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Optimization of External Components for Automotive Smart Power Module to Mitigate Specified HVIC Malfunction

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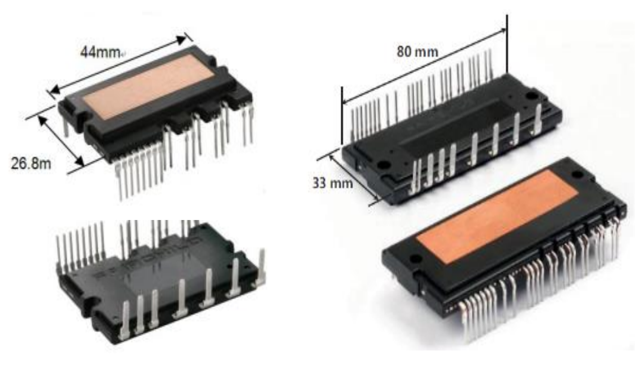
Abstract

This paper presents an optimization approach for external components in automotive auxiliary inverter solutions utilizing the ONSEMI Automotive Smart Power Module (ASPM) series, particularly focusing on E-compressor applications. External component selection is critical for eliminating specific abnormal operations, such as drive IC latch issues in junction-isolated type HVIC. The study addresses one such drive IC latch malfunction problem and proposes methods to mitigate it using external components such as V_{DD} and V_{BS} capacitors, bootstrap resistors.

1 Introduction

ONSEMI has introduced the ASPM27 for 650V and ASPM34 for 1200V for automotive auxiliary inverter applications, offering solutions for E-compressors, oil/water pumps, and super/turbocharger systems. These modules are characterized by compact packaging, optimized performance, and ease of assembly with high reliability in Fig 1 [1,2]. However, occasional abnormal issues arise due to misunderstandings regarding the optimization of external components, despite ONSEMI providing application notes. Particularly, many customers are seeking cost-effective solutions for their systems, often resulting in the use of small-value components or the removal of external components, which can inadvertently trigger specific abnormal operations.



(a) ASPM27 for 650V (b) ASPM34 for 1200V

Fig. 1. Outline overview for ASPM27 and ASPM34

2 Main Proposal

2.1 Abnormal operation

Figure 2 illustrates a typical application circuit for the ASPM product and ONSEMI provides certain external components also in an application note for stable operation. However, improper external component values can lead to unexpected turn-on during a system or double pulse test (DPT) switching, as depicted in Fig 3. Even when the HIN(VGE) has already turned off with zero voltage, the high side output is unexpectedly turned on again.

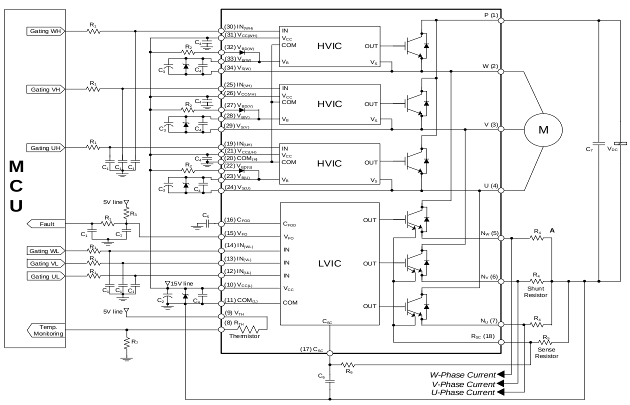


Fig. 2. Typical full application circuit for ASPM series

Here, the values of the external components are arbitrarily determined by a particular customer, rather than being prescribed by ONSEMI. Particularly, unexpected configurations of the external capacitors for V_{DD} and

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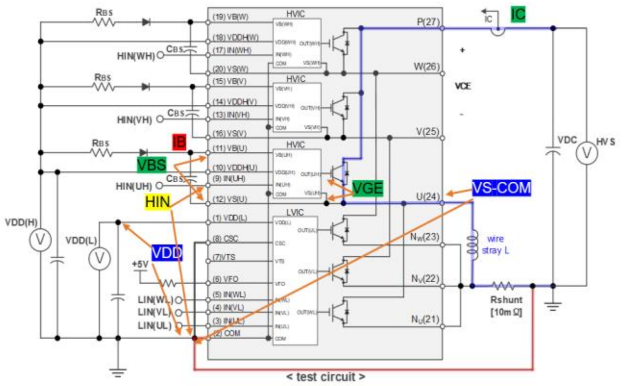
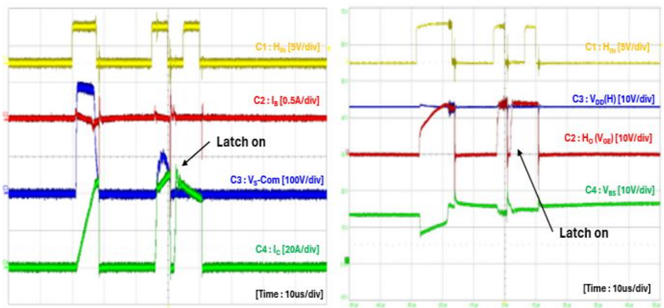
VBS, as well as the value of the bootstrap external resistor, can lead to unforeseen malfunctions such as HVIC latch-on.



(a) DPT test circuit and measurement point



(b) Unexpected waveform: VDC=600V, VDD=13V, VBS=13V, Ic=45A, Tc=25ºC

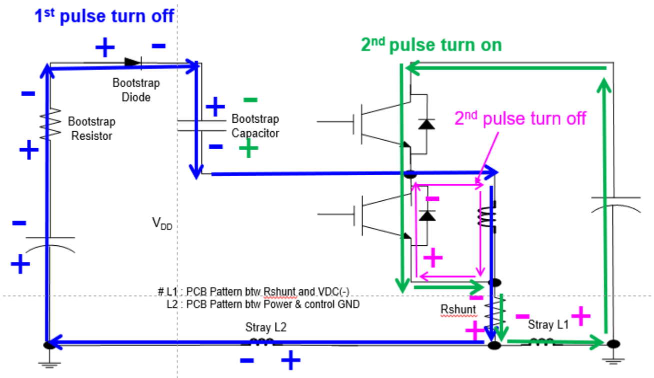
Fig. 3. DPT circuit and abnormal waveforms

2.2 Abnormal operation mechanism and

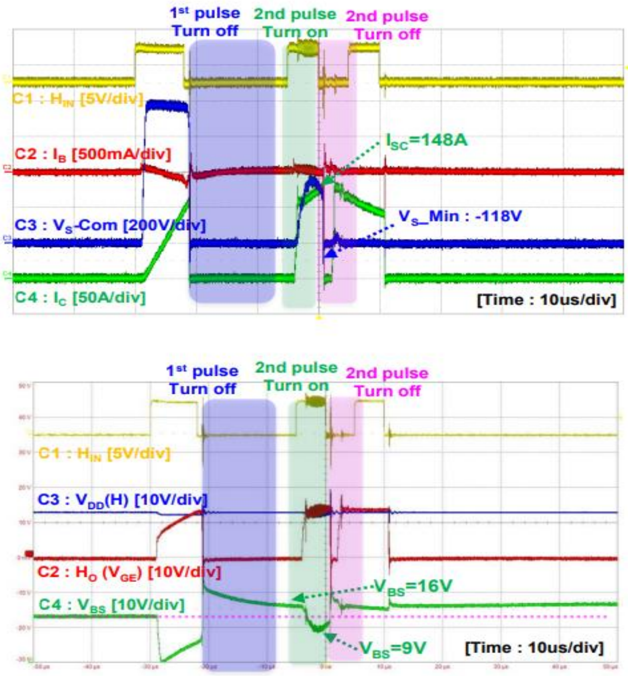
Figures 4 and 5 present detailed depictions of the abnormal operation mechanism. The mechanism underlying these erroneous actions can be delineated as follows and explained in three distinct stages.

1. During the first pulse turn off, a small VDD/VBS capacitor and a small resistor can make high VBS.
2. Upon the second pulse turn on, the heightened VBS, facilitated by the increased gate voltage of the high-side IGBT and the small VBS capacitor, can generate high current, leading to a drop in VBS.
3. Subsequently, during the second pulse turn off, a deficient ground PCB pattern and high IGBT current contribute to elevating the negative VS.

Ultimately, the conjunction of high IGBT current due to high VBS, the resulting VBS drop, and the elevated negative VS can yield a shortened turn-off time, potentially leading to the overlap of Reset & Negative VS [3].



(a) Abnormal operation path in three distinct stages



(b) Abnoraml operation waveform in three distinct stages

Fig. 4. Abnormal operation mechanism

These malfunctions can be easily rectified through the following table 1, which not only facilitates the elimination of these errors but also ensures system stability.

	VDD capacitor	VBS capacitor	Bootstrap resistor
External component value by unexpected malfunction	100 [uF]	10 [uF]	4.7 [ohm]
Suggested external component value	200 [uF]	33 [uF]	20 [ohm]

Table. 1. Suggested external component value

The table lists recommended values for each VDD, VBS, and bootstrap resistor as suggested by ONSEMI and

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the calculation method is well-explained in the application note for those products [1,2] and also got normal operation waveform with suggested external component as shown Fig. 5.

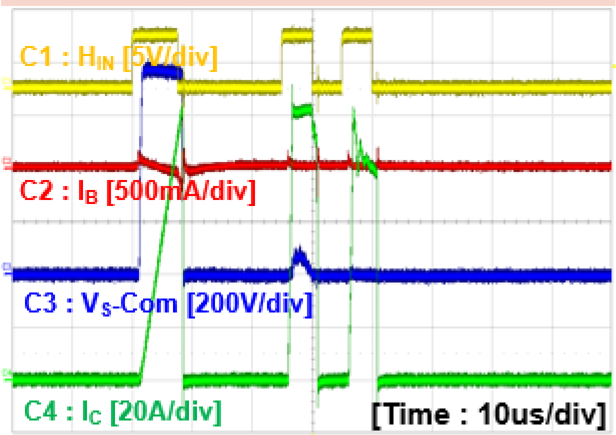

Fig. 5. Normal operation waveform with suggested external component

3 Conclusion

This paper presents a solution against the malfunctions by effect of external component, and it offers an advantage with simple solution.

4 References

[1] AN-9075, Smart Power Module, Motion 1200 V SPM 2 Series User's Guide, by ONSEMI

[2] AND-9800/D, Automotive Smart Power Module, 650 V ASPM27 Series, application note, by ONSEMI

[3] Kinam Song, Wonhi Oh, Jinkyu Choi, Seunghyun Hong and Sangmin Park: A New 1200 V HVIC with High Side Edge Trigger in order to Solve the Latch on Failure by the Negative VS Surge, Proc. ISPSD 2018, 351-354

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