R_{DS(MAX)}$ for 4 V operation, it must be approximated by consulting the chart of $R_{DS(ON)}$ vs V_{IN}. The R_{DS} reported for 5 V at 100 mA and 3 A can be scaled by the ratio seen in the chart to derive the R_{DS} for 4 V V_{IN} at 25 °C:

$$130m\Omega \times 63m\Omega / 60m\Omega = 136.5m\Omega$$

Derated for temperature:

$$136.5\ m\Omega \times (1 + 0.002800 \times (125\ °C - 25\ °C)) = 174.7\ m\Omega.$$

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

$$P_{D(CHA)} = I^2_{OUT} \times R_{DS} = (1A)^2 \times 174.7m\Omega = 174.7mW$$

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

$$P_{D(MAX)} = I^2_{OUT} \times R_{DS}$$

$$P_{D(100mA)} = (100mA)^2 \times 174.7m\Omega$$

$$P_{D(100mA)} = 1.75mW$$

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

$$P_{D(87.5\%D/C)} = 0.875 \times 1.75mW$$

$$P_{D(87.5\%D/C)} = 1.53mW$$

The power dissipation for 100 mA load at 87.5% duty cycle is 1.53 mW. Now the power dissipation for the remaining 12.5% of the duty cycle at 3 A is calculated:

$$P_{D(MAX)} = I^2_{OUT} \times R_{DS}$$

$$P_{D(3A)} = (3A)^2 \times 174.7m\Omega$$

$$P_{D(3A)} = 1572mW$$

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

$$P_{D(12.5\%D/C)} = 0.125 \times 1572mW$$

$$P_{D(12..5\%D/C)} = 196.7mW$$

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

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

$$P_{D(Total)} = 174.7mW + 1.53mW + 196.7mW$$

$$P_{D(Total)} = 373mW$$

The maximum power dissipation for the AAT4282A operating at an ambient temperature of 85 °C is 373 mW. The device in this example has a total power dissipation of 571 mW. This is well within the thermal limits for safe operation of the device; in fact, at 85 °C, the AAT4282A handles a 3 A pulse for up to 25% 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 AAT4282A:

- V_{IN} and V_{OUT} should be routed using wider than normal traces
- 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 Description

The AAT4282A Evaluation Board is used to test the performance of the AAT4282A. An Evaluation Board schematic diagram is provided in Figure 19. Layer details for the Evaluation Board are shown in Figure 20.

Package Information

Package dimensions for the 8-pin FTDFN package are shown in Figure 21. Tape and reel dimensions are shown in Figure 22.

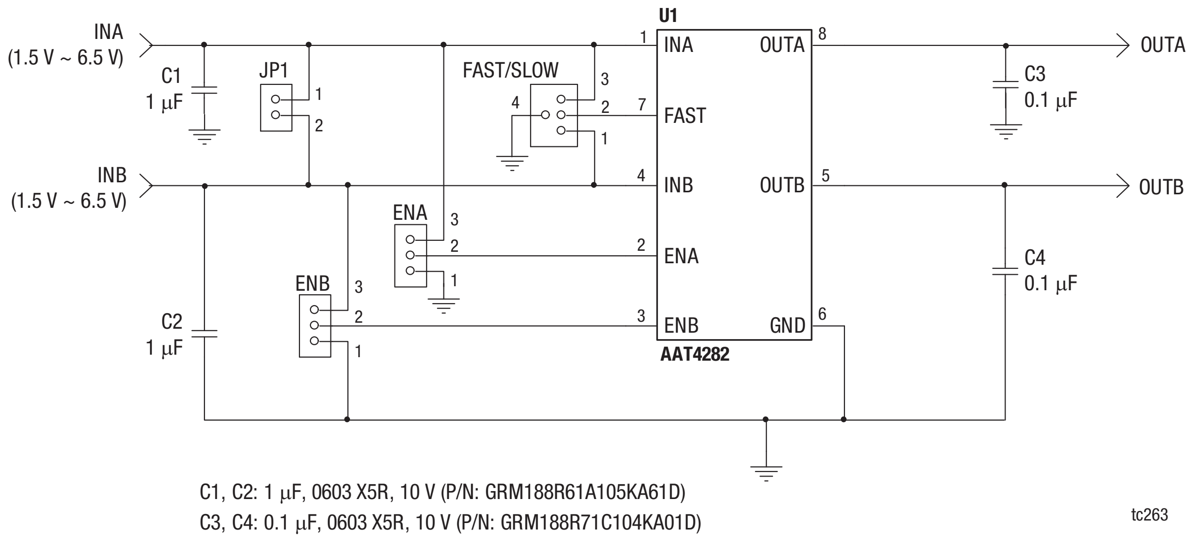
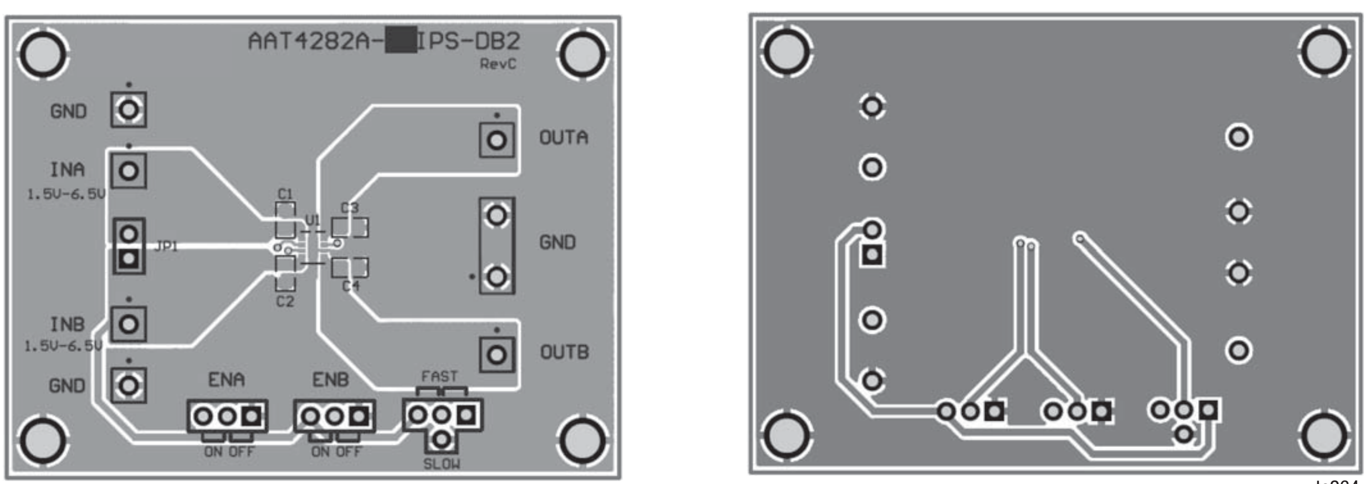


Figure 19. AAT4282A Evaluation Board Schematic



(a) Top Side

(b) Bottom Side

Figure 20. AAT4282A Evaluation Board Layer Details

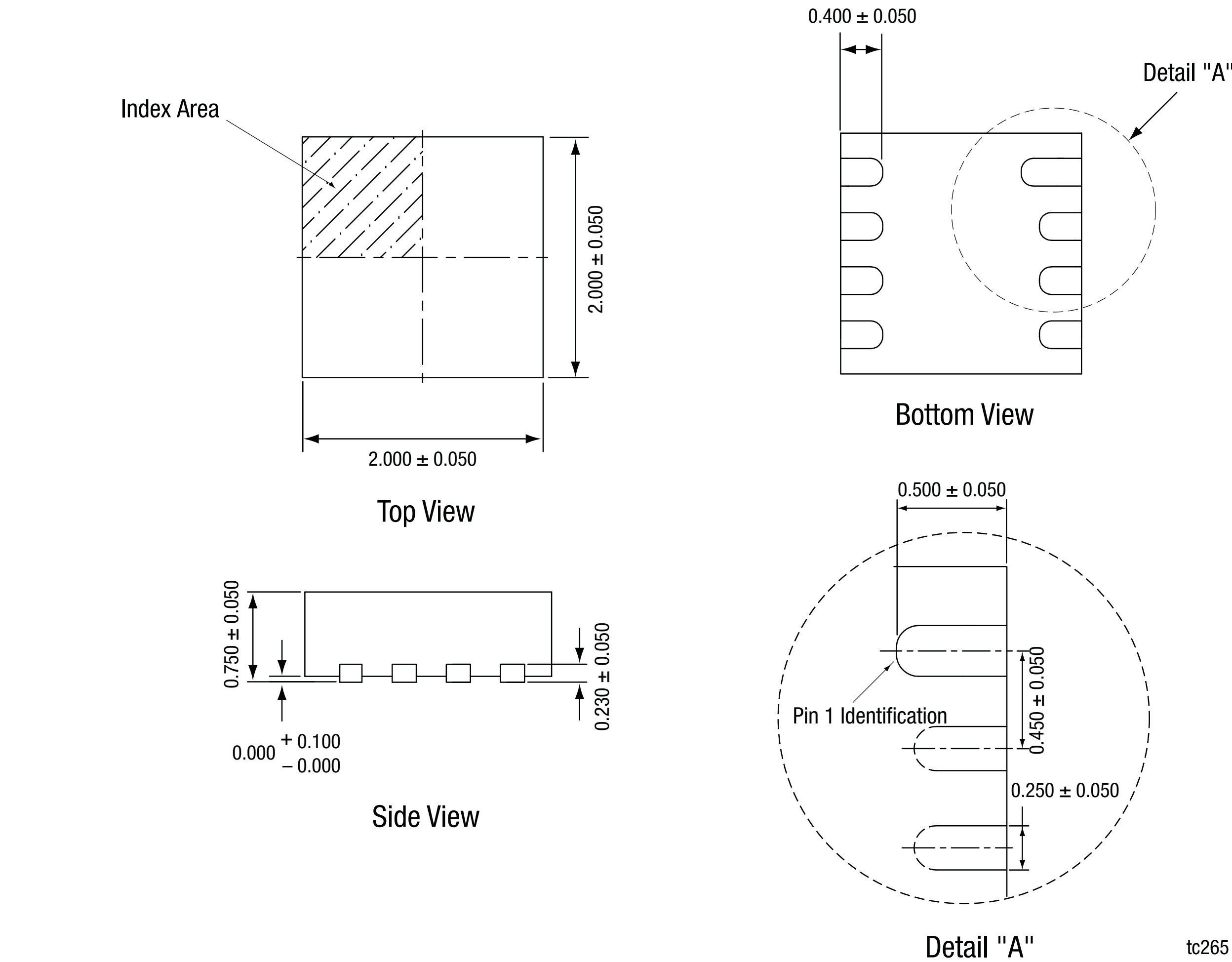
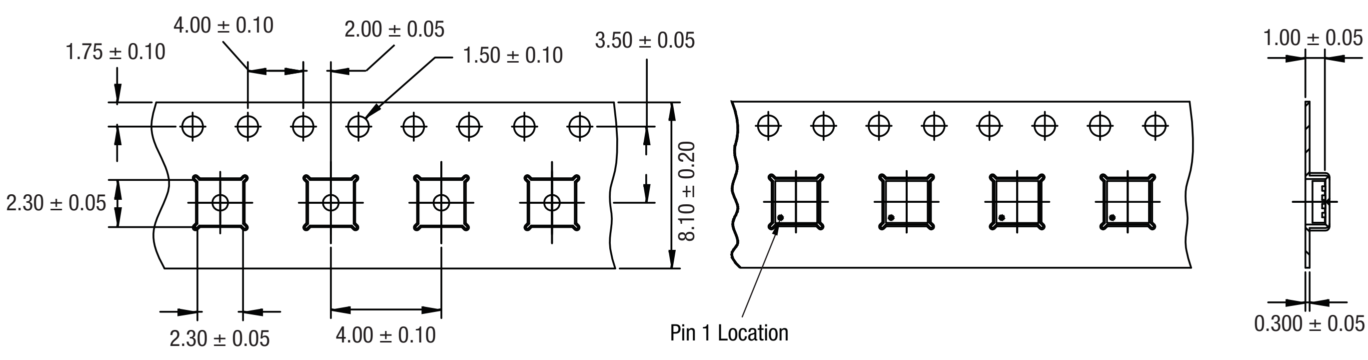


Figure 21. AAT4282A 8-pin FTDFN Package Dimensions



All dimensions are in millimeters.

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Figure 22. AAT4282A Tape and Reel Dimensions

Ordering Information

Model Name	Part Marking (Note 1)	Manufacturing Part Number (Note 2)	Evaluation Board Part Number
AAT4282A slew rate controlled load switch	WKXYY	**AAT4282AIPS-3-T1**	AAT4282AIPS-3-EVB

Note 1: XYY = assembly and date code.

Note 2: Sample stock is generally held on part numbers listed in **BOLD**.