PROFET+ Current Sense with Low Battery Voltage

PROFET +

Application note

By Stéphane Fraissé

Automotive Power

Never stop thinking

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 provide information about the current sense SENSE behaviour during low battery voltage. It shows possibilities and limitation of the PROFET + devices during phases where the battery voltage falls down close to the undervoltage shutdown of the PROFET +.

2 Introduction

All terms and physical quantity discussed in the current application note are sumed up in **Figure 1**. The schematic is simplified in regards to the real application to ease up the understanding. The real application schematic can be found in the PROFET + data sheet in usage.

The schematic consists in a PROFET + device, supplied on its V_S pin via the battery voltage called V_{BAT}. GND pin of the PROFET + is connected to the GND of the system via a GND network. The current consumption of the PROFET + is called I_{GND}. The voltage drop which is resulting of the GND network and I_{GND} is called V_{GND_SHIFT}.

The PROFET + switches a load L and a load current I_L flows. L has a certain impedance resulting a voltage V_{OUT}.

The PROFET + provides load diagnosis via the IS pin. The output current is called I_{IS}. The I_{IS} current is converted to a voltage V_{IS} via a R_{IS} resistor. The voltage is read by a micro controller for system diagnosis with a A/D converter. To protect the A/D stage of the micro controller, a resistor R_{A_D} is used.

Two additional voltages related to the battery voltage V_{BAT} are defined. V_S, effective supply voltage of the PROFET + and V_{IS_DROP}, representing the voltage between battery voltage and current sense pin IS.

The micro controller is supplied by a voltage V_{DD}, referenced to GND.

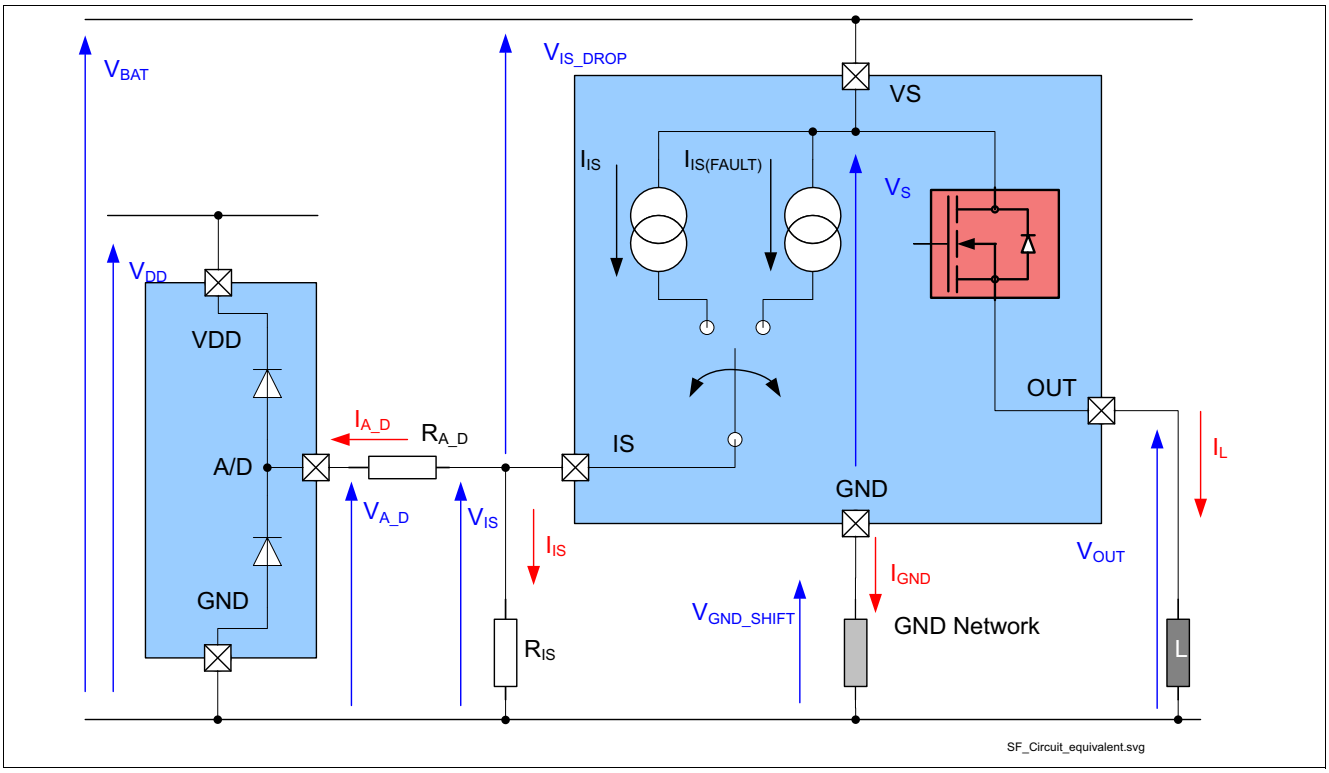

Figure 1 Hardware simplified Schematic

3 SENSE Behaviour in Nominal Operating Range

The SENSE provided at the IS pin is proportional to the load current I_L. **Figure 2** shows as an example the function $I_{IS} = f(I_L)$ of the BTS5020-2EKA. Because the current sense generator I_{IS} is not perfect and is not matched to I_{IS_FAULT}, the maximum diagnosable load current is limited. This limitation is called SENSE dynamic. It is in the range of 19A for the BTS5020-2EKA. At this load current, the SENSE is at least 6mA. With higher load current, the BTS5020-2EKA cannot guarantee analog diagnosis and the information is mixed with failure (short circuit) information. The voltage representation of the **Figure 2** can be found in the **Figure 3**. The resistor R_{IS} is coresponding to the datasheet suggested value so 1.2kΩ. In such a representation, it is assumed the is not connected to the micro controller. Therefore, no voltage limitation of the IS pin takes place. The second assumption is the battery voltage is high enough to provide such an high voltage shown on the graphic, up to 16.8V. **Figure 4** is the representation of the SENSE pin and its representation at the A/D converter, the V_{A_D} potential. **Figure 5** becomes the software compatible representation of the load current assuming a 10bit AD.

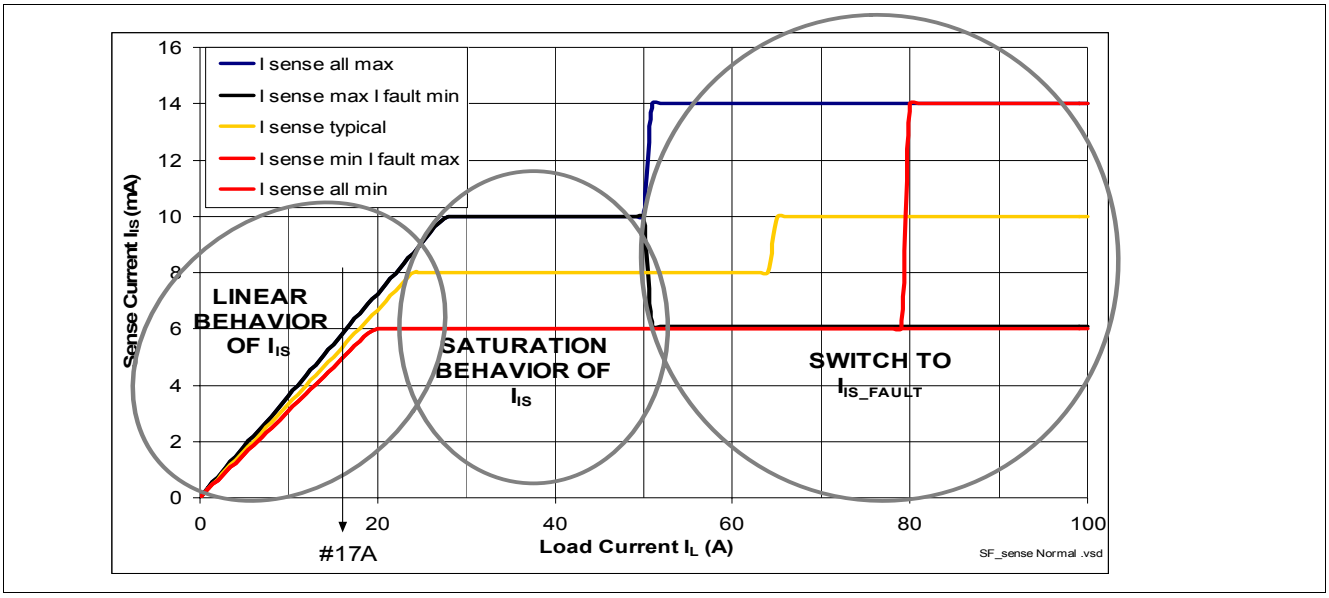

Figure 2 SENSE Function of the Load Current with BTS5020-2EKA

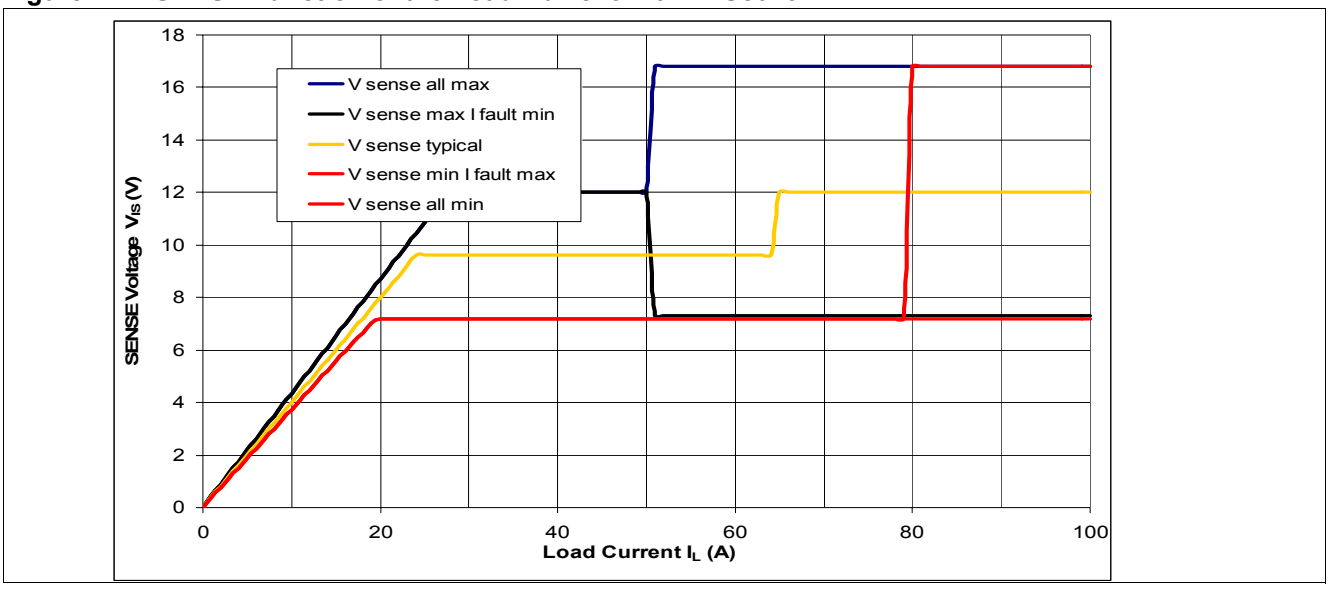

Figure 3 SENSE Voltage Function of the Load Current with BTS5020-2EKA

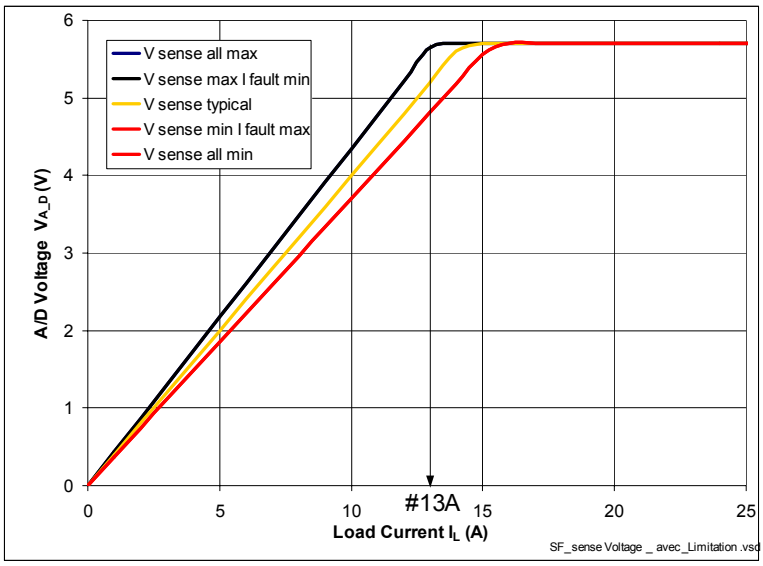

Figure 4 A/D Voltage Function of the Load Current with BTS5020-2EKA

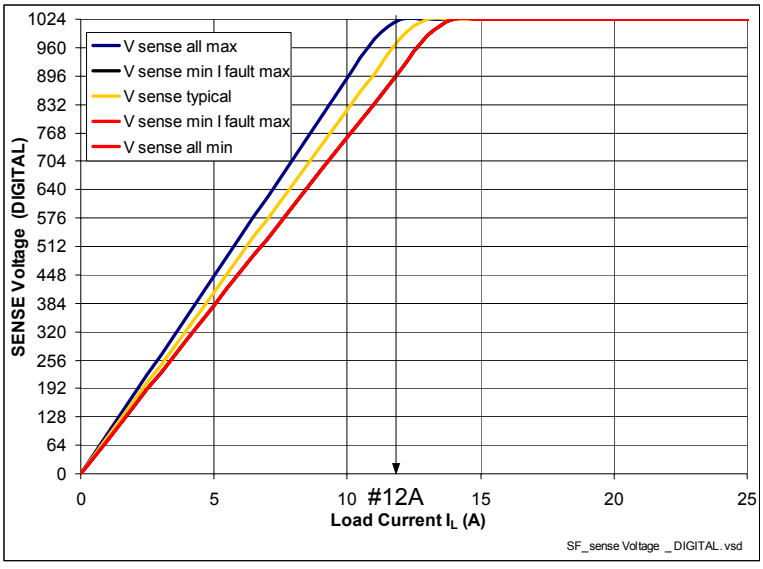

Figure 5 A/D representation Function of the Load Current with BTS5020-2EKA

4 SENSE Behaviour in low Battery Operating Range

During low battery operation, the behaviour of the SENSE doesn't differ so much from the Nominal Operating Range. The limitation comes from the maximum voltage the IS pin can provide. The PROFET + datasheet defines the parameter V_{IS_RANGE} (parameter P_7.5.6). This voltage should be at least 3V. The voltage drop between VS and IS pins (V_{IS_DROP}) should be at least 3V to have a proper diagnosis. In a theoretical possible but application useless case, with IS pin shorted to GND, the **Figure 2** remains correct down to the under voltage shutdown of the PROFET + so 3.5V typical V_S.

Let's consider for example, V_{BAT} = 6V, resulting in a V_S voltage of 5V (assuming the V_{GND_SHIFT} = 1V). V_{IS} cannot the be higher than VBAT = 6V and can be down to V_{BAT} - 3V = 3V min. With such assumption, **Figure 3** becomes much different and it shown on **Figure 6**. The SENSE dynamic is now 8.5A instead of the former 19A. **Figure 4** becomes **Figure 7** and **Figure 8** show the SENSE dynamic translated to the micro controller port A/D.

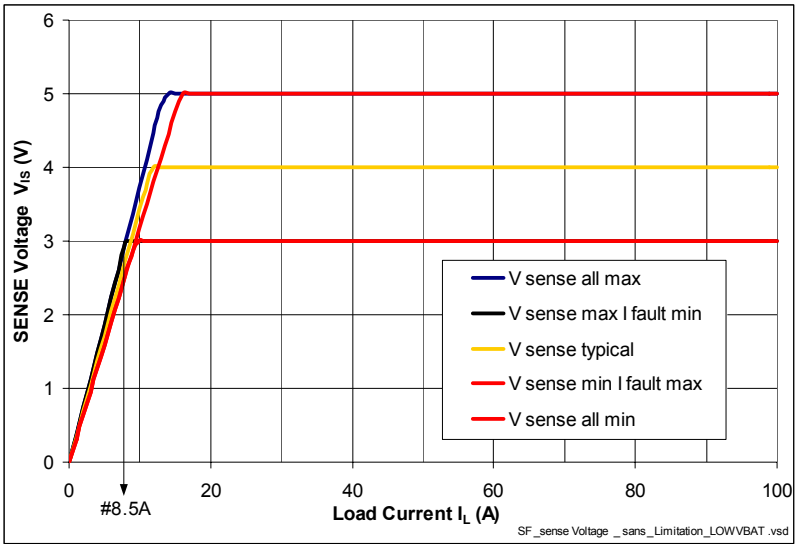

Figure 6 SENSE Voltage Function of the Load Current with BTS5020-2EKA

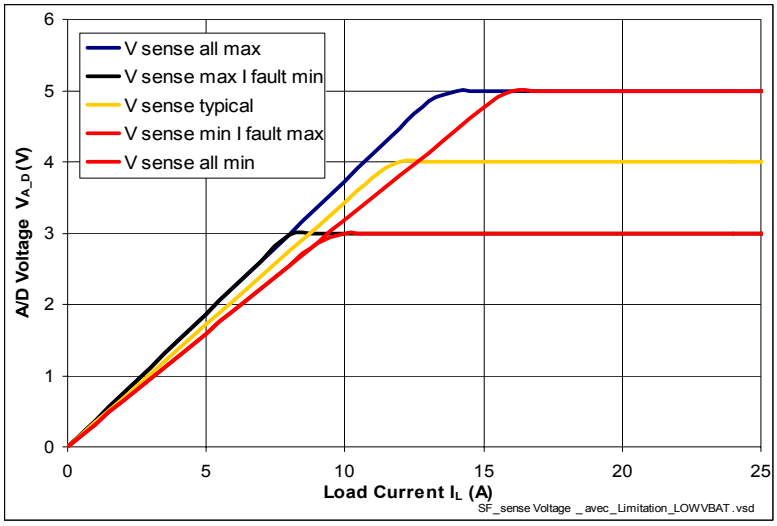

Figure 7 A/D Voltage Function of the Load Current with BTS5020-2EKA

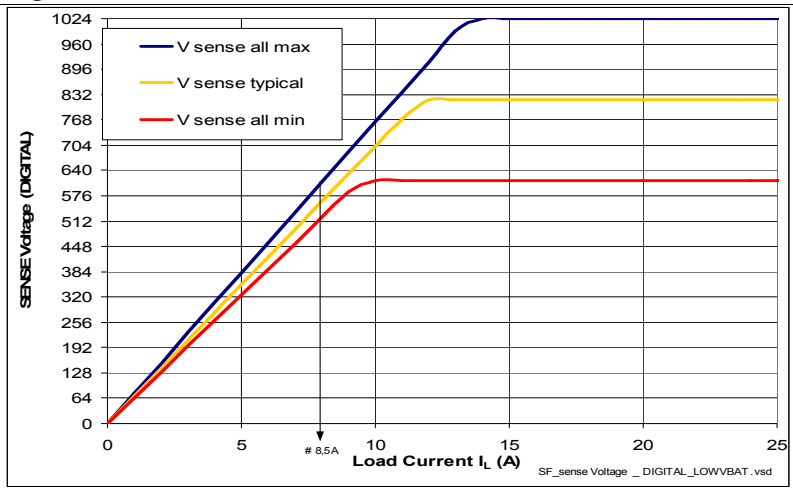

Figure 8 A/D Voltage Function of the Load Current with BTS5020-2EKA

The SENSE dynamic is limited during low battery operation by the V_{IS} voltage. Taking the BTS5020-2EKA as an example, from a SENSE dynamic of 16.5A, the value can goes down to 8.5A so half the value. In other words, the BTS5020-2EKA signals a load current higher than 8.5A the same way than a short circuit with a V_{BAT} of 6V. The micro controller should interpret a voltage of 3V at the A/D converter as a short circuit event if the battery voltage is 3V.

At first sight, this value can appear low but it should be balanced to the effective load current at 6V V_{BAT}. **Table 1** sums up the SENSE dynamic of all PROFET + devices and **Table 2** shows the maximum current the planned load exhibits at 6V battery. There is no overlapping and even good safety margin.

Table 1 PROFET + SENSE Dynamic

mΩ	**8**	**10**	**12**	**16**	**20**	**30**	**45**	**90**	**120**	**180**
k_{ILIS_TYP}	4500	4250	4000	3500	3000	2150	1500	1500	550	550
I_{L_MAX} SENSE dynamic 13.5V	27.4	25.8	24.3	21.3	16.6	11.9	8.3	8.3	3.0	3.0
I_{L_MAX} SENSE dynamic 6V	9.8	9.2	8.7	7.6	6.9	4.9	3.4	3.4	1.2	1.2

Table 2 PROFET + Load Current

mΩ	**8**	**10**	**12**	**16**	**20**	**30**	**45**	**90**	**120**	**180**
LOAD (W)	65	55	3x27+5	55	2x27+5	2x21	27	21	10	5
I_{L_MAX} in DC (no PWM) 13.5V supply	5.3	4.5	7.3	4.5	5.0	3.9	2.3	2.0	0.8	0.4
I_{L_MAX}in DC (no PWM) 6V supply	3.5	3.0	4.9	3.0	3.3	2.6	1.5	1.3	0.5	0.3

5 Conclusion

Using PROFET + at low battery voltage is possible. The diagnosis works with limitation. The micro controller should monitor the current battery voltage and interprets A/D information accordingly.

6 Revision History

PROFET+ Current Sense with Low Battery Voltage

Revision History: Rev 0.0, 2010-06-30

Previous Version(s):
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Page	**Subjects (major changes since last revision)**

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