

**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications**

## General Description

The AAT4681 SmartSwitch enables separate stand-alone AC adapter and PMU USB chargers to independently control a single low  $R_{DS(ON)}$  power MOSFET between battery and system power output. A 20V version is available for multi-cell Li-ion applications and a 6V version is available for single-cell Li-ion applications.

The two P-channel power MOSFETs required in UMPC applications for controlling independent charger ICs can be consolidated to a single device, saving space and reducing cost. The single 20mΩ P-channel device in the AAT4681/-1 has four times lower  $R_{DS(ON)}$  than the equivalent path resistance formed by two series devices.

Ordering options are available for multi-cell and single-cell Li-ion versions. For the single-cell application, a 6V device with dual independent gate control is available. For 2-cell and 3-cell applications a 20V ordinary P-channel device is available in the same package and pin configuration. Both devices are available in the TDFN-10L 3mm x 3mm package.

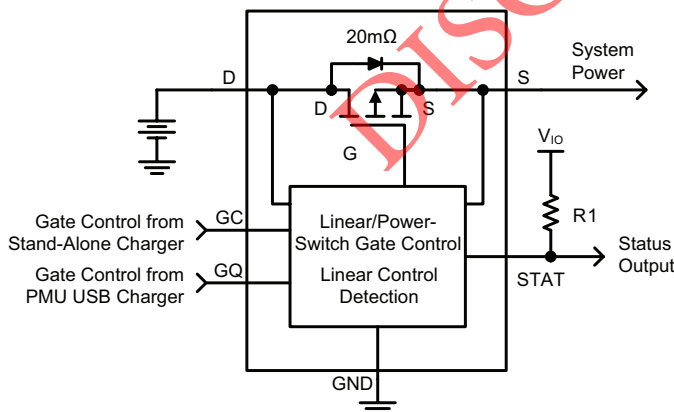
## Features

- Multi-Cell 20V Device and Single-Cell 6V Device
- Dual Independent Gate Controls
  - Independent Linear Regulator and SMPS Power Switch States are Maintained
- 3mm x 3mm TDFN-10L package
- Temperature Range: -40°C to 85°C

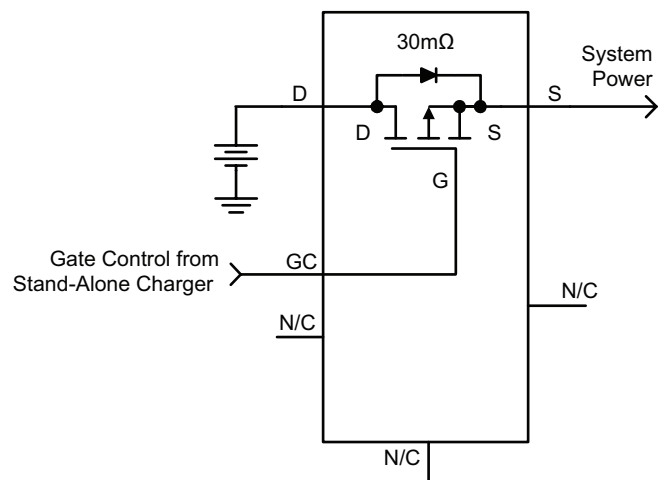
## Applications

- Smart Phones
- Sub Notebooks
  - Smartbooks
  - Netbooks
- Ultra-Mobile PCs
- Wireless Media Devices

## Typical Application



**AAT4681, AAT4681-1**



**AAT4681-2**

# AAT4681

## 20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications

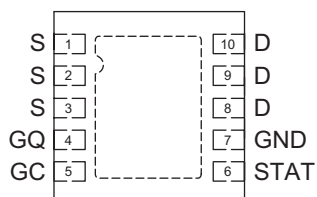
### Pin Descriptions

| Pin #    | Pin Name   |           | Function                                                                                               |
|----------|------------|-----------|--------------------------------------------------------------------------------------------------------|
|          | AAT4681/-1 | AAT4681-2 |                                                                                                        |
| 1, 2, 3  | S          | S         | Source connection.                                                                                     |
| 4        | GQ         | N/C       | Gate control from PMU charger.                                                                         |
| 5        | GC         | GC        | Gate control from stand-alone charger.                                                                 |
| 6        | STAT       | N/C       | Open drain status output. "STAT" signal "high" means QC is "on" and "STAT" signal low means GQ is "on" |
| 7        | GND        | N/C       | Ground connection                                                                                      |
| 8, 9, 10 | D          | D         | Drain connection.                                                                                      |

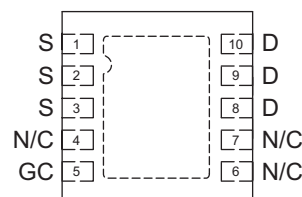
### Pin Configuration

**TDFN33-10L**  
(Top View)

**AAT4681/-1**



**AAT4681-2**



**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications****Absolute Maximum Ratings<sup>1</sup>**

| Symbol                    | Description                                         | Value                    | Units     |
|---------------------------|-----------------------------------------------------|--------------------------|-----------|
| <b>AAT4681, AAT4681-1</b> |                                                     |                          |           |
| $V_D, V_S$                | Drain or Source Voltage to GND                      | 6.0                      | V         |
| $V_{STAT}$                | STAT to GND                                         | -0.3 to 6.0              | V         |
| $I_{STAT}$                | STAT Current                                        | 10                       | mA        |
| $V_{GC}, V_{GQ}$          | Gate Voltage Levels to GND                          | -0.3 to 6.0              | V         |
| $I_D$                     | Continuous Drain Current @ $T_A = 85^\circ\text{C}$ | AAT4681                  | $\pm 7$   |
|                           |                                                     | AAT4681-1                | $\pm 5$   |
| $I_{DM}$                  | Pulsed Drain Current <sup>2</sup>                   | $\pm 10$                 | A         |
| $I_S$                     | Continuous Source Current (Source-Drain Diode)      | -1.5                     | A         |
| <b>AAT4681-2</b>          |                                                     |                          |           |
| $V_{DS}$                  | Drain-Source Voltage                                | -20                      | V         |
| $V_{GS}$                  | Gate-Source Voltage                                 | $\pm 12$                 | V         |
| $I_D$                     | Continuous Drain Current                            | $T_A = 25^\circ\text{C}$ | $\pm 4.0$ |
|                           |                                                     | $T_A = 70^\circ\text{C}$ | $\pm 3.2$ |
| $I_{DM}$                  | Pulsed Drain Current                                | $\pm 24$                 | A         |
| $I_S$                     | Continuous Source Current (Source-Drain Diode)      | -1.5                     | A         |

**Thermal Characteristics<sup>3</sup>**

| Symbol                              | Description                                       | Value       | Units                     |
|-------------------------------------|---------------------------------------------------|-------------|---------------------------|
| $T_J$                               | Operating Junction Temperature Range              | -40 to +125 | $^\circ\text{C}$          |
| $T_{LEAD}$                          | Maximum Soldering Temperature (at leads, 10 sec.) | 300         | $^\circ\text{C}$          |
| <b>TDFN33-10L Thermal Impedance</b> |                                                   |             |                           |
| $\theta_{JA}$                       | Maximum Junction-to-Ambient Thermal Resistance    | 50          | $^\circ\text{C}/\text{W}$ |
| $P_D$                               | Maximum Power Dissipation <sup>4</sup>            | 2           | W                         |

1. Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

2. Pulse width <300μs, duty cycle <1%.

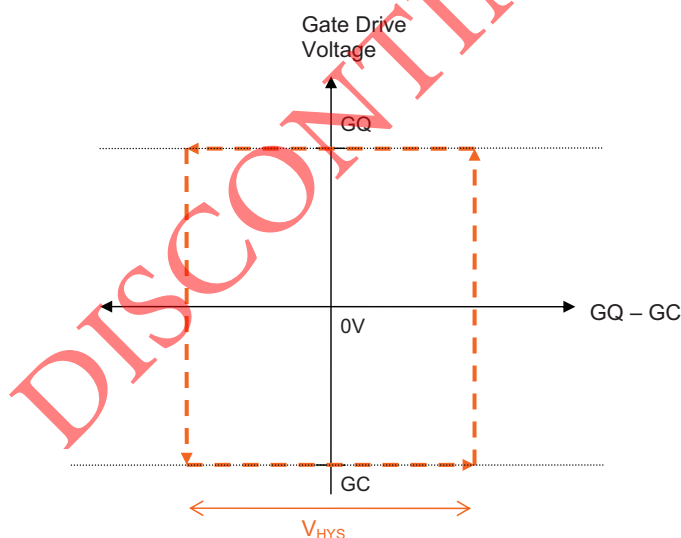
3.  $T_J$  is calculated from the ambient temperature  $T_A$  and power dissipation  $P_D$  according to the following formula:  $T_J = T_A + P_D \cdot \theta_{JA}$ .

4. Thermal Resistance is specified with approximately 1 square inch of 1 oz. copper.

**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications****Electrical Characteristics**

$T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , unless otherwise noted. Typical values are at  $T_A = +25^{\circ}\text{C}$ .

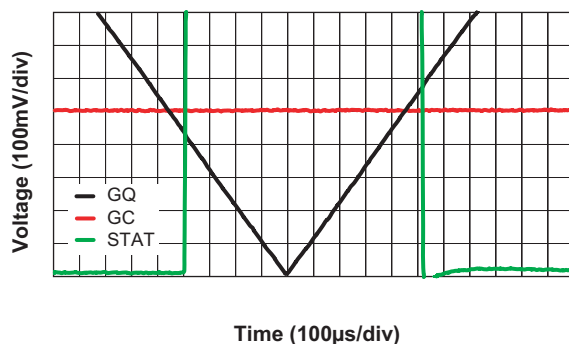
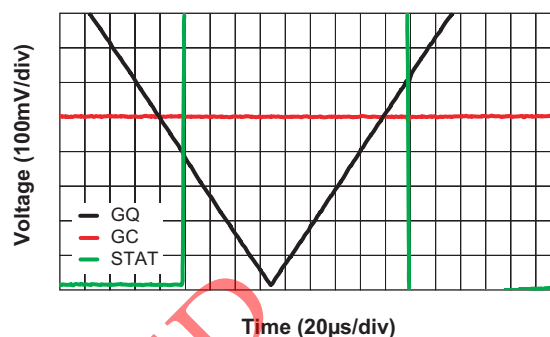
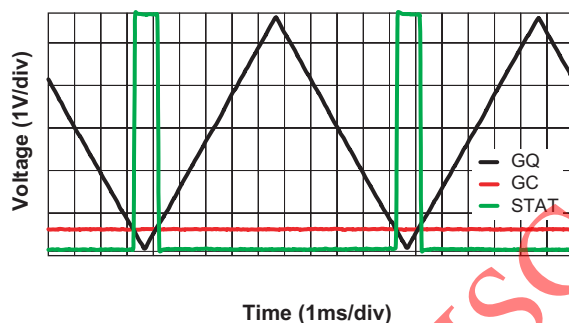
| Symbol            | Description                             | Conditions                                                                                               | Min | Typ   | Max | Units            |
|-------------------|-----------------------------------------|----------------------------------------------------------------------------------------------------------|-----|-------|-----|------------------|
| <b>AAT4681/-1</b> |                                         |                                                                                                          |     |       |     |                  |
| $V_{SYS}$         | Input Voltage Range <sup>1</sup>        |                                                                                                          | 1.8 |       | 5.5 | V                |
| $V_{UVLO}$        | Under-Voltage Lockout                   | For $V_{SYS} < V_{UVLO}$ , GC active                                                                     |     | 1.4   |     | V                |
| $I_Q$             | Quiescent Current                       | $V_D = 4.2\text{V}$ , $T_J = 55^{\circ}\text{C}$                                                         |     | 3.6   | 15  | $\mu\text{A}$    |
| $I_{DSS}$         | Drain-Source Leakage Current            | $V_{GS} = 0\text{V}$ , $V_{DS} = -5.5\text{V}$ , $T_J = 55^{\circ}\text{C}$                              |     |       | -5  | $\mu\text{A}$    |
| $R_{DS(on)}$      | P-Channel On Resistance <sup>2</sup>    | $V_D = V_{GC} = 4.2\text{V}$ , $V_{GQ} = \text{GND}$ , $I_D = 5\text{A}$ ,<br>$T_A = 25^{\circ}\text{C}$ |     | 18    | 25  | $\text{m}\Omega$ |
|                   |                                         |                                                                                                          |     | 23    | 28  |                  |
| $V_{HYS}$         | GQ-GC Transition Hysteresis             |                                                                                                          |     |       | 300 | mV               |
| $t_{GSW}$         | GQ-GC Transition Delay                  | Slew rate of QG @ 1ms                                                                                    |     | 10    |     | $\mu\text{s}$    |
| $V_{STATLOW}$     | STAT Logic Output Low                   | $I_{STAT(SINK)} = 1\text{mA}$                                                                            |     | 0.025 | 0.4 | V                |
| $I_{STAT(SINK)}$  | STAT Logic High Leakage Current         | $V_{STAT} = 5.5\text{V}$ , $V_{GC} = 5.5\text{V}$ , $V_{GQ} = \text{GND}$                                |     | 0.005 | 1   | $\mu\text{A}$    |
| <b>AAT4681-2</b>  |                                         |                                                                                                          |     |       |     |                  |
| $BV_{DSS}$        | Drain-Source Breakdown Voltage          | $V_{GS} = 0\text{V}$ , $I_D = -250\mu\text{A}$                                                           | -20 |       |     | V                |
| $R_{DS(ON)}$      | Drain-Source On-Resistance <sup>2</sup> | $V_{GS} = -4.5\text{V}$ , $I_D = -4.0\text{A}$                                                           |     | 27    | 40  | $\text{m}\Omega$ |
| $I_{D(ON)}$       | On-State Drain Current                  | $V_{GS} = -4.5\text{V}$ , $V_{DS} = -5\text{V}$ (pulse) <sup>2</sup>                                     | -24 |       |     | A                |
| $V_{GS(th)}$      | Gate Threshold Voltage                  | $V_{GS} = V_{DS}$ , $I_D = -250\mu\text{A}$                                                              |     | -0.8  |     | V                |



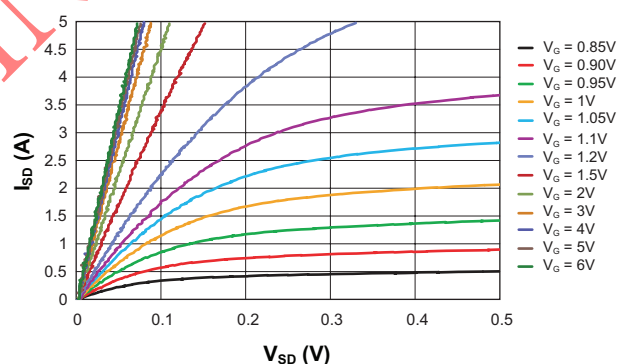
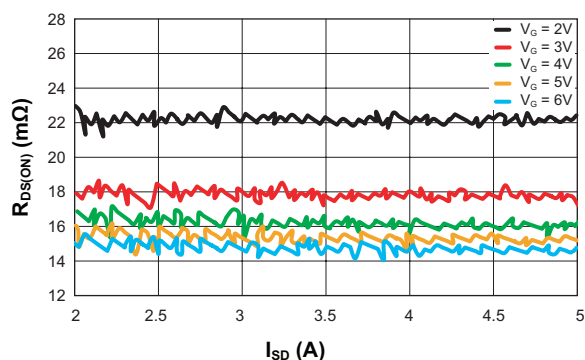
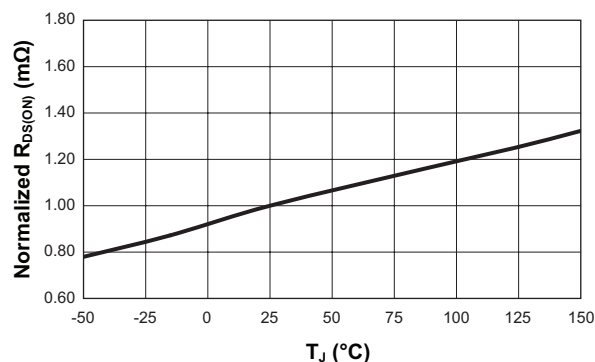
- Where  $V_{SYS}$  is the greater of  $V_D$  or  $V_S$ .
- Pulse width  $< 300\mu\text{s}$ , duty cycle  $< 1\%$ .

## 20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications

## AAT4681/-1 Typical Electrical Characteristics

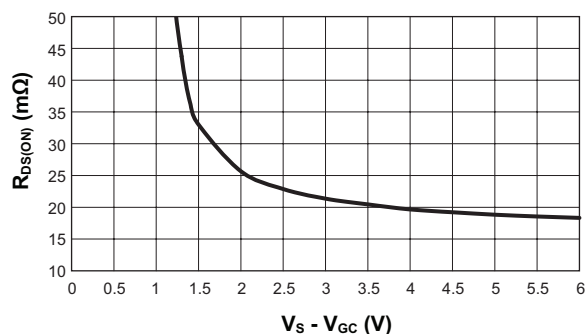
Hysteresis, GQ Ramp Time = 2.5ms  
(S = 5.5V; GC = 0.5V; R<sub>STAT</sub> = 5K; V<sub>IO</sub> = 5.5V)Hysteresis, GQ Ramp Time = 500μs  
(S = 5.5V; GC = 0.5V; R<sub>STAT</sub> = 5K; V<sub>IO</sub> = 5.5V)Timing  
(S = 5.5V; GC = 0.5V; GQ ramp time = 2.5ms;  
R<sub>STAT</sub> = 5K; V<sub>IO</sub> = 5.5V)

Shutdown Current vs. Shutdown Voltage

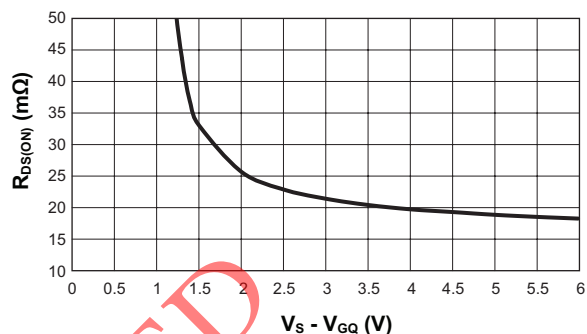
R<sub>DS(ON)</sub> vs. I<sub>SD</sub>On-Resistance vs. Junction Temperature  
(V<sub>S</sub> = 6V; I<sub>DS</sub> = 5A; Pulse width <300μs; Duty Cycle < 1%)

**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications****AAT4681/-1 Typical Electrical Characteristics****On-Resistance vs. Gate Voltage  $G_C$**  $V_S = 6V$ ;  $V_{GQ} = 0V$ ;  $I_{DS} = 5A$ ;

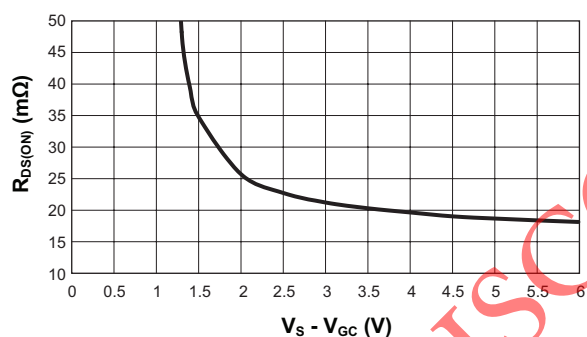
Pulse Width &lt; 300μs, Duty Cycle &lt; 1%)

**On-Resistance vs. Gate Voltage  $G_C$**  $V_S = 6V$ ;  $V_{GQ} = 0V$ ;  $I_{DS} = 5A$ ;

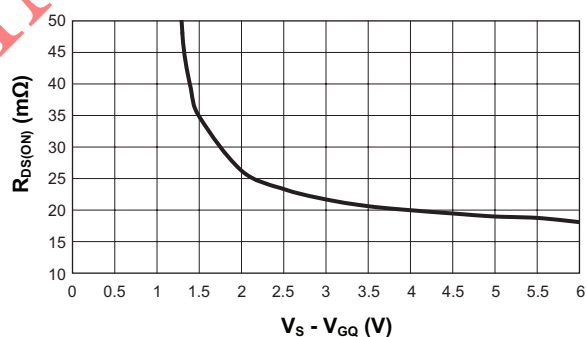
Pulse Width &lt; 300μs, Duty Cycle &lt; 1%)

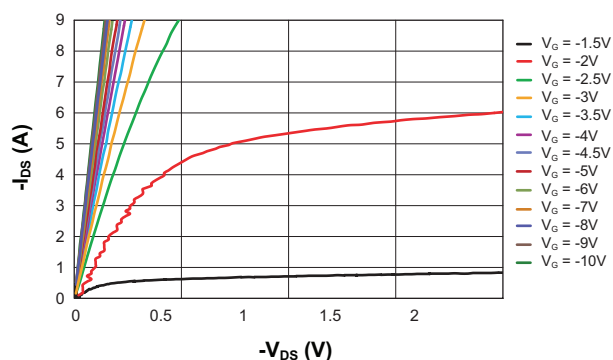
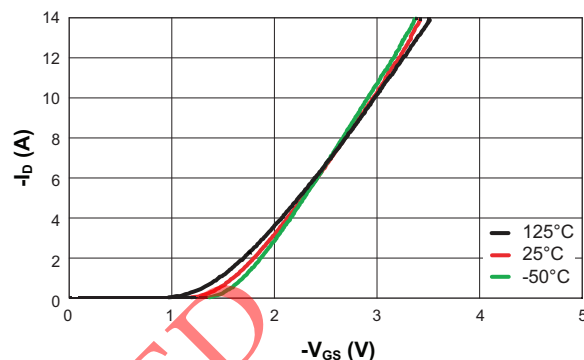
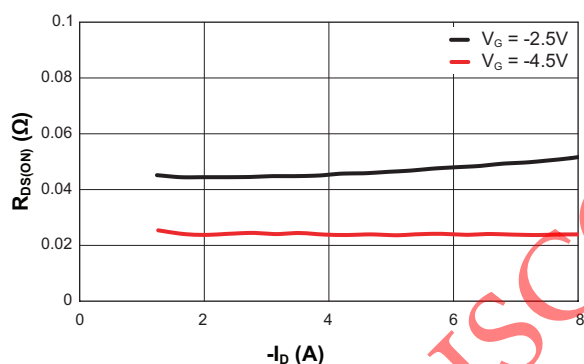
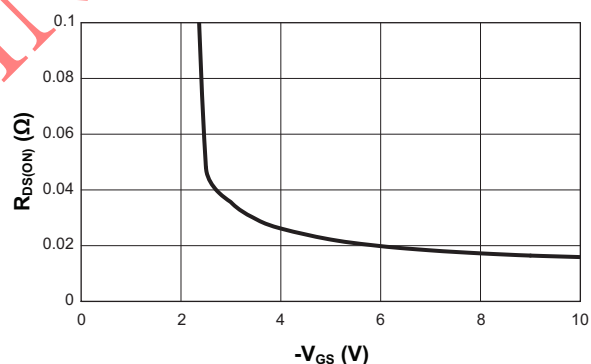
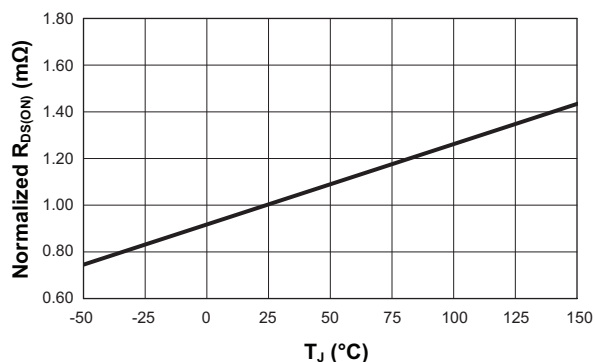
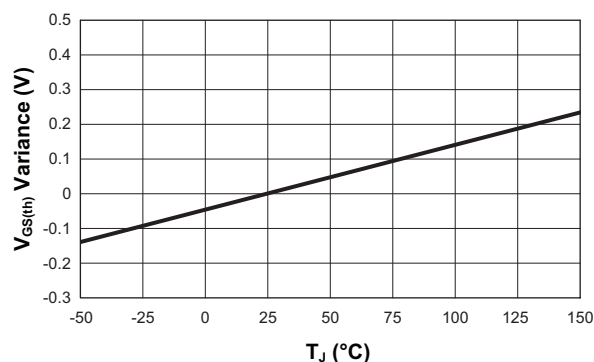
**On-Resistance vs. Gate Voltage  $G_C$**  $V_S = 6V$ ;  $V_{GQ} = 0V$ ;  $I_{DS} = 7A$ ;

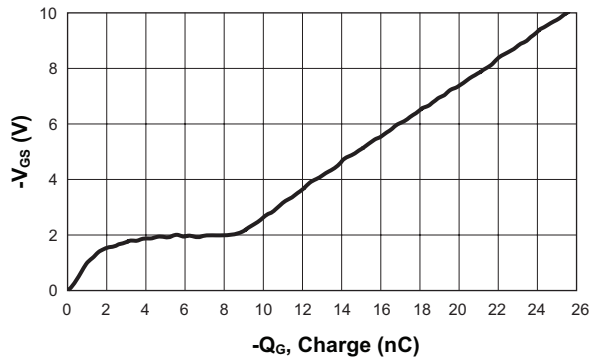
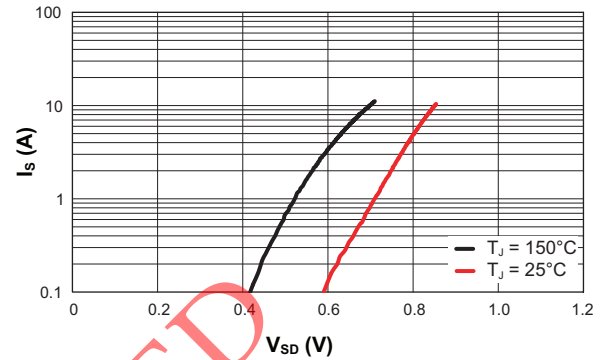
Pulse Width &lt; 300μs, Duty Cycle &lt; 1%)

**On-Resistance vs. Gate Voltage  $G_Q$**  $V_S = 6V$ ;  $V_{GQ} = 0V$ ;  $I_{DS} = 7A$ ;

Pulse Width &lt; 300μs, Duty Cycle &lt; 1%)



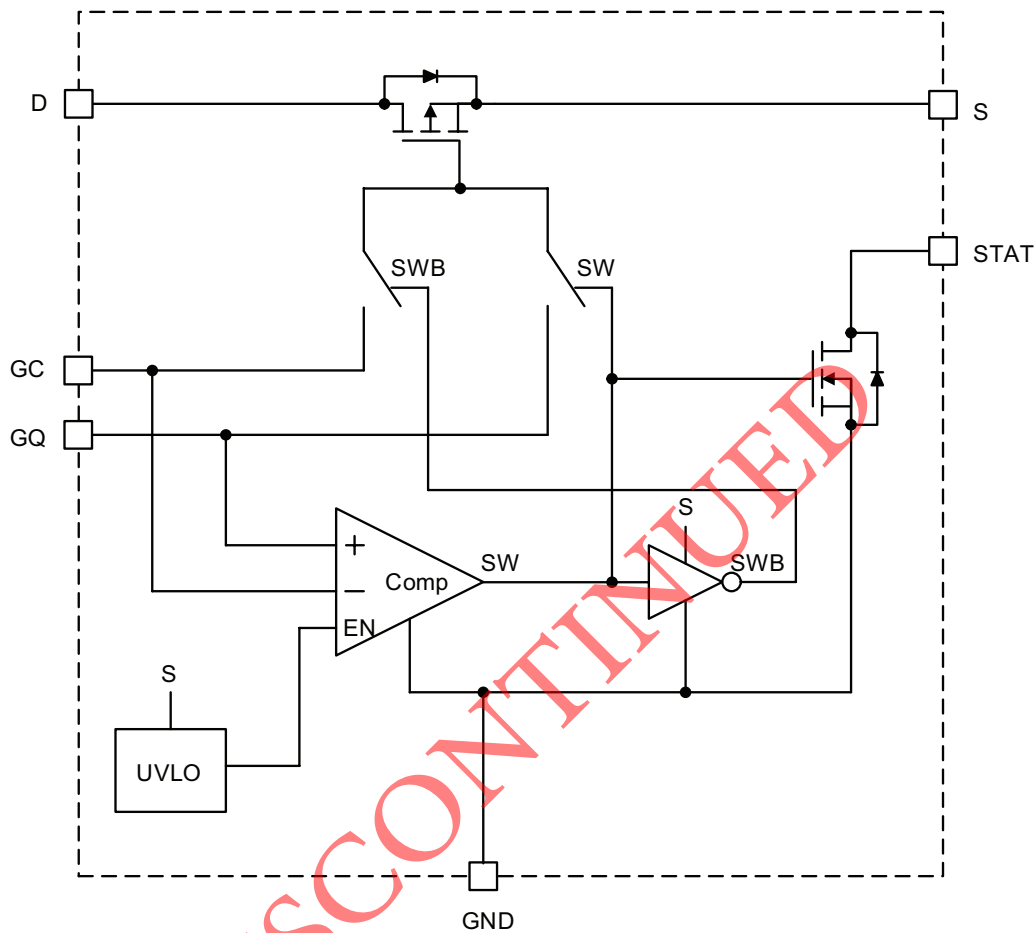
**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications****AAT4681-2 Typical Electrical Characteristics****Output Characteristics****Transfer Characteristics****On-Resistance vs. Drain Current****On-Resistance vs. Gate-Source Voltage****On-Resistance vs. Junction Temperature**  
( $V_{GS} = -4.5V$ ;  $I_D = -5.9A$ )**Threshold Voltage vs. Junction Temperature**

**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications****AAT4681-2 Typical Electrical Characteristics****Gate Charge****Source-Drain Diode Forward Voltage**

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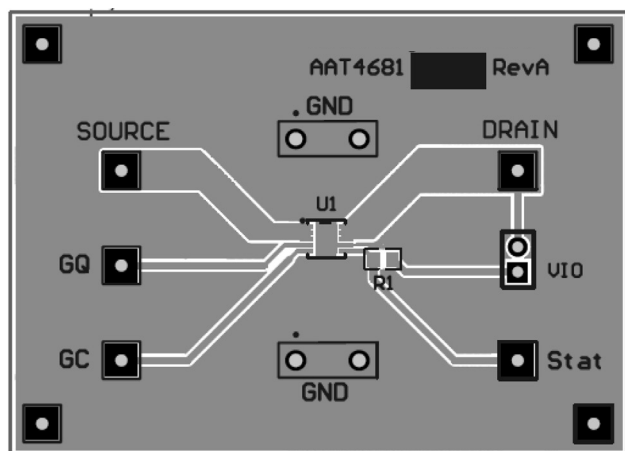


## Functional Block Diagram

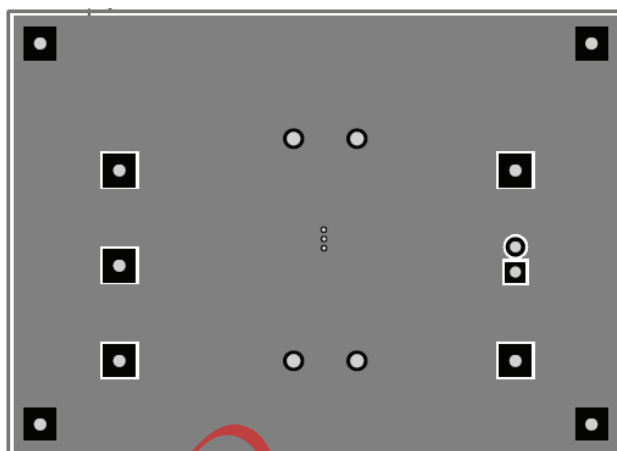


| GC<br>(Gate Control from<br>Stand-Alone Charger) | GQ<br>(Gate Control from<br>PMU USB Charger) | P-Ch Gate Voltage Control Source |
|--------------------------------------------------|----------------------------------------------|----------------------------------|
| Vin                                              | Vin                                          | GC                               |
| Linear                                           | 0V                                           | GC                               |
| 0V*                                              | Linear                                       | GQ                               |
| 0V                                               | 0V                                           | GC                               |
| float                                            | float                                        | GC                               |

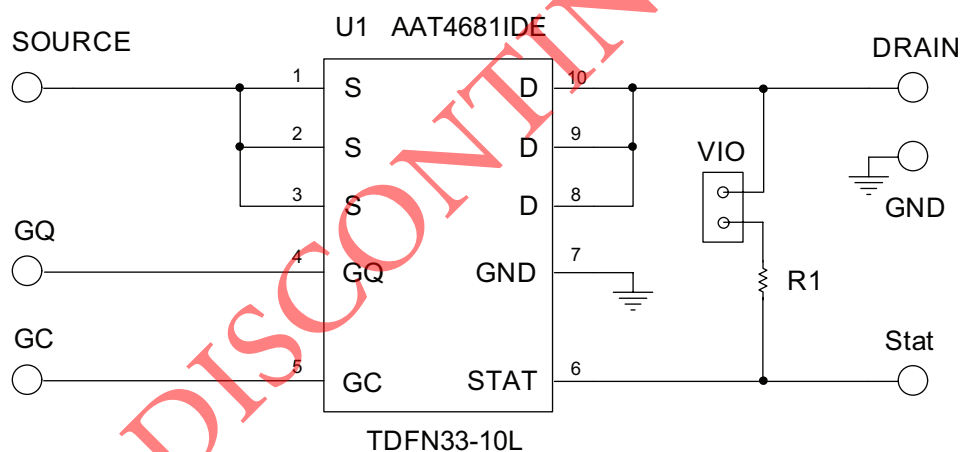
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**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications**

**Figure 1: AAT4681IDE Evaluation Board  
Top Side Layout.**



**Figure 2: AAT4681IDE Evaluation Board  
Bottom Side Layout**



**Figure 3: AAT4681IDE Evaluation Board Schematic.**

**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications****Ordering Information**

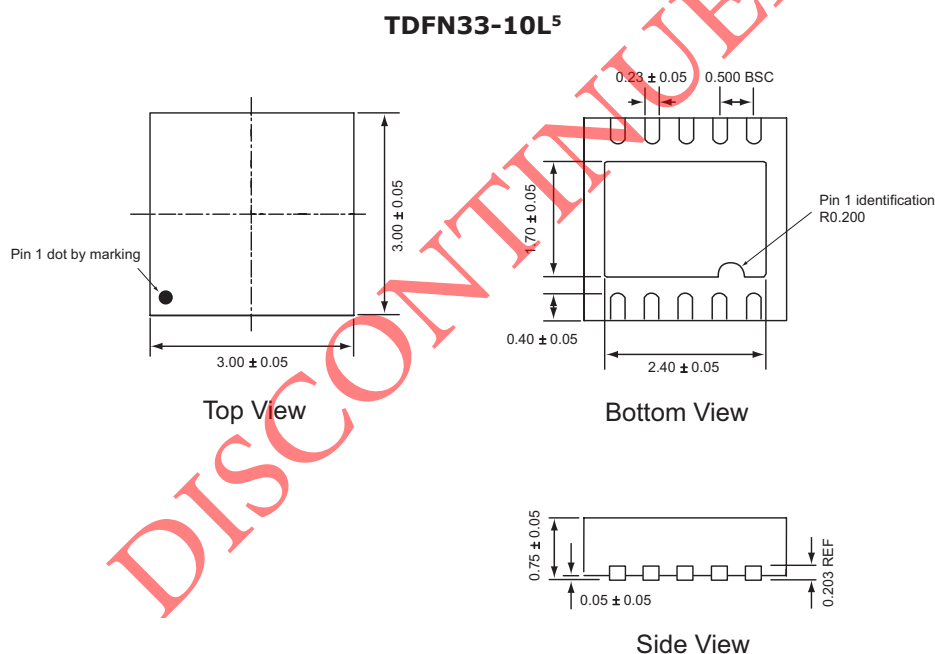
| Package    | Marking <sup>1</sup> | Continuous Drain Current (A) | Part Number (Tape and Reel) <sup>2</sup> |
|------------|----------------------|------------------------------|------------------------------------------|
| TDFN33-10L | J8XYY                | $\pm 7.0^3$                  | <b>AAT4681IDE-T1</b>                     |
| TDFN33-10L | F5XYY                | $\pm 5.0^3$                  | <b>AAT4681IDE-1-T1</b>                   |
| TDFN33-10L | Y4XYY                | $\pm 3.2^4$                  | <b>AAT4681IDE-2-T1</b>                   |



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**

All dimensions in millimeters.

1. XYY = assembly and date code.

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

3.  $T_A = 85^\circ\text{C}$ .

4.  $T_A = 70^\circ\text{C}$ .

5. 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.

**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications**

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