Application Note

NOVOSENSE

Electronic Fuel Injection System

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ABSTRACT

This application note introduces the function of NOVOSENSE NSPAS3M absolute pressure sensor in an electronic fuel injection system for automotive or motorcycle. It describes how to integrate NSPAS3M into the manifold absolute pressure sensor module (MAP) and some critical electrical characteristics are presented in detail. This application note is also useful as a reference to design the MAP module.

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1.Introduction

As shown in Figure 1, for modern combustion engine with electronic fuel injection system, the manifold air temperature and pressure values are important parameters for ECU to calculate the correct amount of fuel to be injected to achieve highest fuel burning efficiency and optimized engine performance.

The pressure and temperature inside the manifold is measured by the temperature manifold absolute pressure sensor (TMAP). Usually a negative temperature coefficient thermistor (NTC) is used to measure the temperature. For the pressure measurement application the NOVOSENSE NSPAS3M series of absolute pressure sensors is well-suited.

This application note mainly focuses on the following topics:

- Brief introduction of (T)MAP sensor design concept
- Pin definition
- Typical application circuit of NSPAS3M
- Critical electrical characteristics of NSPAS3M via evaluation data

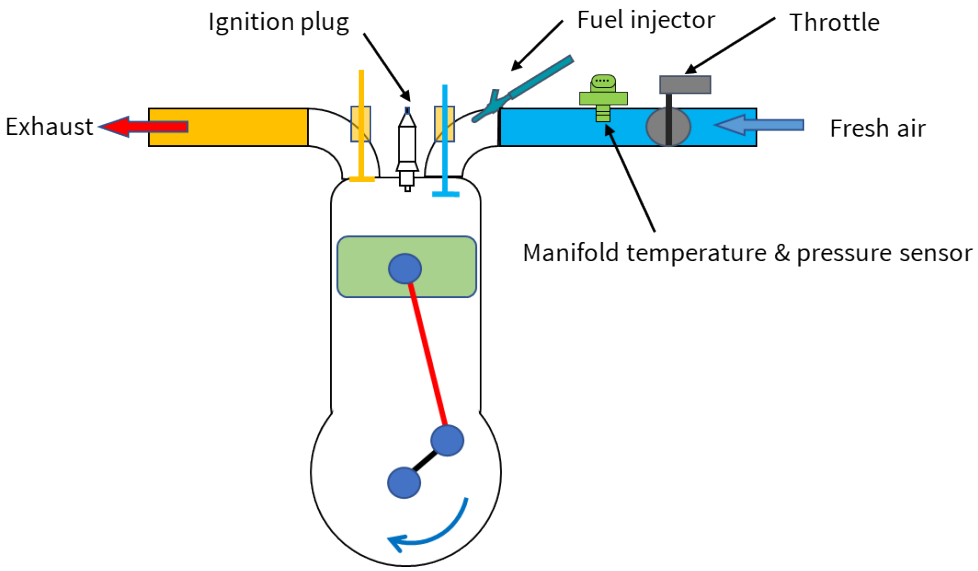

Figure 1. Electronic fuel injection system for automotive and motorcycle

Figure 2. Picture of a MAP module with an NSPAS3M sensor inside

2.Typical (T)MAP sensor design concept

Figure 3 demonstrates the basic design concept of a typical TMAP module with 7 different components highlighted in different colors. These separate components are assembled into the final functional module in the following 3 steps.
Firstly, the integrated pressure sensor is soldered to the PCB by surface mounting technology (SMT) while the NTC thermistor is connected to the PCB by traditional tin soldering. Then the pre-assemble PCB in last step is inserted into the housing and fixed with glue & thin solder. Finally, a cover is mounted on the top of PCB module to protect it from external environment with dust and water drops.

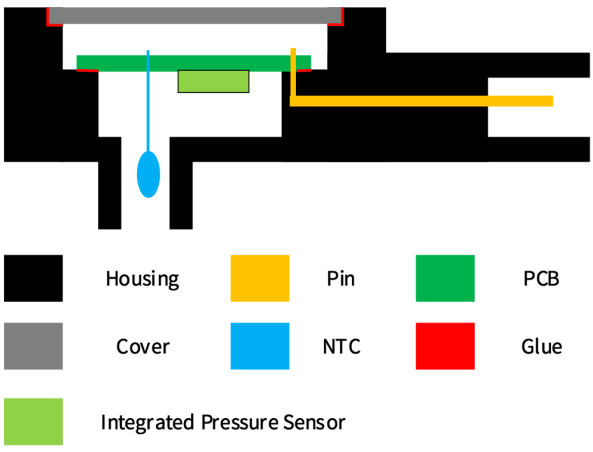

Figure 3. Cross-section of a TMAP Module

3.Pin definition

As shown in Figure 4, pin definition of NSPAS3M is compatible with Infineon KP2XX series for analog output application. Figure 5 illustrates the PCB layout of NSPAS3M & KP2XX which could replace each other without PCB modification.

In addition, NSPAS3M is optimized for motorcycle & automotive application with double wire bonding for each pad which could ensure better robustness and reliability.

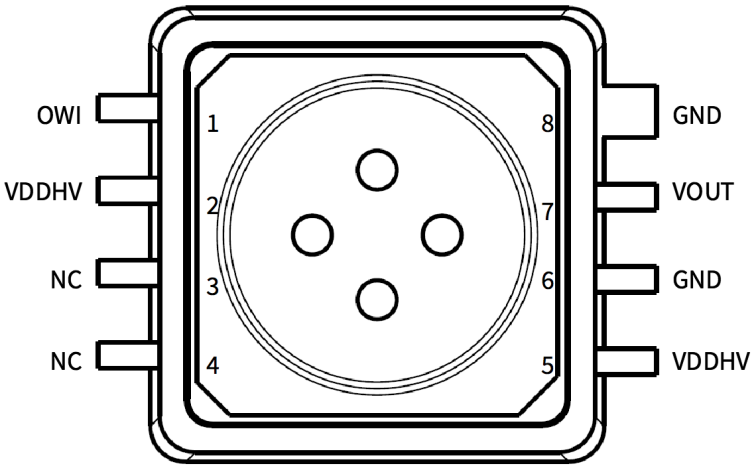

Figure 4. Pin definition of NSPAS3M series

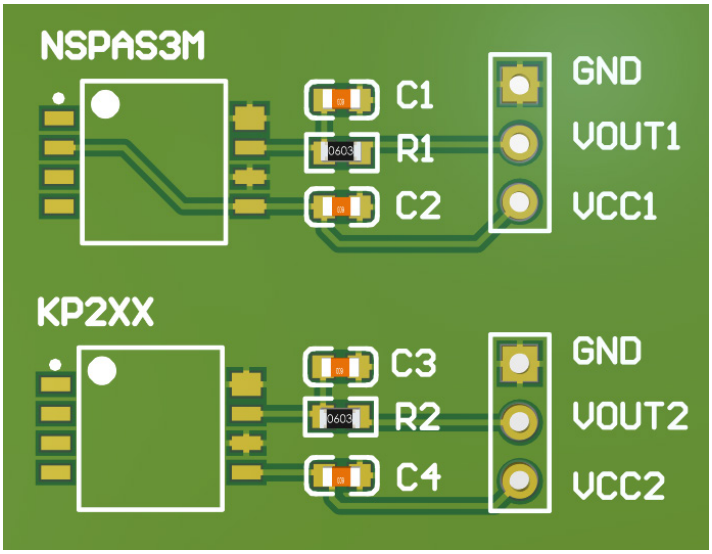

Figure 5. Pin to pin compatible demonstration

4.Typical application circuit

Figure 4 illustrates the typical application circuit for NSPAS3M series which could ensure the basic function of the sensor at most working conditions. If there is additional EMC requirement, beads and TVS could be used to improve the system performance. Please refer to the specific EMC application note AN-12-0001 for details.

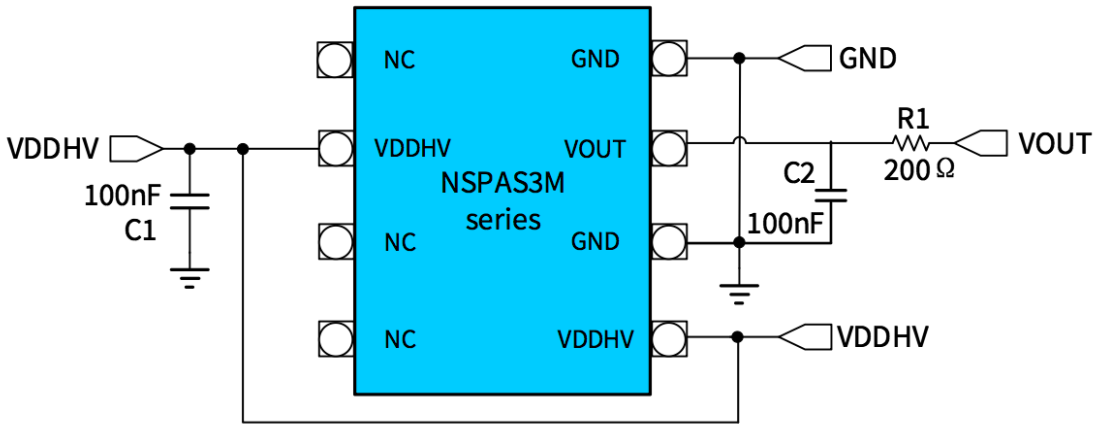

Figure 6. Application circuit of NSPAS3M

5.Evaluation data

The response time and accuracy are the most critical performance indicators of pressure sensor for manifold pressure measurement application. These two characteristics are discussed in detail in this section with evaluation data for NSPAS3M, and other similar options on the market.

5.1.Response time

Step response time of NSPAS3M115RRG1 is around 315μs.

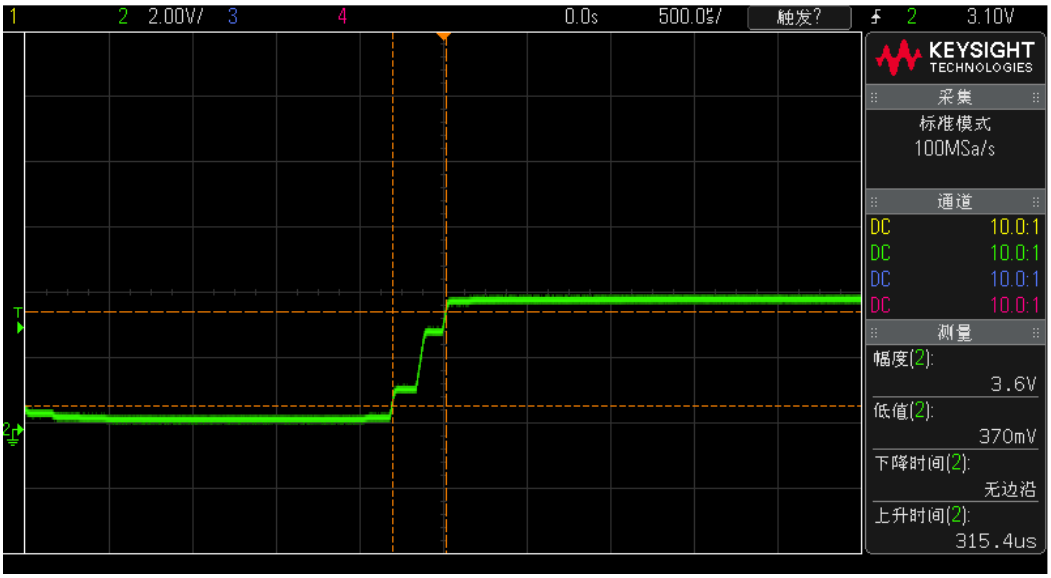

Figure 7. NSPAS3M115RRG1 response time

Step response time of other option A is around 500µs.

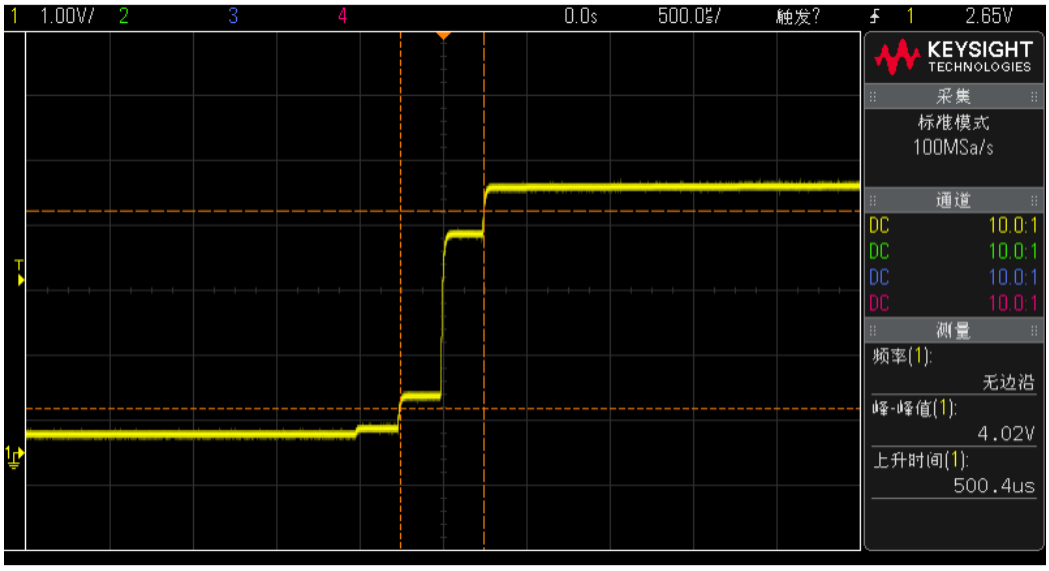

Figure 8. Option A response time

Step response time of other option B is around 500μs.

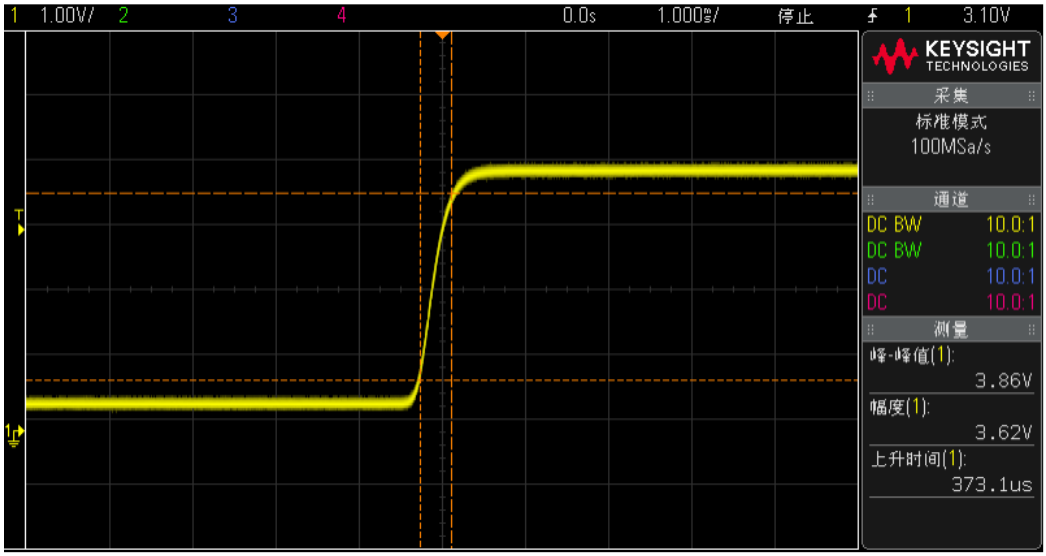

Figure 9. Option B response time

5.2.Initial accuracy

Initial accuracy of NSPAS3M115RRG1 is less than 1%F.S. in temperature range of -40~125°C.

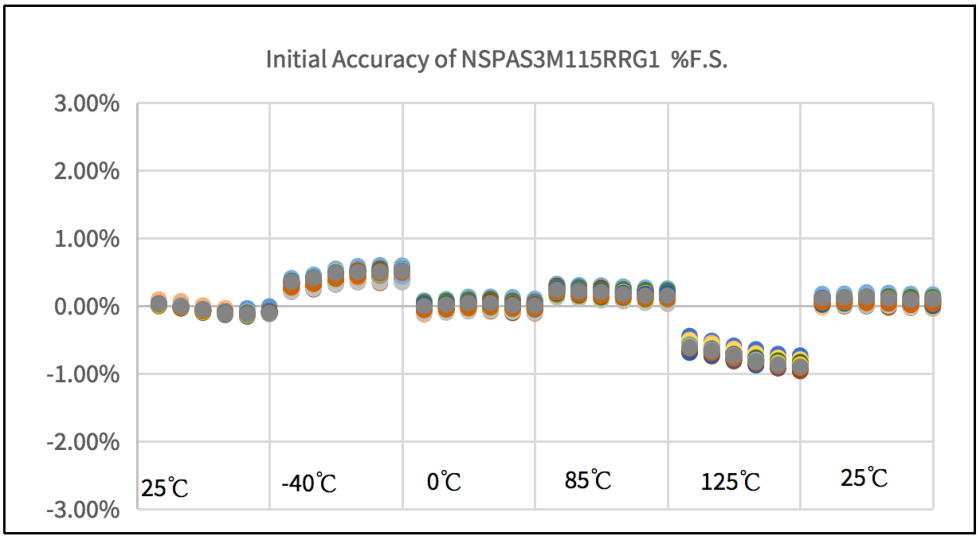

Figure 10. NSPAS3M115RRG1 initial accuracy

Initial accuracy of option A is around 1.5%F.S. in temperature range of -40~125°C.

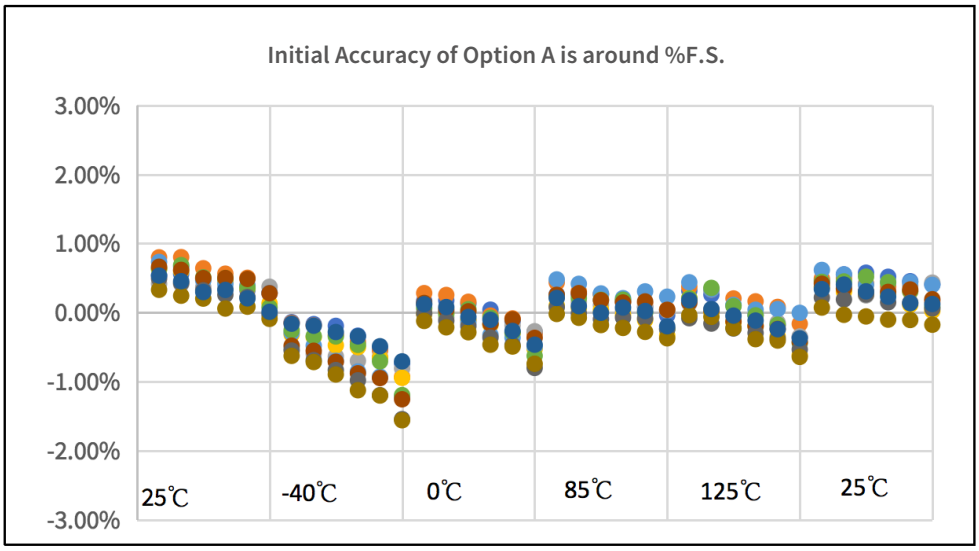

Figure 11. Option A initial accuracy

Initial accuracy of option B is around 0.6%F.S. in temperature range of -40~125°C.

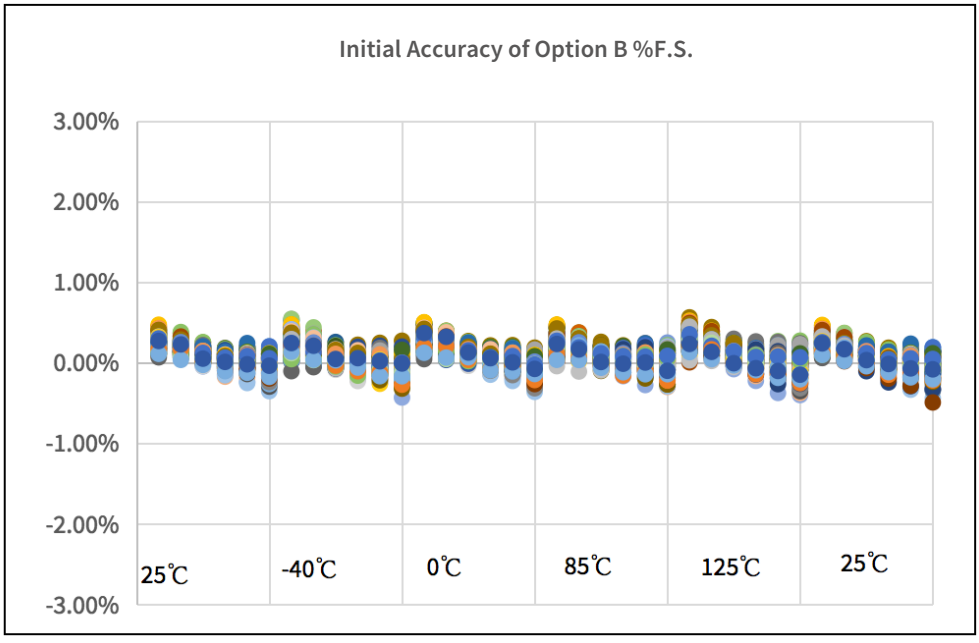

Figure 12. Option B initial accuracy

5.3.Accuracy after reflow

Reflow peak temperature: 260°C.

Post reflow accuracy of NSPAS3M115RRG1 is less than 1%F.S. in temperature range of -40~125°C.

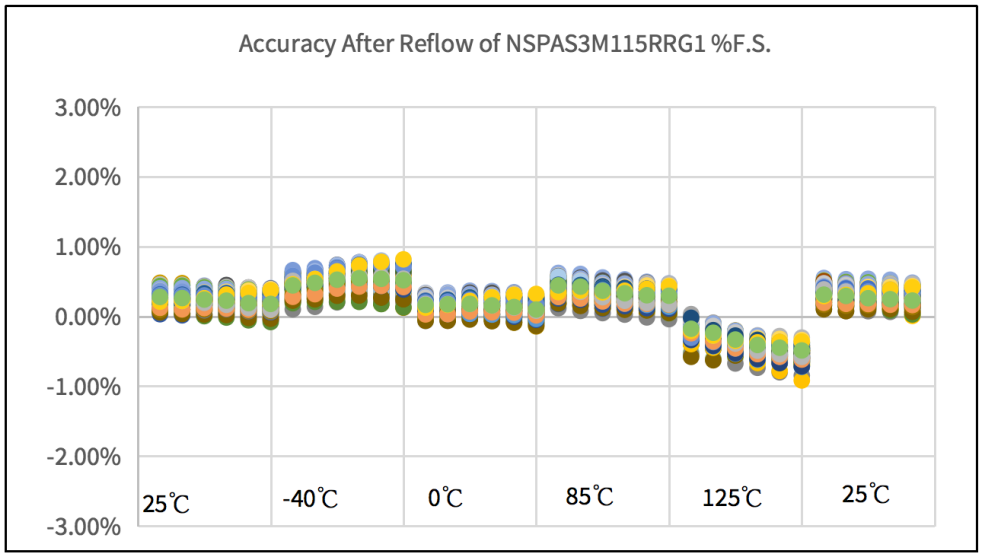

Figure 13. NSPAS3M115RRG1 accuracy after reflow

Post reflow accuracy of option A is around 2.2%F.S. in temperature range of -40~125°C.

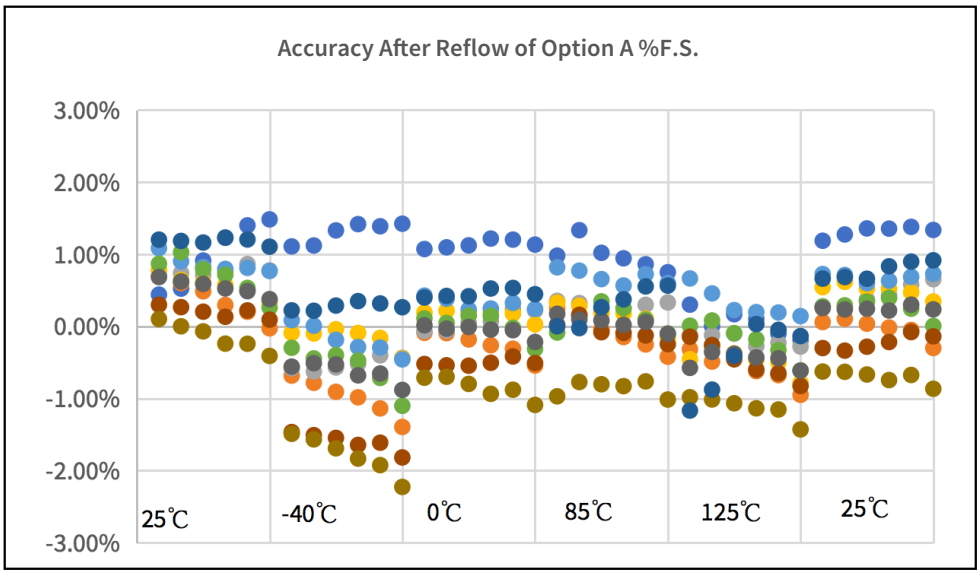

Figure 14. Option A initial accuracy after reflow

Post reflow accuracy of option B is less than 0.8%F.S. in temperature range of -40~125°C.

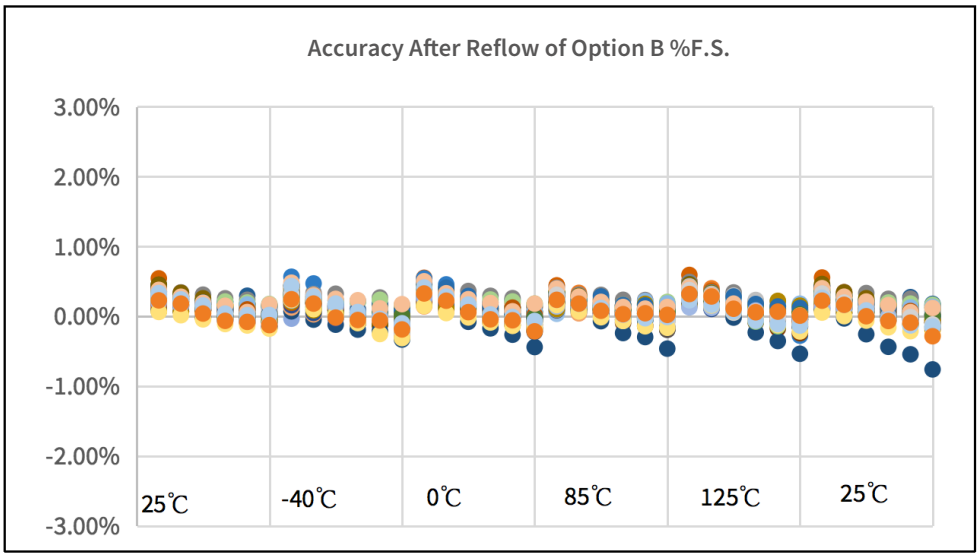

Figure 15. Option B accuracy after reflow

5.4.Accuracy after TC

Thermal cycle test condition: -40~125°C, dwell time 15mins, transfer time < 30s, 500 cycles.
Post TC accuracy of NSPAS3M115RRG1 is less than 1%F.S. in temperature range of -40~125°C.

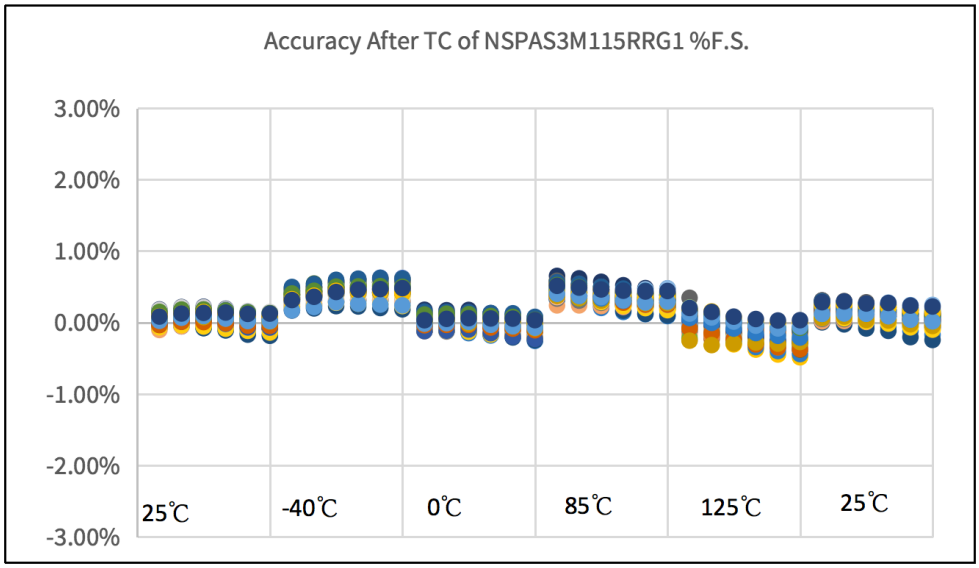

Figure 16. NSPAS3M115RRG1 accuracy after TC

Post TC accuracy of option A is around 2.4%F.S. in temperature range of -40~125°C.

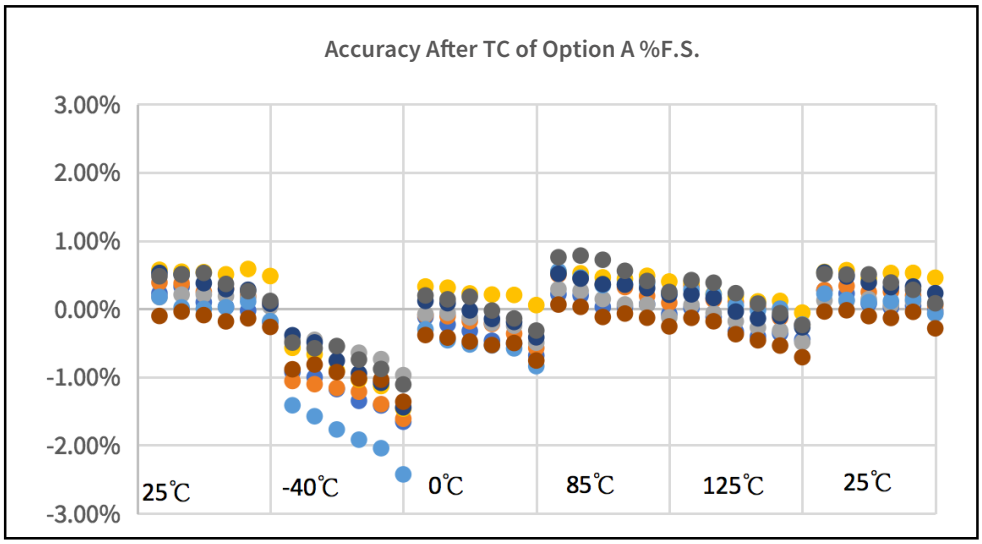

Figure 17. Option A accuracy after TC

Post TC accuracy of option B is less than 0.7%F.S. in temperature range of -40~125°C.

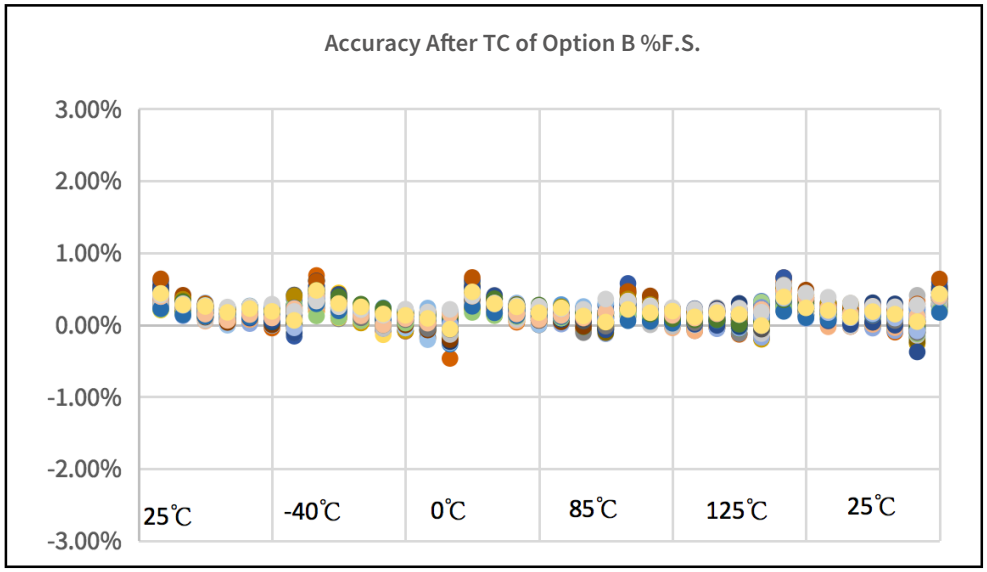

Figure 18. Option B accuracy after TC

5.5.Accuracy after HAST

HAST test condition: 130°C, 85%RH, 230kPa, 5.5V power supply, 96 hours.

Post HAST accuracy of NSPAS3M115RRG1 is less than 1%F.S. in temperature range of -40~125°C.

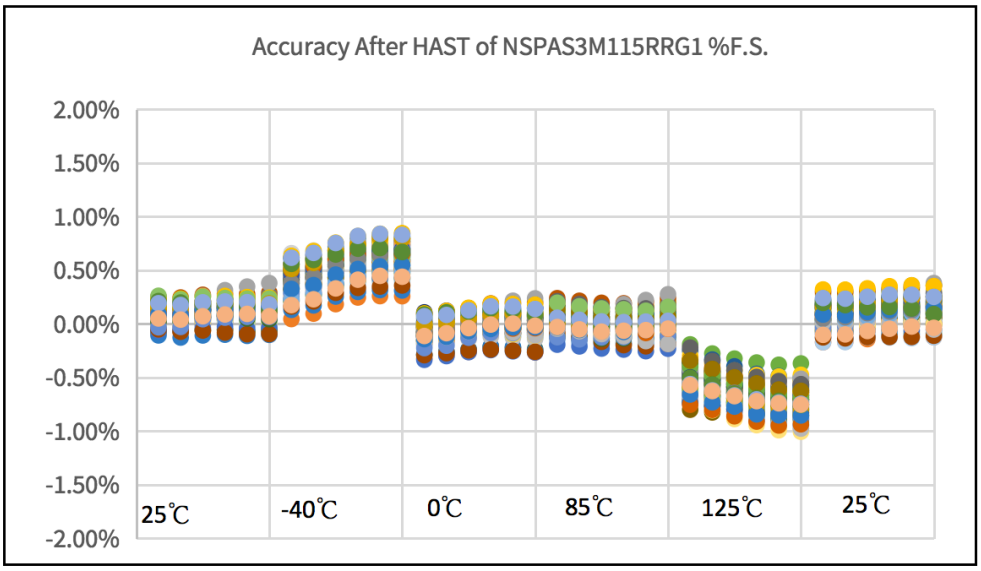

Figure 19. NSPAS3M115RRG1 accuracy after HAST

Post HAST accuracy of option A is around 1.2%F.S. in temperature range of -40~125°C.

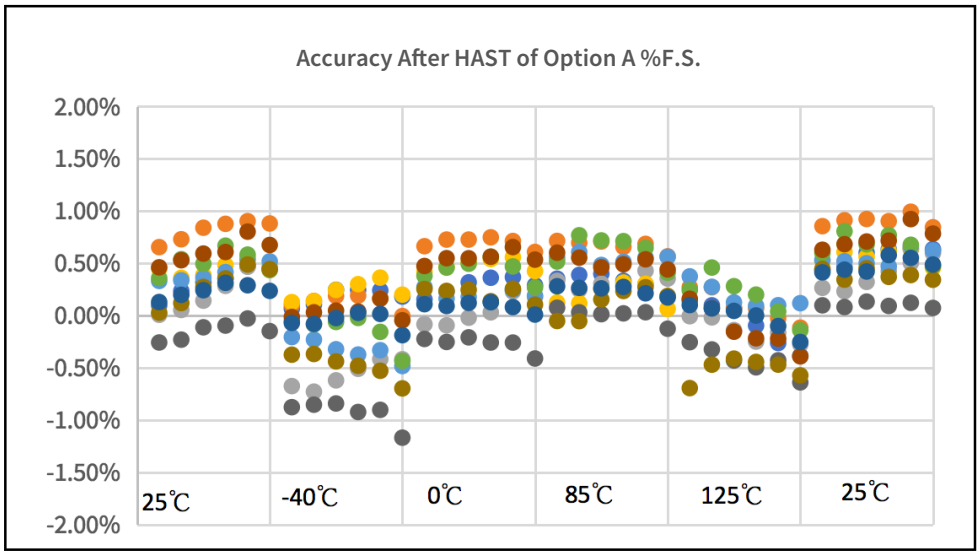

Figure 20. Option A accuracy after HAST

Post reflow accuracy of option B is less than 0.8%F.S. in temperature range of -40~125°C.

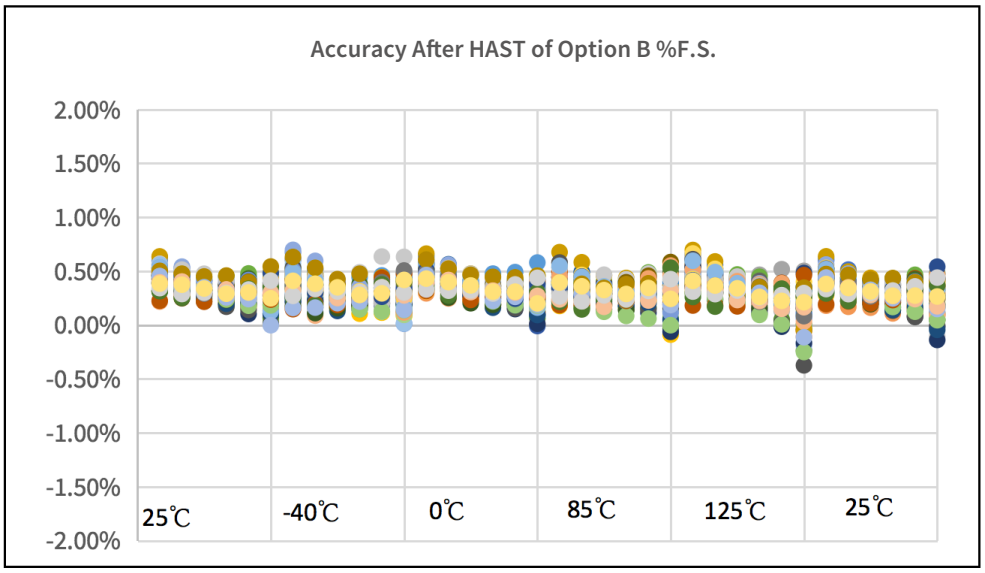

Figure 21. Option B accuracy after HAST

5.6.Evaluation data comparison

The evaluation results of option B , option A and NSPAS3MN115RRG1 are summarized as follows:

Items	Option B	Option A	NSPAS3M115RRG1
Response time	373μs	500μs	315μs
Initial accuracy	0.6%	1.5%	1.0%
Post reflow accuracy	0.8%	2.2%	1.0%
Post TC accuracy	0.7%	2.4%	1.0%
Post HAST accuracy	0.8%	1.2%	1.0%

6.Summary

This application note describes how NSPAS3M absolute pressure sensor fulfills its function in the electronic fuel injection system for modern combustion engine including the (T)MAP module design concept and the application circuit. Then the evaluation data of response time and accuracy are demonstrated in detail which could be reference for component selection.

7.Revision history

Revision	Description	Author	Date
1.0	Initial version	Charles Chen	2023/08/17

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