

**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.

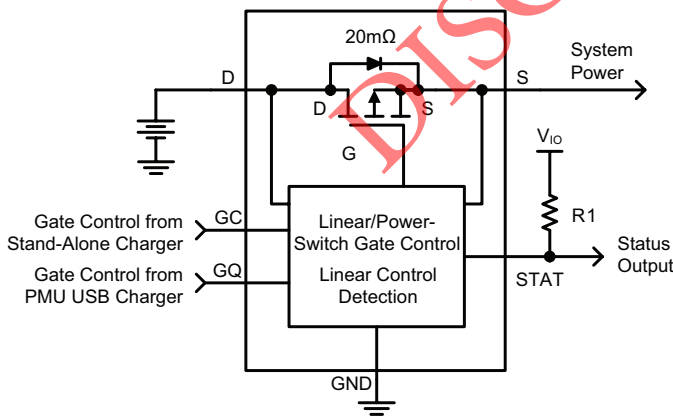
**Features**

- 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

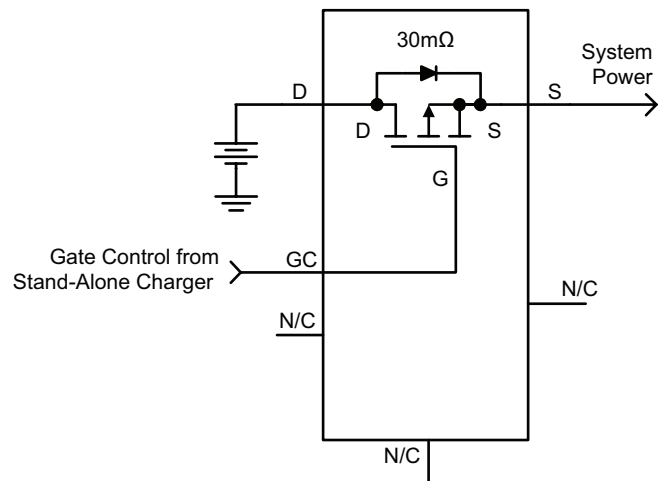
**Applications**

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

**Typical Application**



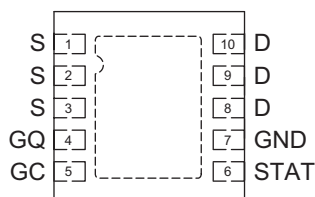
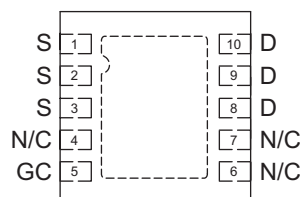
**AAT4681, AAT4681-1**



**AAT4681-2**

**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****DISCONTINUED**

**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	$\pm 7$	A
		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	$T_A = 25^\circ\text{C}$	$\pm 4.0$	A
		$T_A = 70^\circ\text{C}$	$\pm 3.2$	A
$I_{DM}$	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%.

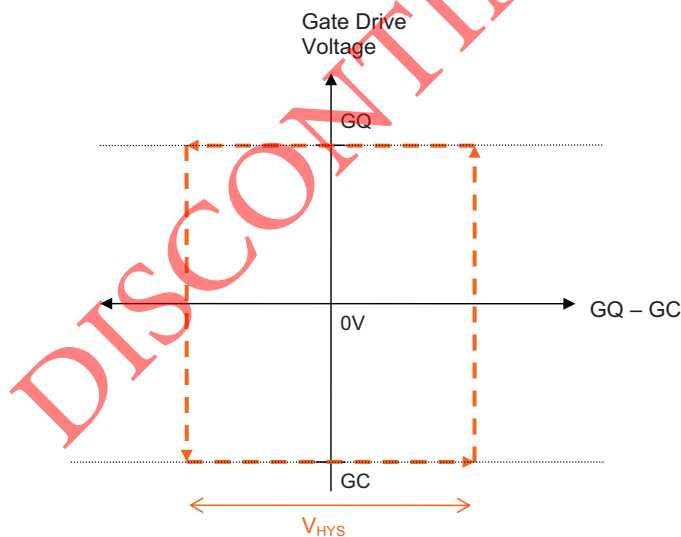
3.  $T_J$  is calculated from the ambient temperature  $T_A$  and power dissipation  $P_D$  according to the following formula:  $T_J = T_A + P_D \cdot \theta_{JA}$ .

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

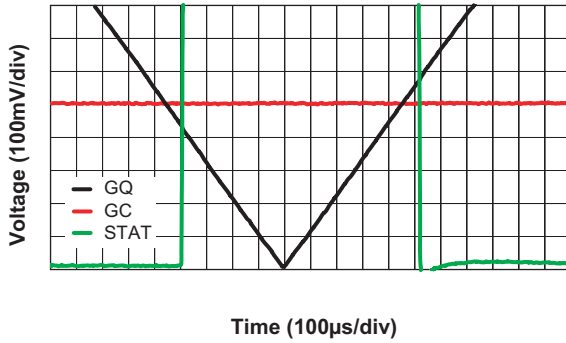


- Where  $V_{\text{SYS}}$  is the greater of  $V_{\text{D}}$  or  $V_{\text{S}}$ .
- Pulse width  $< 300\mu\text{s}$ , duty cycle  $< 1\%$ .

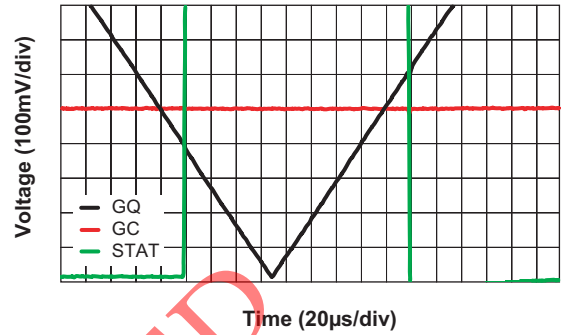
## 20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications

### 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)



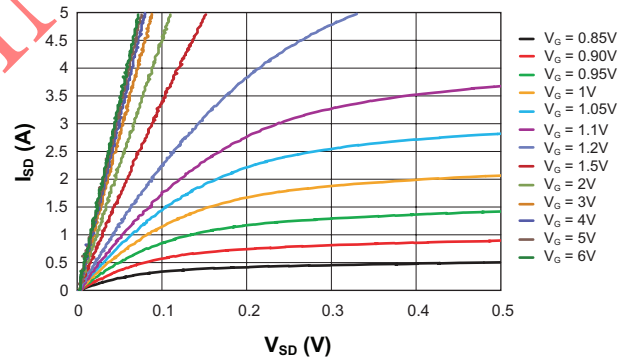
Hysteresis, GQ Ramp Time = 500µs  
(S = 5.5V; GC = 0.5V; R<sub>STAT</sub> = 5K; V<sub>IO</sub> = 5.5V)



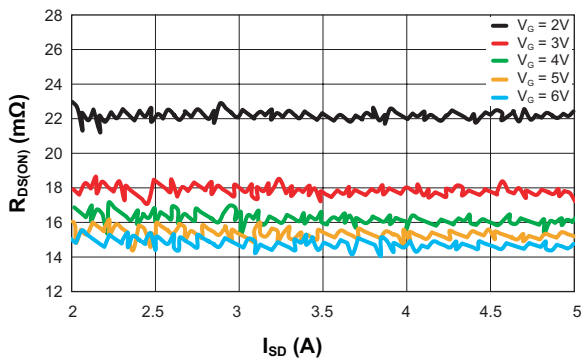
Timing  
(S = 5.5V; GC = 0.5V; GQ ramp time = 2.5ms;  
R<sub>STAT</sub> = 5K; V<sub>IO</sub> = 5.5V)



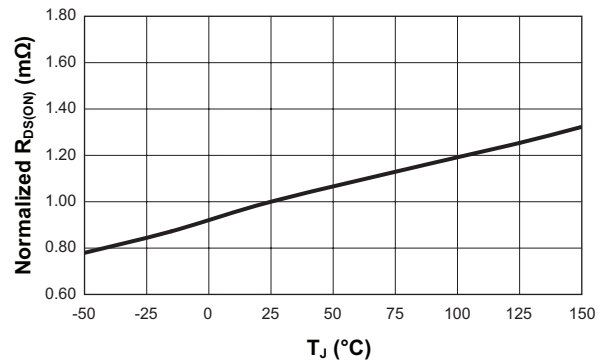
Shutdown Current vs. Shutdown Voltage



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%)

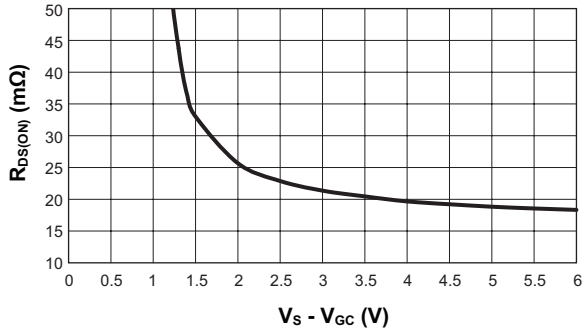


## 20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications

### AAT4681/-1 Typical Electrical Characteristics

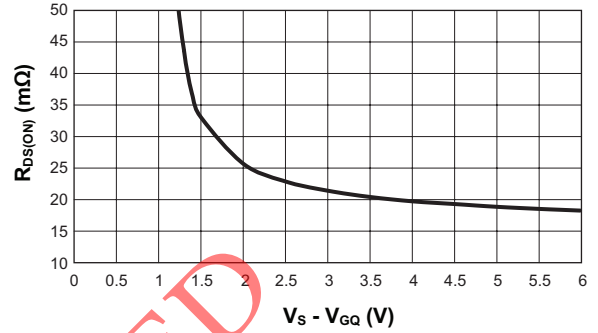
**On-Resistance vs. Gate Voltage  $G_C$**

$V_S = 6V$ ;  $V_{GQ} = 0V$ ,  $I_{DS} = 5A$ ;  
Pulse Width < 300μs, Duty Cycle < 1%



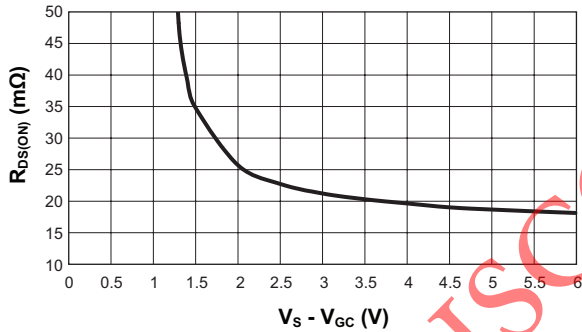
**On-Resistance vs. Gate Voltage  $G_C$**

$V_S = 6V$ ,  $V_{Gc} = 0V$ ,  $I_{DS} = 5A$ ;  
Pulse Width < 300μs, Duty Cycle < 1%



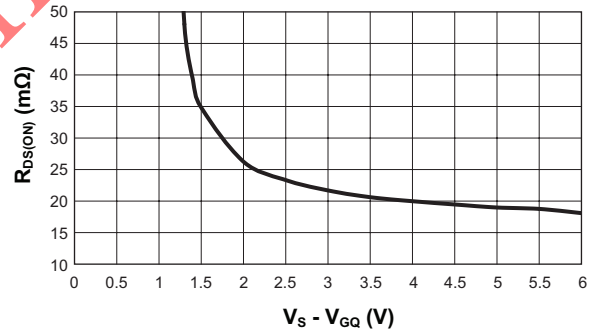
**On-Resistance vs. Gate Voltage  $G_C$**

$V_S = 6V$ ,  $V_{GQ} = 0V$ ,  $I_{DS} = 7A$ ;  
Pulse Width < 300μs, Duty Cycle < 1%



**On-Resistance vs. Gate Voltage  $G_Q$**

$V_S = 6V$ ,  $V_{GQ} = 0V$ ,  $I_{DS} = 7A$ ;  
Pulse Width < 300μs, Duty Cycle < 1%

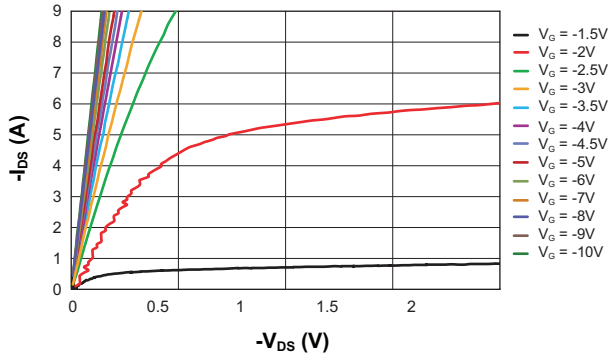


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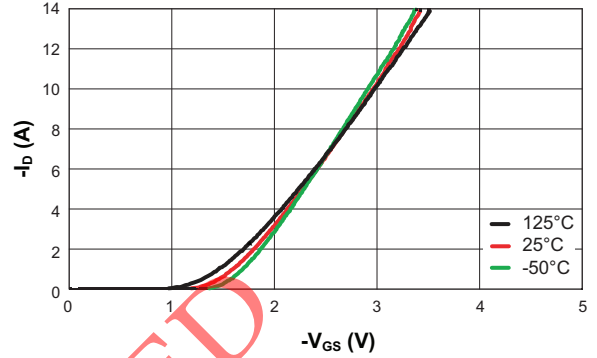
## 20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications

### AAT4681-2 Typical Electrical Characteristics

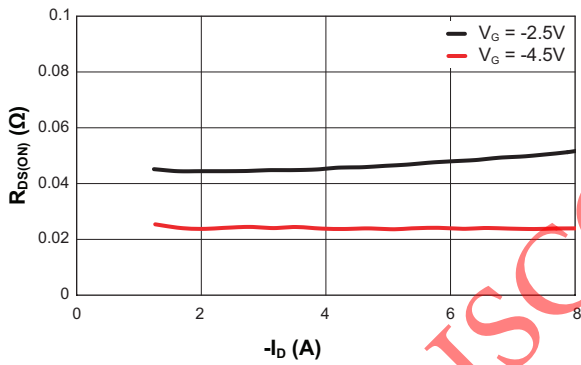
Output Characteristics



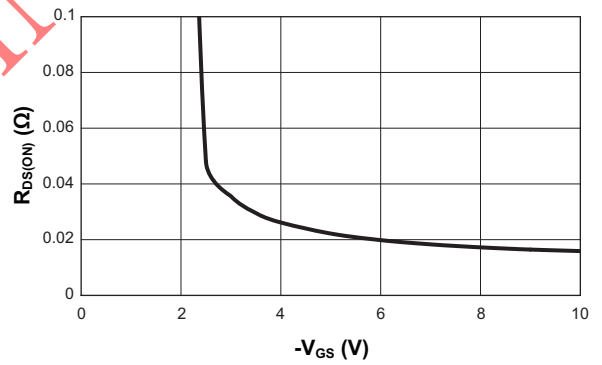
Transfer Characteristics



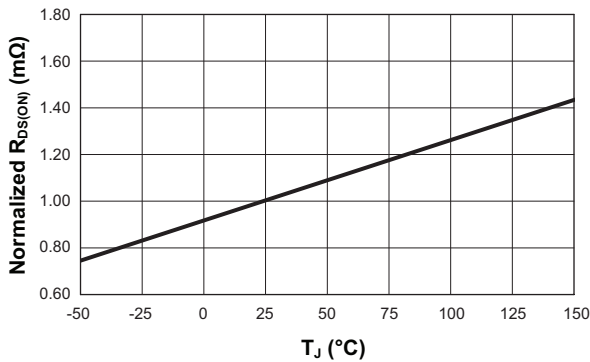
On-Resistance vs. Drain Current



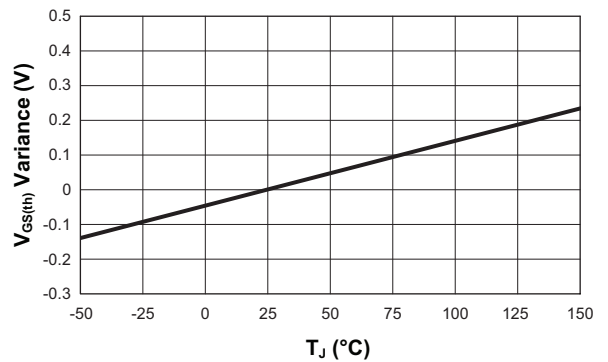
On-Resistance vs. Gate-Source Voltage



On-Resistance vs. Junction Temperature  
( $V_{GS} = -4.5V$ ;  $I_D = -5.9A$ )



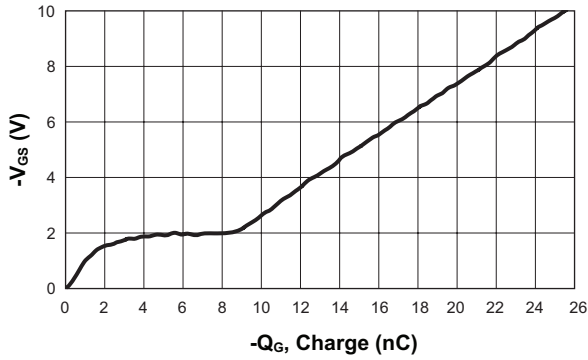
Threshold Voltage vs. Junction Temperature



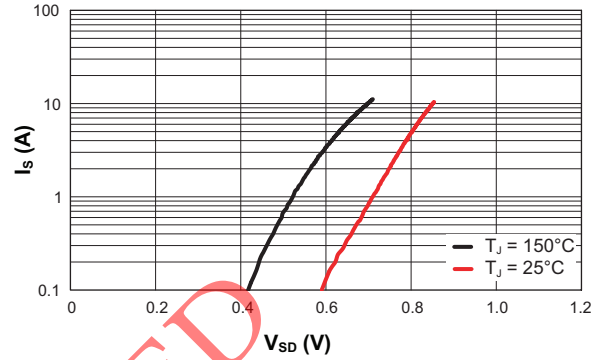
## 20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications

### AAT4681-2 Typical Electrical Characteristics

Gate Charge



Source-Drain Diode Forward Voltage

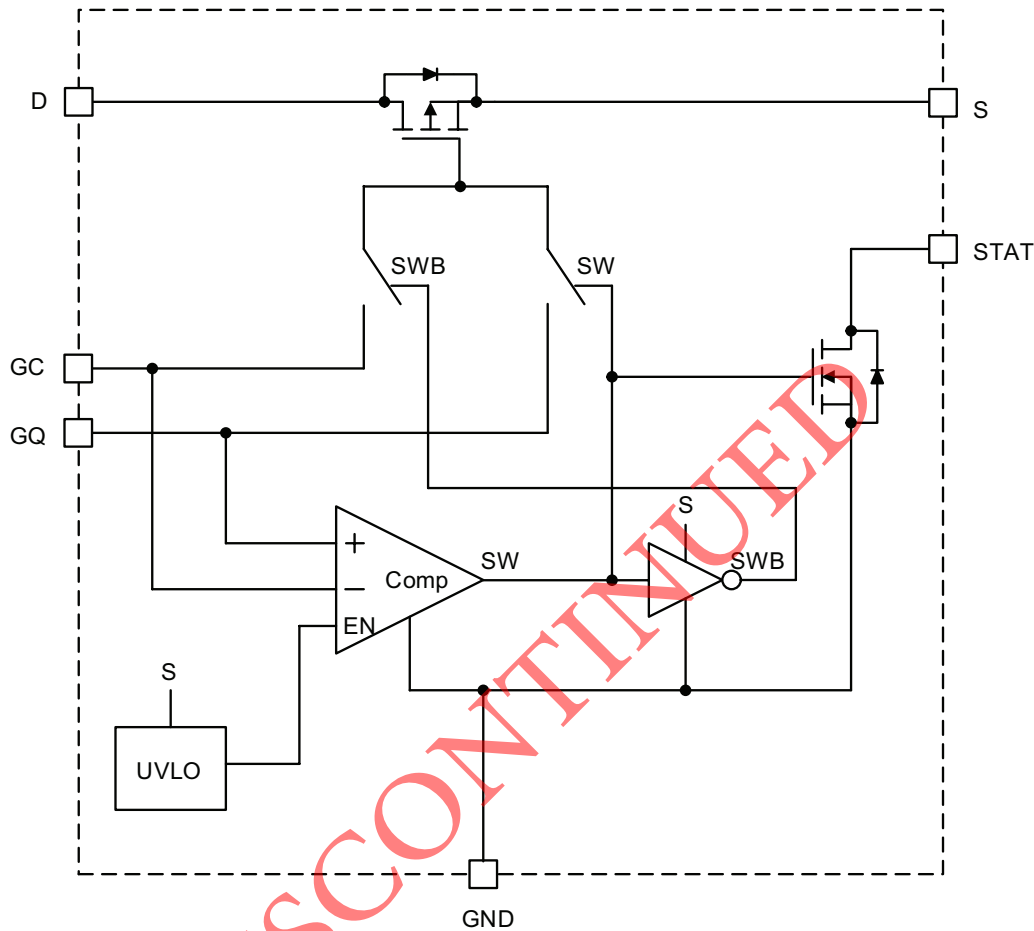


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## 20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications

### Functional Block Diagram



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

\*Switch to GQ when GQ > GC even if QC is not equal to zero.

# AAT4681

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

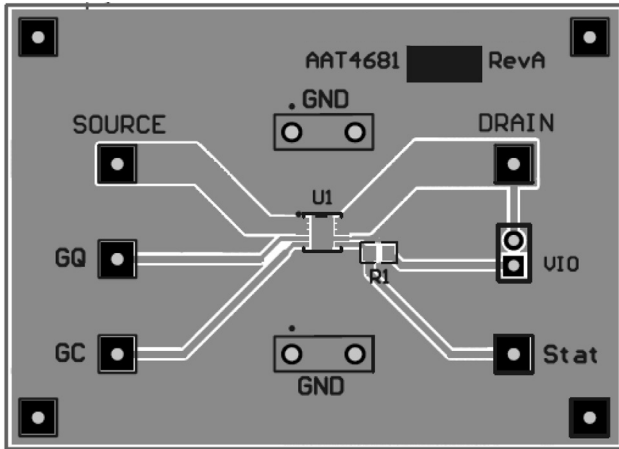


Figure 1: AAT4681IDE Evaluation Board Top Side Layout.

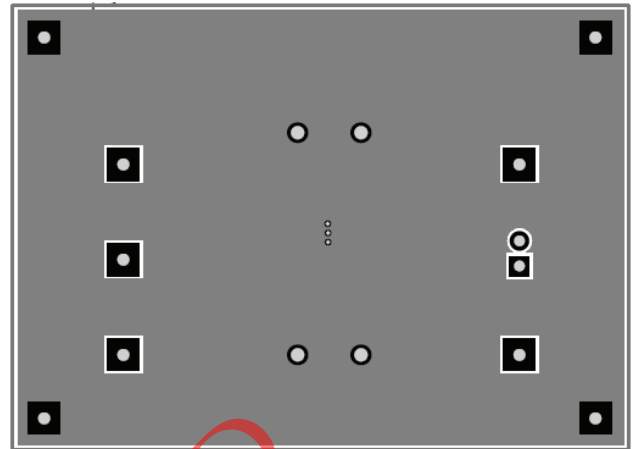


Figure 2: AAT4681IDE Evaluation Board Bottom Side Layout

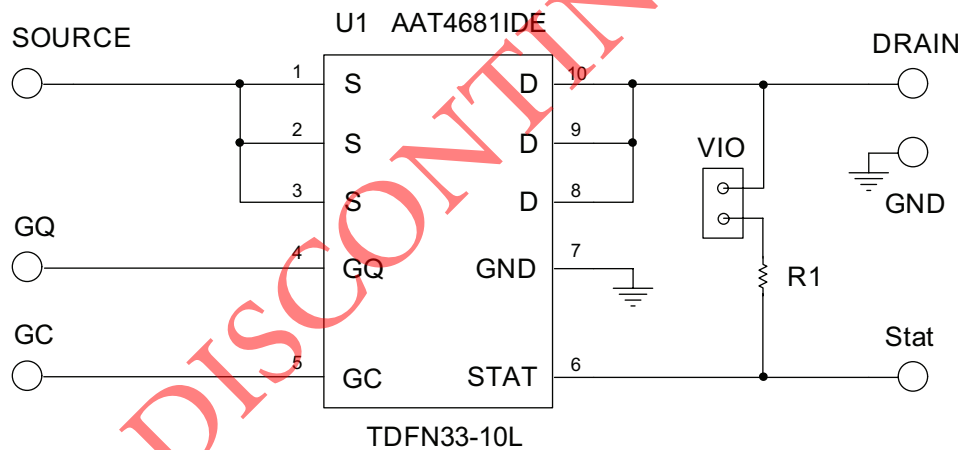


Figure 3: AAT4681IDE Evaluation Board Schematic.

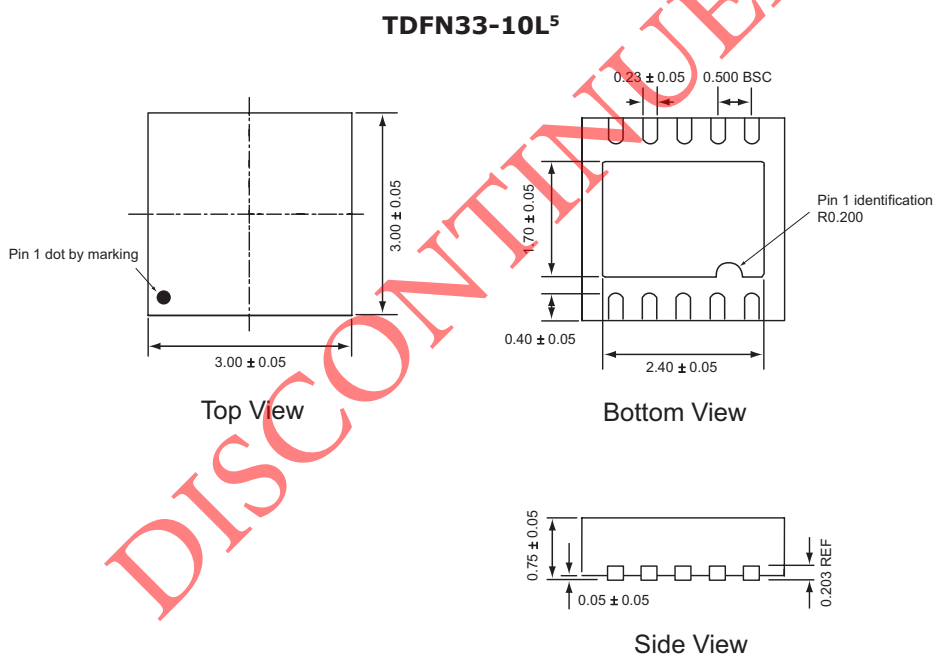
**20mΩ P-Channel SmartSwitch for UMPC Battery Charging Applications****Ordering Information**

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>



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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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