Lamp Driving Capability of PROFET+

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Application note

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Automotive Power

1 Abstract

Note: The following information is given as a hint for the implementation of the device only and shall not be regarded as a description or warranty of a certain functionality, condition or quality of the device.

This Application Note describes the background of the lamp switching capability of the PROFET+ 12V family and shows both the theoretical and practical considerations. It analyzes the switching capability of PROFET+ 12V devices and provides an overview of influencing factors of a real vehicle setup. The aim is to give hints on how to determine the right device for a dedicated load and realistic setup.

2 Introduction

The main application of PROFET+ is to switch ON lamps. During the switching phase, the lamp exhibits an important transient current called the inrush current. This current appears for the PROFET+ to be similar to short circuit and it implies a risk that the device switches OFF for protection reasons. This means PROFET+ devices are limited in terms of lamp driving capability.

3 Measured Inrush with Ideal Setup

3.1 Mathematical Reminder

The inrush current of a lamp resembles the initial response of a RC network. **Figure 1** provides circuit and current timing characteristic of an RC circuit, assuming an ideal supply (V_{BAT}) and switch S.

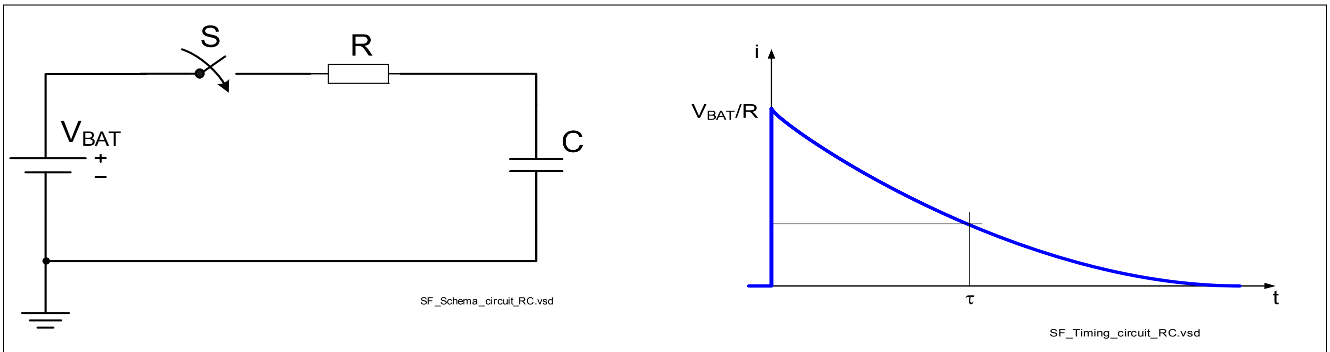

Figure 1 Reminder of RC Load Timing

Equation (1) provides the current over time in the circuitry. $I_O = V_{BAT} / R$, $\tau = RC$.

$$i(t) = I_0 \times e^{((-t)/\tau)} \qquad i(\tau) = I_0 \times 0,367 \tag{1}$$

3.2 Application to Lamp Inrush

Figure 2 shows the typical inrush phenomenon. The set-up is ideal, meaning no or negligible parasitic impedance between the supply voltage generator to the switch and almost no parasitic impedance between the switch and the lamp.

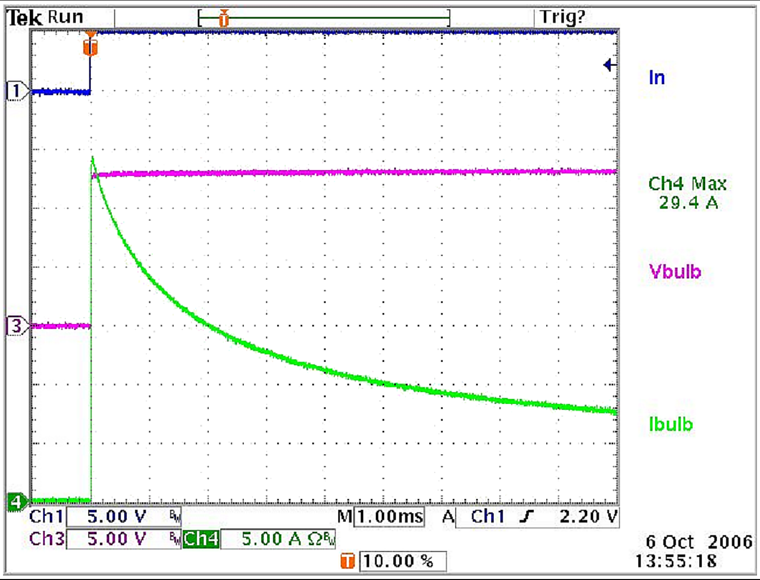

Figure 2 Typical Inrush Current of a 27W Lamp. V_{BAT} = 13.5V, T_A = 25°C

The inrush current we see at the beginning of a switch ON event of a lamp is due to the fact that the filament is cold and it's resistance is low, therefore consuming a lot of power. As the filament's temperature rises its resistance increases until it reaches a temperature stable point. In **Figure 3** the current consumption and the filament's temperature (scaling 1:100) of a 27W bulb is simulated. The conditions and parameters of **Figure 2** were approximated.

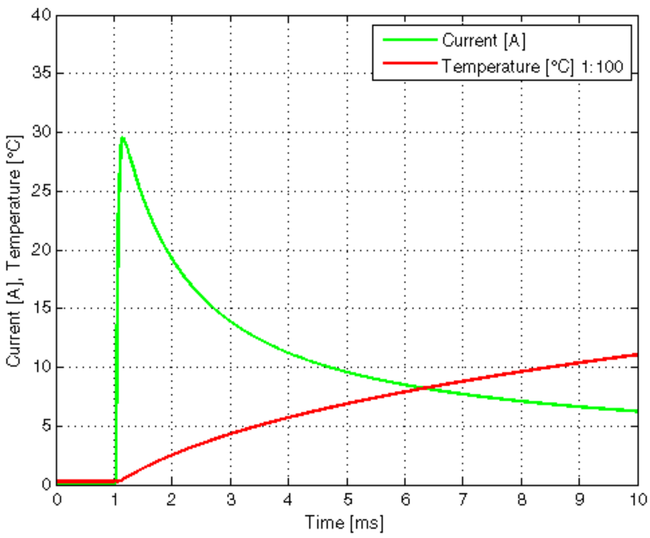

Figure 3 Simulated Inrush and the Filament Temperature (in 100°C) of a 27W Lamp

Out of these considerations, a basic model of the lamp can be constructed and represented on **Figure 4**.

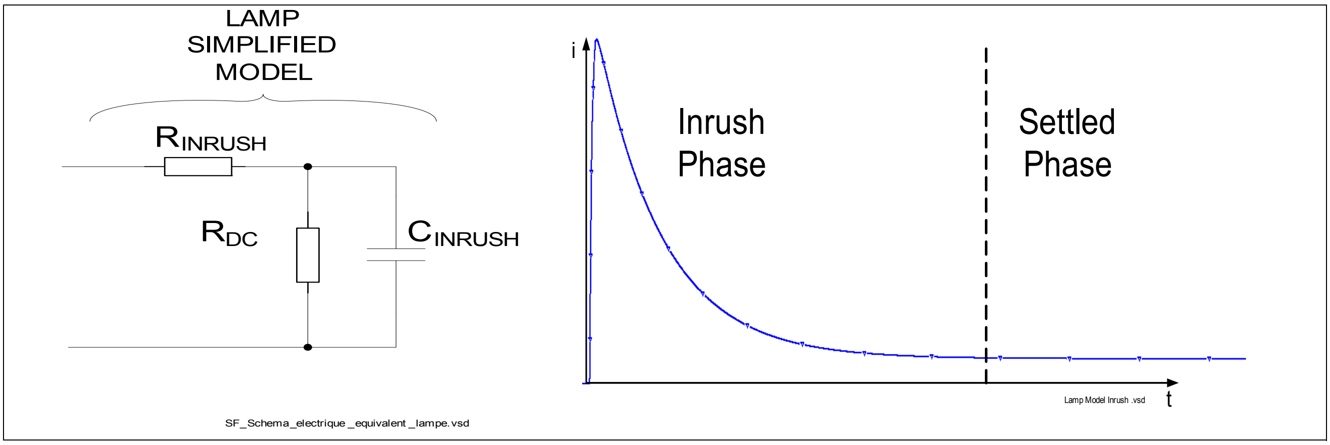

Figure 4 Equivalent Simplified Model of a Bulb Lamp and Simulated Current Consumption

Three physical values R_{INRUSH}, C_{INRUSH} and R_{DC} define the simplified model of a lamp. C_{INRUSH} represents the inrush current and the equivalent energy to be stored to reach thermal equilibrium of the filament. R_{INRUSH} limits the current of the inrush. R_{DC} represents the current flowing during DC operation in the filament, when the filament's temperature has stabilized. R_{INRUSH} and C_{INRUSH} represent the filament resistance at the inrush phase while R_{INRUSH} and R_{DC} equates to the resistance in the settled phase.

Table 1 shows how a lamps' behavior can be described by three parameters I_{DC}, I_{INRUSH} and τ. I_{DC} defines the current consumption in the settled phase, I_{INRUSH} is the initial peak current and the time constant τ describes the transition to the settled phase.

Table 2 provides the translation of the observation in electrical quantities for building models that comply with the circuit in Figure 4. R_{DC} will be influenced mainly by the supply voltage as the ambient temperature plays no role. The hot filament temperature (easily above 2000°C) is far from the ambient temperature (-40°C to 150°C) range. The inrush will be mainly influenced by the filament's temperature prior to the switch ON. The worst case can be defined at -40°C and the typical case at ambient +25°C.

Table 1 Lamp Characteristics in Amps and Time

Lamp [W]	I_{DC} [A]		I_{INRUSH} [A] @ 25°C		I_{INRUSH} [A] @ -40°C		τ[µs] at 25°C
	13.5V	***16V***	***13.5V***	***16V***	***13.5V***	***16V***	
21	1.9	2.1	25.9	30.2	34.7	40.8	4570

Table 2 Lamp Characteristics in Ohm and Farad

Lamp [W]	R_{DC} [Ω]		R_{INRUSH} [Ω]		C_{INRUSH} [mF]	
	13.5V	***16V***	***25°C***	***-40°C***	***25°C***	***-40°C***
21	5.91	7.1	0.693	0.533	6.58	8.57

4 Vehicle Set-Up

Within a car, truck or any other vehicle, the environment and circuit to turn ON a lamp is never ideal and deviates from the current graphs presented in the previous chapter. Besides resistances, the switching behavior is mainly defined by inductances that influence the current slopes.

4.1 Mathematical Reminder

Figure 5 provides circuit and current timing characteristic of an RL circuit, assuming an ideal supply voltage (V_{BAT}) and ideal switch (S).

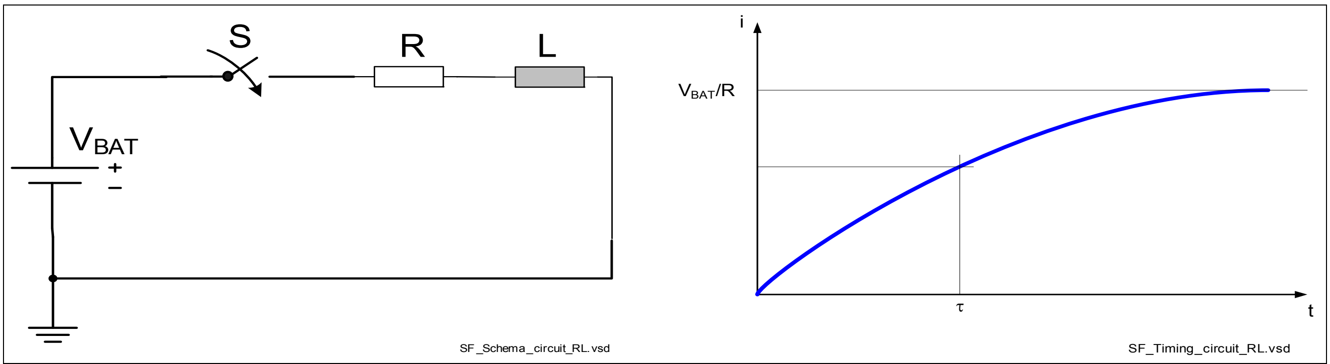

Figure 5 Reminder of the RL Load Timing

The switch S is closed at the time t=0.

Equation (2) provides the resulting current over time in the circuitry. $I_O = V_{BAT}$ / R, τ = L/R.

$$i(t) = I_0 \times (1 - e^{((-t)/\tau)}) \qquad i(\tau) = I_0 \times 0,632 \tag{2}$$

4.2 Application in the Vehicle Environment

Figure 6 sums up the mechanical and electrical chain of supply, from battery to lamp to show an equivalent to the vehicle environment.

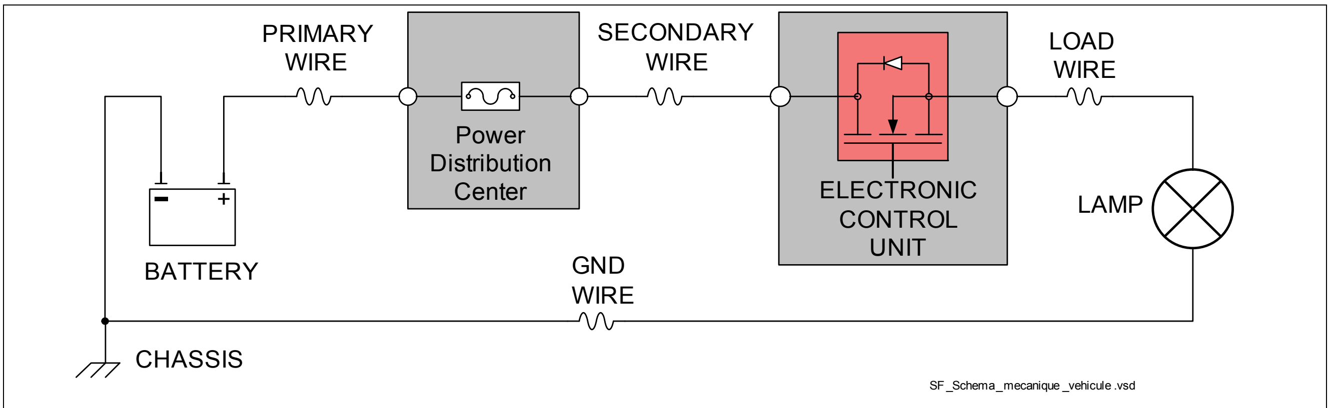

Figure 6 Schematic of Vehicle Architecture

Figure 7 provides the electrical equivalence to each block.

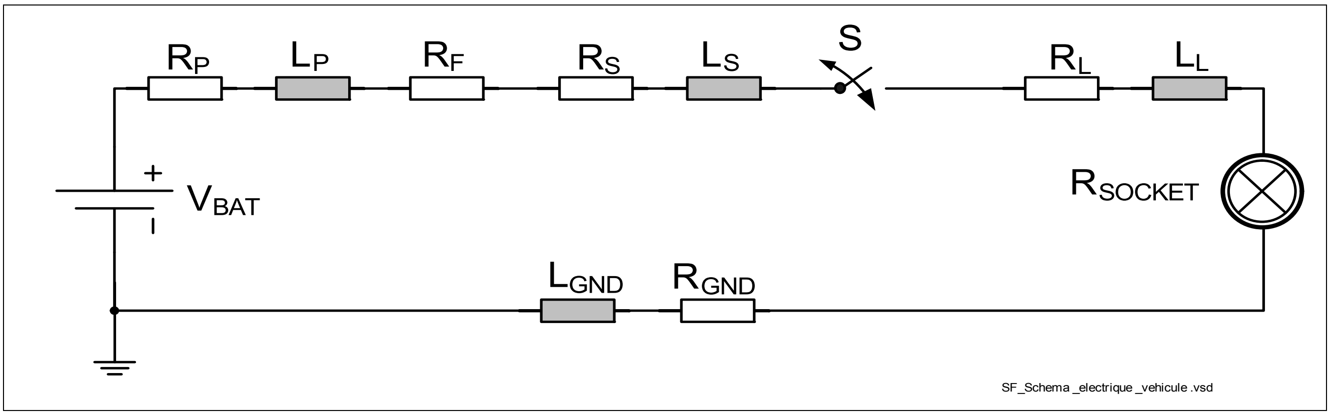

Figure 7 Equivalent Electrical Characteristic of the Vehicle Architecture

- V_{BAT} is an ideal voltage supply.
- R_P is the primary resistance; internal resistance of the battery, primary wire resistance and battery connector resistance; considered to be usually 5mΩ.
- L_P is the primary inductance; primary wire inductance; lower than 1µH, usually.
- R_F is the fuse box resistance; fuse resistance, resistance of the connectors of the fuse box and relay; from 3 to 20mΩ.
- R_S is the secondary resistance; secondary wire resistance, input connector of the ECU and PCB supply traces; usually in the range of 10mΩ.
- L_S is the secondary inductance; secondary wire inductance; from 1 to 5µH which is depending on the module's location compared to battery.
- R_L is the load cable resistance; load wire resistance, output connector of the ECU, $R_{DS(ON)}$ of the device and PCB output traces; at least 20mΩ, increasing up to 100mΩ.
- L_L is the load cable inductance; secondary wire inductance; ranging from 1 to 5µH which is depending on the module's location compared to the load.
- R_{SOCKET} is the contact resistance of the lamp socket; around 20mΩ.
- R_{GND} is the GND cable resistance; GND wire resistance, output connector of the ECU and lamp holder resistance; usually in the range of 10mΩ.
- L_{GND} is the load cable GND inductance; GND wire inductance; usually < 1µH
- S is the PROFET+ switch considered ideal

Combining **Figure 4** and **Figure 7** results in **Figure 8**, representing the simplified electrical circuit of a lamp driven inside a vehicle.

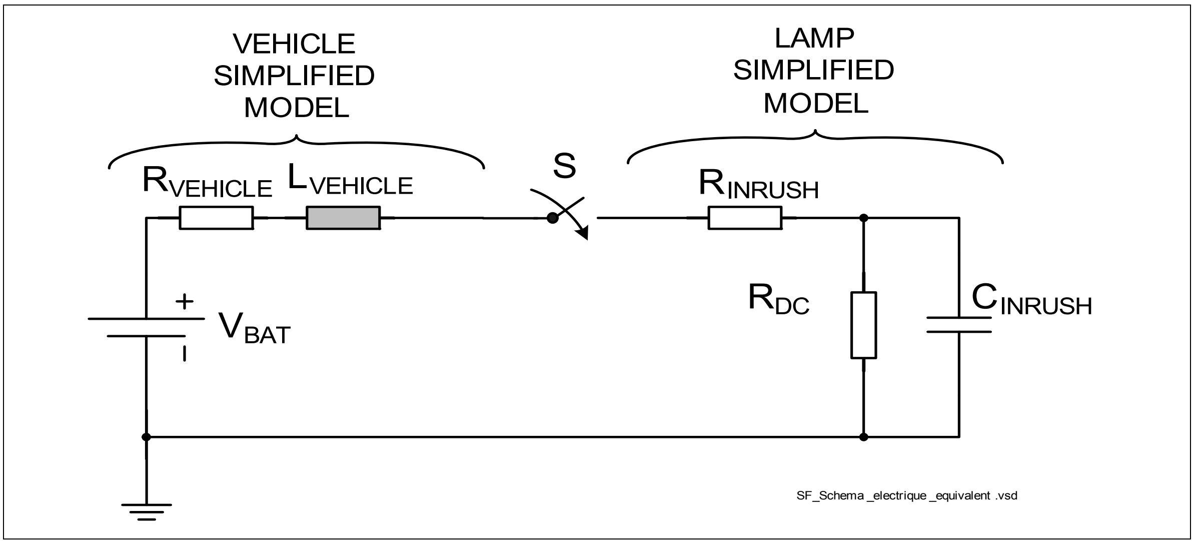

Figure 8 Equivalent Electrical Characteristic of a Lamp Driven Inside a Vehicle

- V_{BAT} is an ideal voltage supply
- $R_{VEHICLE}$ is the "vehicle's resistance"; $R_{VEHICLE} = R_P + R_F + R_{DS(ON)} + R_S + R_L + R_{SOCKET} + R_{GND}$; ranging from 45 to 130mΩ.
- $L_{VEHICLE}$ is the "vehicle's inductance"; $L_{VEHICLE} = L_P + L_S + L_L + L_{GND}$; ranging from 2 to 10µH.
- R_{INRUSH} is lamp resistance for the initial phase when the filament is cold; R_{INRUSH} is limiting charging current of C_{INRUSH}.
- R_{DC} is the dominant lamp resistance at hot; R_{DC} is mainly defining the DC current of the lamp in ON; $R_{DC} >> R_{INRUSH}$.
- C_{INRUSH} is the equivalent capacitor of the lamp.

5 Lamp Inrush in a Vehicle

Using **Figure 8**, the real application case can be easily simulated. Each vehicle is different, each lamp and $R_{DS(ON)}$ of the PROFET+ are different. **Figure 9** provides a qualitative explanation of the signals which will be observed. In blue the ideal inrush is sketched, in red the real applicative inrush where the vehicle setup effects are included. The maximum peak current is reduced and delayed, due to $R_{VEHICLE}$ and $L_{VEHICLE}$. For low wattage lamps, $R_{VEHICLE}$ is usually negligible ($R_{VEHICLE}$ can't be considered bigger than 200mΩ while R_{INRUSH} is closed to 2Ω). For high wattage lamps, $R_{VEHICLE}$ has a more significant effect.

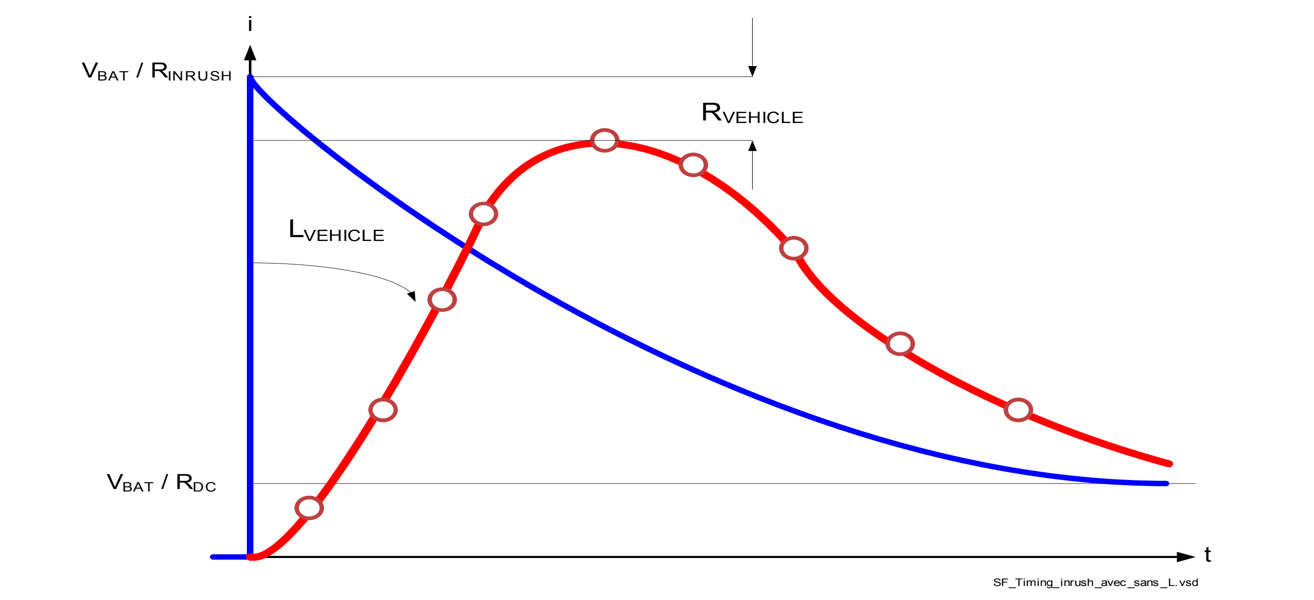

Figure 9 Influence of the System on the Lamp Inrush.

Figure 10 shows the influence of increasing cable length separated in a variation of the resistance and the inductance of a setup with a H4 55W bulb at 25°C and V_{BAT}=16V. The different setups were simulated with Orcad Allegro using the PROFET+ behavioral models. In case of higher $R_{VEHICLE}$ there will be an increasing voltage drop across the power line which leads to a smaller voltage across the bulb and smaller energy needed at the turn ON sequence. This influence of the resistance $R_{VEHICLE}$ on the inrush and turn ON energy is strongly depending on the resistance of the lamp load (R_{INRUSH} and R_{DC}) and is often negligible for small lamp loads.

It can be observed that if only the inductance changes the spanned area between the x-axis and each curve has approximately the same value which means the peak of the maximum power gets shifted but the energy needed to turn on the lamp remains the same.

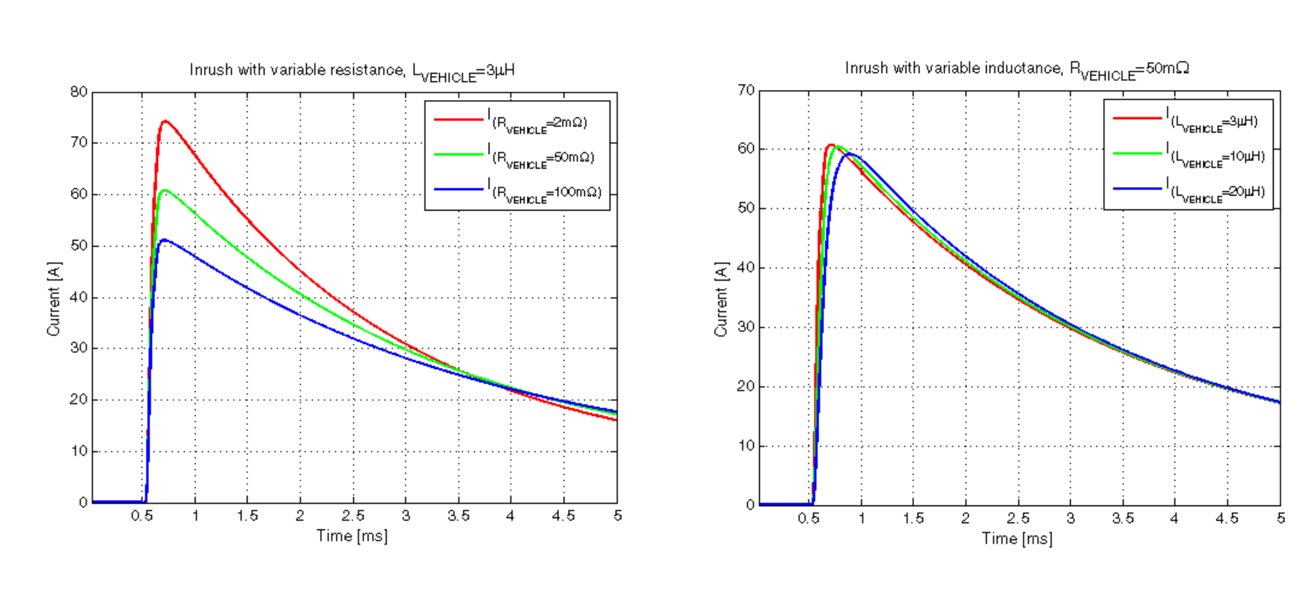

Figure 10 Simulated Influence of Resistance and Inductance on Lamp Inrush (H4 55W)

Table 3 compares both the ideal and vehicl case for a typical 21W lamp. The vehicle's electrical impedance effect is clearly observable for lamp of 21W and higher. In addition, Figure 11 provides a graphical analysis showing the benefit of the vehicles's influence.

Table 3 Lamp Inrush with and Without vehicle influence ($R_{VEHICLE}$ = 70mΩ)

Lamp [W]	T_{LAMP} = 25°C				T_{LAMP} = -40°C			
	V_{BAT} = 13.5V		V_{BAT} = 16V		V_{BAT} = 13.5V		V_{BAT} = 16V	
	ideal	**vehicle**	ideal	**vehicle**	ideal	**vehicle**	ideal	**vehicle**
21	25.9	22.7	30.2	26.9	34.7	29.3	40.8	34.7

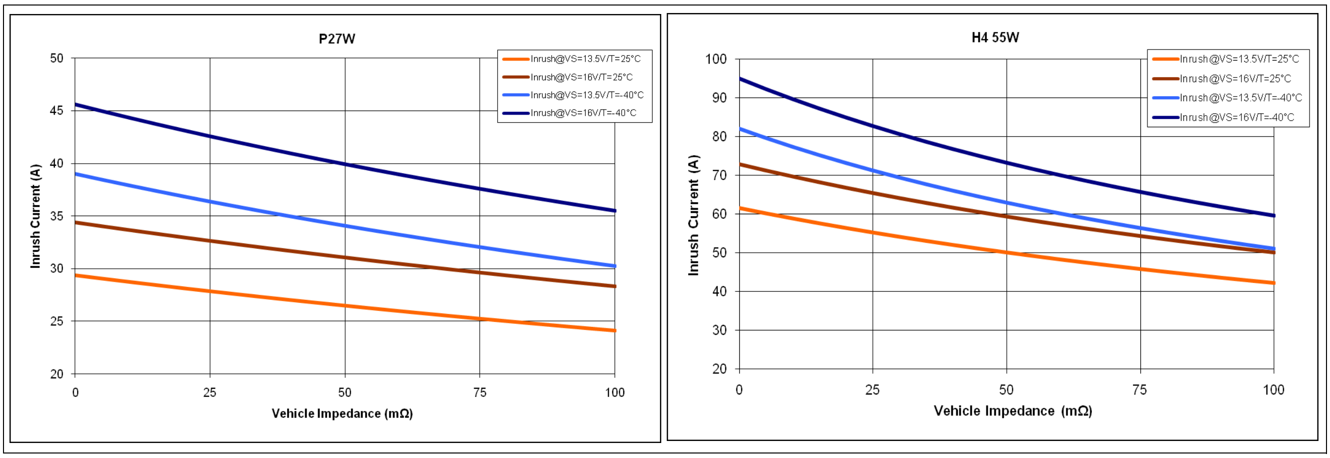

Figure 11 Inrush Value as Function of the Vehicle's Impedance

Figure 12 gives a more general overview of the influence of the impedance, which equals the wire harness as a variable in the vehicle's setup.

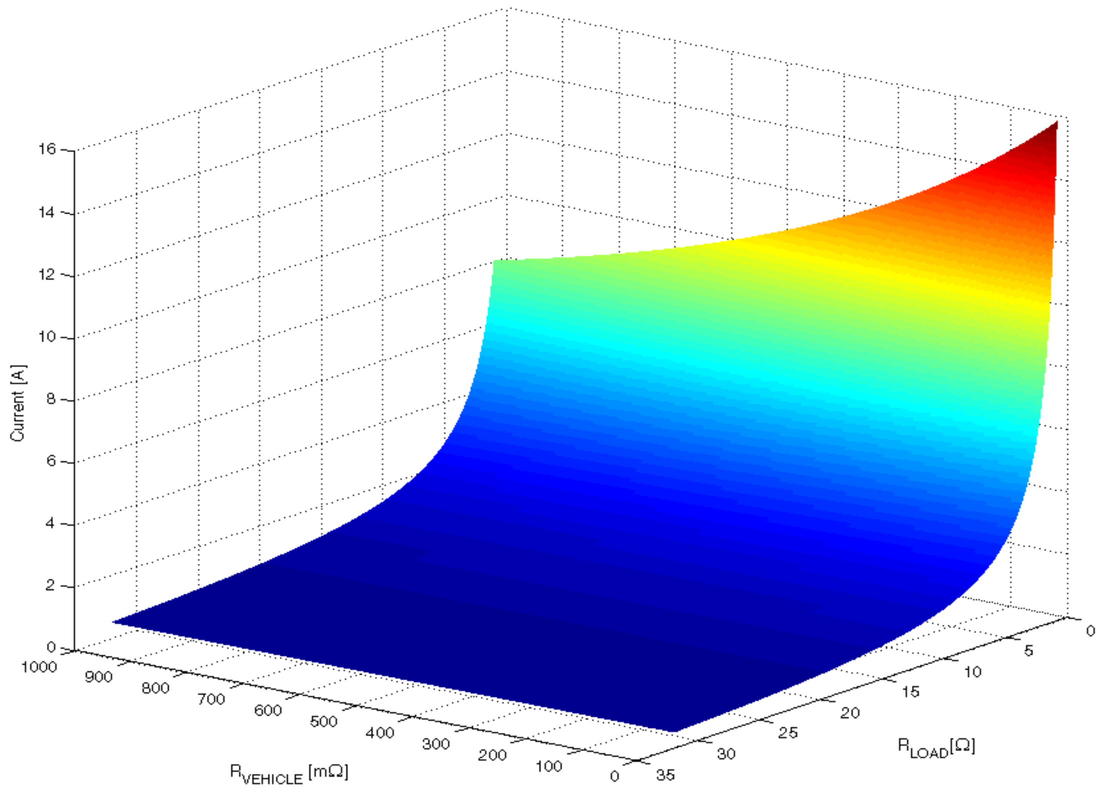

Figure 12 Wire Harness Influence on Different Loads

It can be observed that loads with smaller resistance are strongly influenced by an increasing impedance of the cable while high-ohmic loads are not.

6 PROFET+ Protection

6.1 Current Limitation

PROFET+ devices limit the current during short circuit condition. **Table 4** compares current limitation value for PROFET+ devices related to the targeted loads, in the typical (V_{BAT} = 13.5V and T_{LAMP} = 25°C) and the worst case (V_{BAT} = 16V and T_{LAMP} = -40°C). In the worst case scenario, the device current limitation will be reached during the inrush phase of the lamp.

Table 4 Lamp Inrush compared to PROFET+ Current Limit with Vehicle Influence ($R_{VEHICLE}$=70mΩ)

Lamp [W]	Inrush [A]		recommended PROFET+	$I_{LIM(MIN)}$ [A]	$I_{LIM(TYP)}$ [A]	$I_{LIM(MAX)}$ [A]
	T_{AMB} = 25°C ; V_{BAT} = 13.5V	T_{AMB} = -40°C ; V_{BAT} = 16V				
5	5.1	8	BTS5200 BTS5180	5 8	6.5 11	8 13
10	9.7	14.9	BTS5120	9	12	15
2x10	19.3	29.8	BTS5090	20	30	40
21	22.7	34.7	BTS5090	20	30	40
21 + 5	27.7	42.7	BTS5045	25	32	40
27	25.4	38.2	BTS5045	25	32	40
27+5	30.4	46.2	BTS5045 BTS5030	25 36	32 47	40 57
H8 35	32.8	48.4	BTS5030	36	47	57
2 x 21	45.3	69.5	BTS5030 BTS5020	36 50	47 65	57 80
2 x 27	50.8	76.4	BTS5030 BTS5020	36 50	47 65	57 80
2 x 21 +5	50.4	77.4	BTS5030 BTS5020	36 50	47 65	57 80
2 x 27 +5	55.8	84.4	BTS5020	50	65	80
H1 55	47.7	68.4	BTS501x	50	65	80
H4 55	46.6	67.6	BTS501x	50	65	80
H7 55	45.6	64.7	BTS501x	50	65	80
3 x 21 + 2x5	78.1	120.2	BTS501x	50	65	80
H9 65	51.1	72.7	BTS5008	65	80	105
3 x 27 + 2x5	86.2	130.6	BTS5008	65	80	105

In case the device current limitation is reached, the junction temperature increases and it's possible that a switch OFF event occurs to limit thermal stress. As PROFET+ devices are restart types, the lamp can be switched ON nevertheless.

6.2 Example of Temperature Swing Event

Figure 13 represents a typical case of device restart, due to current limitation and temperature swing limitation. In case the current limitation $I_{L5(SC)}$ is met, the device sees an equivalent to short circuit event and toggles until the lamp is heated sufficiently to switch it ON permanently.

In this case the BTS5030-2EKA switches on a considerable overload of 3x21W. The impedance for this test was set to R_{VEHICLE} = 65mΩ and L_{VEHICLE}= 2µH, the device temperature T_{DEVICE}= 25°C while the lamps are at T_{LAMP}=-40°C. It can be observed that the first retries shows always the same current value, indicating active current limitation of the device. As the ambient temperature is low, the restart event is due to the temperature swing limiter. The last two restart event shows a lower current, indicating that the inrush is gone but the thermal inertia of the silicon engages overtemperature that trigger the device to shut down and restart after cooling.

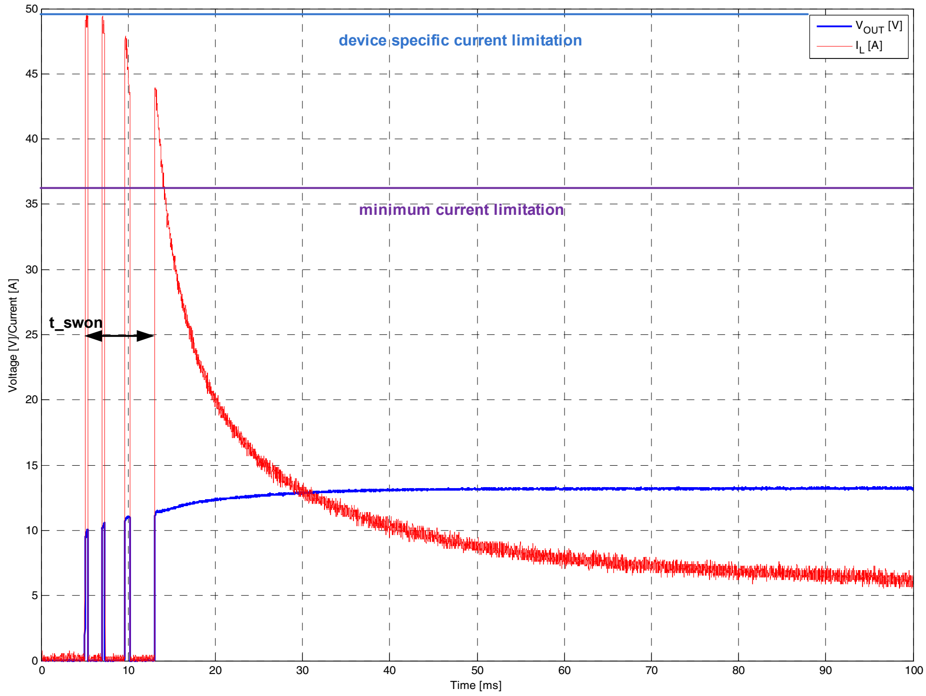

Figure 13 Measurement Switch ON of 3x21W Lamps with BTS5030, V_{BAT}=13.5V

As the PROFET+ has a current limit and restart concept (see PROFET+ PROTECTION App Note) it is possible to switch on loads that are actually bigger than the defined nominal load.

After a certain delay (t_swon), the lamp(s) will be turned ON but nevertheless the PROFET+ device under consideration should not be used if toggling can be expected for every turn ON of the bulbs, as this is a stressful event that shortens the lifetime.

6.3 Example of Over Temperature Event

Figure 14 represents a typical case of a device restart due to extreme ambient temperature. With moderate ambient temperature the device does a clean instant switch ON, but with higher ambient temperature the maximum current is limited due to the increased $R_{\mathrm{DS(ON)}}$. Additionally the maximum temperature is reached very fast which triggers the shutdown.

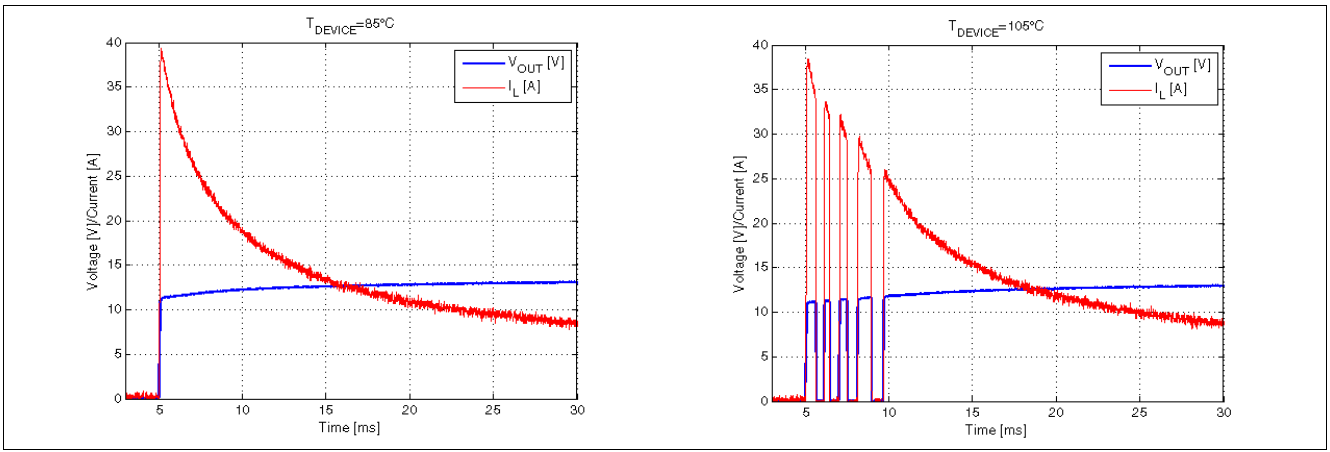

Figure 14 Measured Inrush of BTS5030 with 2x21W+10W Load. V_{BAT} =13.5V T_{LAMP} = 25°C, $R_{VEHICLE}$ = 65mΩ, $L_{VEHICLE}$ = 2µH

Although in the 105°C case the inrush peak is smaller, the device performs a fast switch OFF to protect itself and has to do several retries until the lamp's filament is sufficiently heated to turn it ON constantly. For the PROFET+ switch the turn ON and OFF implies a phase where a matching of the $R_{DS(ON)}$ to the resistance of the lamp happens which leads significant switching losses (compare PROFET+ Application Note Chaper 7.5).

In **Figure 15** the power loss of the PROFET+ is shown for the 85°C and 105°C case.

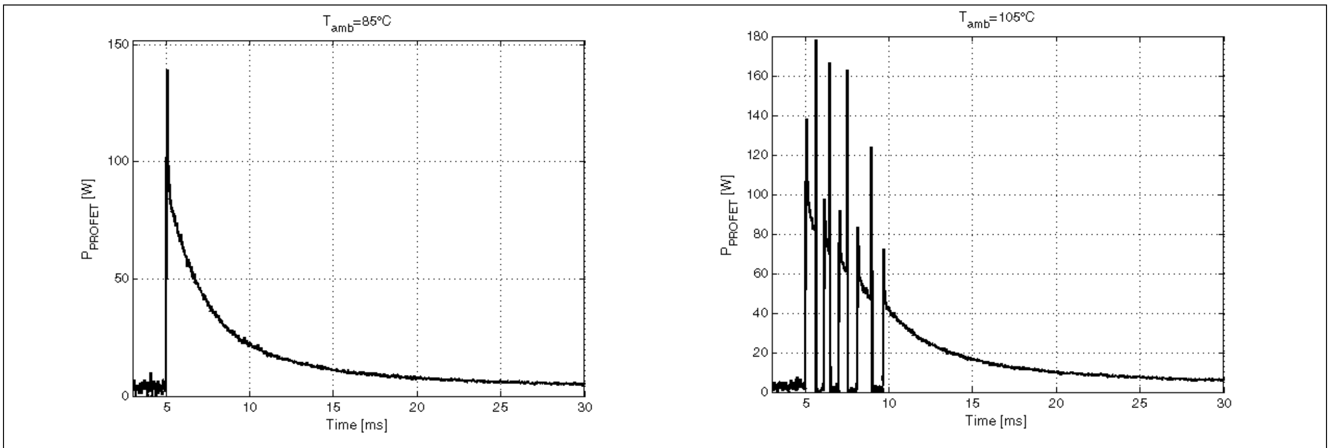

Figure 15 Power Loss of BTS5030 with 2x21W+10W Load. V_{BAT} =13.5V T_{LAMP} = 25°C, $R_{VEHICLE}$ = 65mΩ, $L_{VEHICLE}$ = 2µH

The first peak of the 85°C measurement is similar to the 105°C setup; although the inrush current is smaller, the $R_{DS(ON)}$ is increased. In case the device switches OFF, the power loss of the PROFET+, P_{PROFET} has reached even higher values.

With the high current (>25A) the inductance $L_{VEHICLE}$ = 2µH is already sufficient to cause a short clamping event at switch OFF. This leads to a bigger delta between V_{SUPPLY} to V_{OUT} and results in an increased power loss P_{PROFET}=I_{DS} x V_{DS} .

6.4 Lamp Measurements on the High-Ohmic PROFET+ Family

Out of the lab measurements on the PROFET+ high-ohmic 2-channel devices, **Table 5** was created to show the lamp switching capability of different devices. As it is hardly possible to measure all different combinations for impedances inside a vehicle, typical values of R_{VEHICLE}= 65mΩ and L_{VEHICLE} = 2µH were chosen. Using the theory described in **Chapter 5** the behavior for different setups can be estimated. To show the worst situations that could appear in a vehicle the following temperature combinations for the PROFET+ and the lamps were applied.

a) T_{LAMP}= -40°C, T_{DEVICE} = 25°C
b) T_{LAMP}= 25°C, T_{DEVICE} = 85°C
c) T_{LAMP}= 85°C, T_{DEVICE} = 105°C

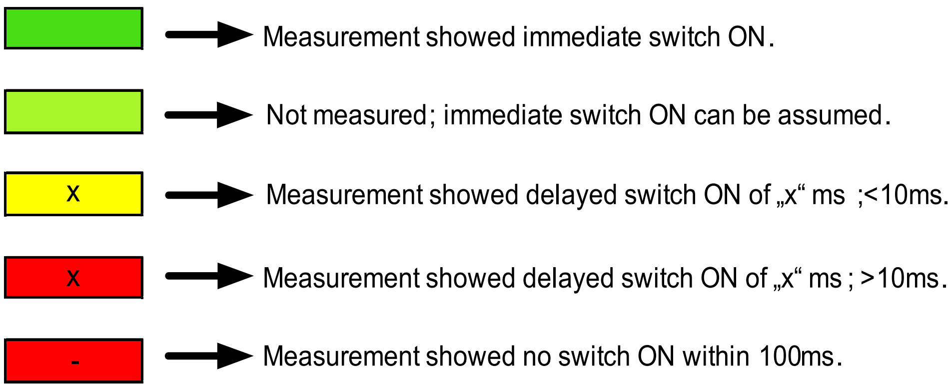

Table 5 Turn on Characteristics of High-Ohmic PROFET+

Bulb Combination	Load	Temp. Bulb	Temp. Device	BTS5020			BTS5030			BTS5045		
				13.5V	15V	18V	13.5V	16V	18V	13.5V	16V	18V
1x21W+1x5W	26W	-40°C	+25°C									
		+25°C	+85°C									
		+25°C	+105°C									
1x27W	27W	-40°C	+25°C									
		+25°C	+85°C									
		+25°C	+105°C									1.6
3x10W	30W	-40°C	+25°C									
		+25°C	+85°C									
		+25°C	+105°C									
1x21W+10W	31W	-40°C	+25°C									5.6
		+25°C	+85°C									2.5
		+25°C	+105°C								1.5	6
1x27W+ 1x5W	32W	-40°C	+25°C									5.8
		+25°C	+85°C									2.7
		+25°C	+105°C								2.5	6.8
H8	35W	-40°C	+25°C							3.3	17.2	34.5
		+25°C	+85°C							1.8	10	21
		+25°C	+105°C						2.3	7.2	19.1	34
1x27W+1x10W	37W	-40°C	+25°C								7.1	17.5
		+25°C	+85°C								8	12
		+25°C	+105°C							3.3	9	19
4x10W	40W	-40°C	+25°C									
		+25°C	+85°C									
		+25°C	+105°C									
27W+3x5W	42W	-40°C	+25°C								12.1	25.7
		+25°C	+85°C								9.9	16.8
		+25°C	+105°C							5	14.8	27
2x21W	42W	-40°C	+25°C						5	13	36	55
		+25°C	+85°C						1	7.6	26	40
		+25°C	+105°C					3.3	5.1	16	34	58
2x21W+5W	47W	-40°C	+25°C						5.1			
		+25°C	+85°C						1.1			
		+25°C	+105°C					3.2	6.6			
2x21W+10W	52W	-40°C	+25°C					4.3	12.1			
		+25°C	+85°C					3	7.7			
		+25°C	+105°C				4.7	10	16			
2x27W	54W	-40°C	+25°C					7.6	22	-	-	94
		+25°C	+85°C				2.4	5.8	11.5	-	-	-
		+25°C	+105°C			4.2	7.8	15.4	29	-	-	-
H1	55W	-40°C	+25°C			13.1	11.5	28	54.3			
		+25°C	+85°C			8.3	8	17.8	32.6			
		+25°C	+105°C	2.4	6.3	15.3	24	41.8	-			
2x27W+5W	59W	-40°C	+25°C				3.2	12.5	33.4			
		+25°C	+85°C				3.9	9	18			
		+25°C	+105°C		1.6	7.6	10.3	20.8	36.6			
3x21W	63W	-40°C	+25°C			17.8	8	34	52.5			
		+25°C	+85°C			19	7.2	17	31			
		+25°C	+105°C	3.8	7.3	16.5	22.5	38.6	62.3			
2x27W+10W	66W	-40°C	+25°C				6.1	23.6	44			
		+25°C	+85°C				6.5	13.8	26.4			
		+25°C	+105°C				17.2	33.2	56.5			
3x21+5W	69W	-40°C	+25°C		7.6	22.3	14.3	39.7	-			
		+25°C	+85°C		10.6	16	10.1	22.7	39			
		+25°C	+105°C	6.6	8.5	22.2	24.6	47.8	-			
3x27W	81W	-40°C	+25°C	18.7	22	-						
		+25°C	+85°C	24.6	33.3	-						
		+25°C	+105°C	25.2	40	-						

To determine the maximum lamp load that an ECU with a PROFET+ can drive, the heat dissipation must be considered. With a typical R_{thJS} value of 5 K/W for the exposed packages, the heat has a good conductor on the backside which heats up the PCB significantly.

Respecting a maximum junction temperature of 150°C and a maximum PCB temperature of 130°C, the maximum switchable load can be met even if the switch on time is small or zero. For the following table a delayed turn on of >10ms is regarded as critical.

Table 6 Thermal Considerations

Load Combination [W]	V_{BAT} [V]	T_J t=0 [°C]	Temp Load t=0[°C]	t_swon [ms]	DC Current t=300ms [A]	T_J t=500s [°C]	T_C t=500s [°C]
BTS5010-1EKA; tested with $R_{VEHICLE}$= 65mΩ and $L_{VEHICLE}$ = 2µH; R_{thJA} = 27.98 K/W; R_{thJS}= 5 K/W							
4x21W+5W	13.5	25	-40	0	8.4	44.7	41.2
		85	25	0	8.4	109.8	105.4
		105	25	0	8.4	135.3	129.9
	16	25	-40	4.6	8.7	46.0	42.2
		85	25	0	8.8	112.2	111.8
		105	25	0	8.8	137.7	131.9
	18	25	-40	16.4	9.3	49.3	45.0
		85	25	5.6	9.3	115.4	109.9
		105	25	2.9	9.5	142.7	136.0
BTS5020-1EKA; tested with $R_{VEHICLE}$= 65mΩ and $L_{VEHICLE}$ = 2µH; R_{thJA} = 33.07 K/W; R_{thJS}= 5 K/W							
3x21W+5W	13.5	25	-40	0	6.8	58.6	53.5
		85	25	0	6.5	123.0	118.0
		105	25	2.4	6.8	155.5	147.9
	16	25	-40	5.7	7.2	62.4	56.8
		85	25	8.4	7.4	134.8	127.2
		105	25	10.7	7.2	162.0	153.3
	18	25	-40	16.7	7.6	66.8	60.5
		85	25	9.3	7.3	133.5	126.2
		105	25	18.5	7.4	165.6	156.4

This table clearly shows that not only is the time to switch on the load a significant factor, and the thermal capability of the PCB might be the restricting factor.

The different packages within the PROFET+ family have different Z_{thJA} and R_{thJA} values. If the BTS5020 would be put inside a PG-DSO-8 EP, the R_{thJA} would increase to approximately 3.5 K/W compared to the PG-DSO14 EP assuming 2s2p PCB. While in the high-ohmic family (20mΩ - 180mΩ) the temperature of the device is the most dominant parameter that strongly contributes to the power loss, the low-ohmic family (8mΩ - 16mΩ) behavior is rather defined by the ambient temperature of the incandescent light bulb filaments, which causes higher inrush peaks. The significant difference in the lamp's capacitance was shown in **Table 2**. The worst case situation for high-ohmic PROFET+ devices is met with T_{LAMP}= 85°C and T_{DEVICE} = 105°C, while the low-ohmic devices with bigger lamp loads would show longer restart times at T_{LAMP}= -40°C and T_{DEVICE} = 25°C.

6.5 Summary

The PROFET+ device family was built to offer scalable devices that fit all kinds of automotive requirements to turn ON lamps. Each device has a DMOS size that is scaled to the targeted load to guarantee a safe switch ON and offer competitive pricing. As the characteristics of a lamp shows that the turn ON phase has more demanding requirements due to the heating of the filament, the switch has to deal with far bigger currents than in the steady state. This lamp behavior can be approximated with an equivalent circuit that consists of two resistors and a capacitor to offer the possibility to simulate lamps also in environments like PSPICE. Besides the characteristic lamp behavior, the vehicle environment also needs to be considered to perform representative lab measurements or software simulations. Extensive tests on the PROFET+ devices showed that the requirements to turn ON lamps even in harsh environments are met. Due to the restart behavior it is also possible to drive overloads, however it is not recommended because it imposes stress on the device.

For partitioning the appropriate switch often the worst case situation within the vehicle is considered, which depends on many different parameters. It can be observed that the high-ohmic PROFET+ devices have a different worst case temperature combination of load- and device-temperature than low-ohmic devices.

7 Revision History

Lamp Driving Capability of PROFET+

Revision History

Version	Subjects (major changes since last revision)
Rev 0.1	
	Modification of the abstract text
Rev 0.2	
	Merging with 2nd app note on bulb switching
Rev 0.3	
	Cover page updated
	Changed timing diagrams
	Replaced “car” with “vehicle” in whole document
	Adapted Fig. “Equivalent Electrical Characteristic of a Lamp driven inside a Vehicle”
	Adapted Fig. “Influence of the System to the Ideal Lamp Inrush”
Rev 0.4	
	Changes to Fig 2 & 3 to 27W
	Corrections on Table1
	Correction on Fig 10
	Corrections in Table 5
	Fig 4 - added a current graph - Equivalent Simplified Model of a Bulb Lamp and Simulated Current Consumption
Rev 1.0.	Correction of typos

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