

Application Note AN- 1181

IPS maximum output current capability consideration

By Andre MOURRIER

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Topics Covered:

Maximum output current capability

- Introduction
- Quick comparison methodology
- Calculation & Result
- Comparison

Introduction

One of the key parameter to choose an IPS is the maximum output current capability. All component suppliers provide this information but each supplier has different conditions:

As an example this is the number given by the datasheet given for the BTS723G:

Parameter and Conditions, each of the two channels at $T_j = -40...+150^{\circ}\text{C}$, $V_{bb} = 24\text{ V}$ unless otherwise specified	Symbol	Values			Unit
		min	typ	Max	
Nominal load current one channel active: two parallel channels active: Device on PCB ¹⁾ , $T_a = 85^{\circ}\text{C}$, $T_j \leq 150^{\circ}\text{C}$	$I_{L(NOM)}$	2.5 4.0	2.9 4.2	--	A

And as a comparison this is the AUIPS7142G from IR:

Symbol	Parameter	Min.	Max.	Units
I_{out}	Continuous output current, $T_{ambient}=85^{\circ}\text{C}$, $T_j=125^{\circ}\text{C}$ $R_{th}=40^{\circ}\text{C/W}$, 6cm^2 footprint	--	1.5	A

As a first result the BTS723G seems have more output current capability than the AUIPS7142G. But a result is nothing without its conditions: need to compare apple with apple.

This is the conditions for the BTS723G

Parameter and Conditions, each of the two channels at $T_j = -40...+150^{\circ}\text{C}$, $V_{bb} = 24\text{ V}$ unless otherwise specified	Symbol	Values			Unit
		min	typ	Max	
Nominal load current one channel active: two parallel channels active: Device on PCB ¹⁾ , $T_a = 85^{\circ}\text{C}$, $T_j \leq 150^{\circ}\text{C}$	$I_{L(NOM)}$	2.5 4.0	2.9 4.2	--	A

This is the conditions for the AUIPS7142G

Symbol	Parameter	Min.	Max.	Units
I_{out}	Continuous output current, $T_{ambient}=85^{\circ}\text{C}$, $T_j=125^{\circ}\text{C}$ $R_{th}=40^{\circ}\text{C/W}$, 6cm^2 footprint	--	1.5	A

How does a quick comparison?

The maximum continuous output current capability depends of two types of parameters:

- Application parameters (ex. Maximum ambient temperature ...).
- Component characteristics (ex. R_{dson} ...)

The application parameters are given for a typical application and identical for the comparison. So the component characteristics are the most relevant for this type of comparison. This is the equation to calculate the maximum output current capability:

Equation 1:

$$I_{out(max)} = \sqrt{\frac{(T_j - T_a)}{R_{th} \times R_{dson}(T_j)}}$$

Where:

$I_{out(max)}$ is the maximum output current to be sure that at ambient temperature equal to T_a , the junction temperature will never reach the T_j .

T_a is the ambient temperature

T_j is the junction temperature during the regular operation.

$R_{dson}(T_j)$ is the ON state resistance of the power MOSFET at T_j temperature.

R_{th} is the static thermal resistance from junction to ambient.

T_j and T_a are the application parameters, so they are define the limit and the condition of use. To do a quick comparison, these parameters are considered as identical for the both component.

Regarding the equation if we remove these two application parameters, the comparison R_{th} and R_{dson} must be enough. Because these values are in the denominator, lower are these two values, higher is the output current capability.

Take a quick look to our example, first the R_{dson} :

BTS723G:

Load Switching Capabilities and Characteristics					
On-state resistance (V_{bb} to OUt); $I_L = 2\text{ A}$, $V_{ce} \geq 7\text{ V}$					
	each channel,	$T_j = 25^{\circ}\text{C}$:	R_{ON}	--	90 105
		$T_j = 150^{\circ}\text{C}$:		--	170 210
					mΩ

AUIPS7142G:

$R_{ds(on)}$	ON state resistance $T_j=25^{\circ}\text{C}$	--	75	100	mΩ	$I_{ds}=2\text{A}$
	ON state resistance $T_j=150^{\circ}\text{C}(2)$	--	135	180		

With the same condition, $I_{out} = 2A$ for the maximum value, the R_{dson} of the AUIPS7142G is better than the AUIPS7142G.

Now take a look to the R_{th} parameters:

The BTS723G:

Parameter and Conditions	Symbol	Values			Unit
		min	typ	Max	
Thermal resistance junction - soldering point ^{(5),(6)}	R_{thjs}	--	--	25	K/W
Thermal resistance junction - ambient ⁽⁵⁾	R_{thja}	--	45	--	--

Always take care to the small note for the conditions:

⁵⁾ Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70µm thick) copper area for V_{bb} connection. PCB is vertical without blown air. See page 15

The AUIPS7142G:

Symbol	Parameter	Typ.	Max.	Units
R_{th1}	Thermal resistance junction to ambient 6cm ² footprint one Mosfet on	45	--	°C/W
R_{th2}	Thermal resistance junction to ambient 6cm ² footprint two Mosfet on	40	--	°C/W

note : $T_j - T_{ambient} = \text{Power dissipated in the 2 channel} \times R_{th}$

With the same conditions, the two R_{th} are equivalent: 45°C/W.

As conclusion, even if at the first look, the output current of the BTS723G seems higher than the AUIPS7142G after a quick analysis it is not true.

Because other parameters are equivalent and the R_{dson} of the AUIPS7142G is better than the BTS723G so the output current capability of the AUIPS7142G is higher.

How does the calculation?

The first quick analysis show that the output capability of the IR device is better than the competitor but how much is it better?

For that use the equation 1 and replace parameters name by the numeric values:

$$I_{out(max)} = \sqrt{\frac{(T_j - T_a)}{R_{th} \times R_{dson(@T_j)}}$$

For the BTS723G:

$$I_{out(max)} = 2.62A = \sqrt{\frac{(150 - 85)}{45 \times 0.210}}$$

For the AUIPS7142G:

$$I_{out(max)} = 2.83A = \sqrt{\frac{(150 - 85)}{45 \times 0.180}}$$

As we have determined in previous quick analysis, the AUIPS7142G output current capability is better than the BTS723G. Now, the calculation is done for the two channels in parallel. We will use the same way to calculate but the current in each channel is divided by 2. So the power dissipated by each channel is also divided by 2. Then multiply by two the current for the two channels:

$$I_{out(Total\ max)} = 2 \times \sqrt{\frac{1}{2} \times \frac{(T_j - T_a)}{R_{th} \times R_{dson(@T_j)}}$$

For the BTS723G:

$$I_{out(Total\ max)} = 3.88A = 2 \times \sqrt{\frac{1}{2} \times \frac{(150 - 85)}{41 \times 0.210}}$$

For the AUIPS7142G:

$$I_{out(Total\ max)} = 4.25A = 2 \times \sqrt{\frac{1}{2} \times \frac{(150 - 85)}{40 \times 0.18}}$$

Where:

$I_{out(Total\ max)}$ is the maximum of the channel1 + channel2

As shown, the first evaluation, the AUIPS7142G has more output current capability than the BTS723.

Finally, the calculation is done for the two channels not in parallel but activated in same time. We will use the same way to calculate but with the two channels activated the maximum output current is divided by two:

$$I_{out(max)} = \sqrt{\frac{1}{2} \times \frac{(T_j - T_a)}{R_{th} \times R_{dson(@T_j)}}$$

For the BTS723G:

$$I_{out(jchannel\ max)} = 1.94A = \sqrt{\frac{1}{2} \times \frac{(150 - 85)}{41 \times (0.210)}}$$

For the AUIPS7142G:

$$I_{out(jchannel\ max)} = 2.125A = \sqrt{\frac{1}{2} \times \frac{(150 - 85)}{40 \times (0.180)}}$$

As shown, the first evaluation, the AUIPS7142G has more output current capability than the BTS723.

Comparison table

Part number	Nb channel	Rth in °C/W	Tj in °C	Tambient in °C	Rdson@150°C in Ohm	Imax in A
<i>BTS723G</i>	1	45	150	85	0,21	2,62
<i>AUIPS7142G</i>		45	150	85	0,18	2,83
<i>BTS723G</i>	2	41	150	85	0,21	3,89
<i>AUIPS7142G</i>		40	150	85	0,18	4,25
<i>BTS724G</i>	4	34	150	85	0,18	2,30