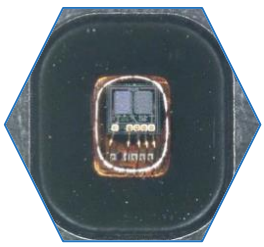
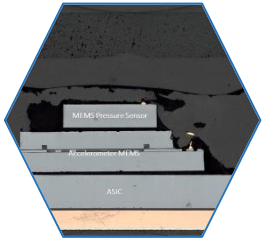
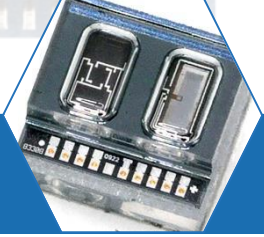


TPMS Comparison 2021

A new generation of tire pressure monitoring systems: tech and cost analysis of five MEMS-based components from Infineon, Melexis, NXP, Senasic, and Sensata.



The tire pressure monitoring system (TPMS) market is evolving with the adoption of automotive safety and environmental regulations, from \$213.6M in 2020 to \$309M expected in 2026, with a CAGR19-26 of 6.3%. TPMS safety applications remains the biggest portion of the MEMS pressure sensor market with new Chinese regulation. TPMS are increasingly sophisticated, with more and more functions such as 2 - 3 frequencies for communication and the addition of an accelerometer to measure radial acceleration. Today, the latest generation of TPMS from the main manufacturers are not only pressure monitoring systems but also sensors used to gauge the speed and position of the tires to improve the control of the trajectory.

In this report we analyze the latest generation of five major TPMS manufacturers: Infineon, Melexis, NXP, Sensata, and Senasic. In total, two European companies, two American, and one Chinese. The five components studied are the SP40PLUS from Infineon, the MLX91804 from Melexis, the NTM88 from NXP, the SM704 from Sensata, and the SNP729 from Senasic. Two models of supply chains are possible, and all components are developed internally – for example, Infineon, Melexis, and NXP, or Sensata and Senasic, which develop the ASIC die and purchase the pressure sensors.

For three of these TPMS – the SP40PLUS, MLX91804, and SNP729 – we make a comparison with the oldest versions to

observe the evolution of the technologies. The encapsulation is an important axis of evolution with 2 - 3 dies assembled and stacked in smaller volume.

The pressure sensors are either capacitive absolute pressure sensors or piezoresistive absolute pressure sensors. Two accelerometers use a capacitive technology similar to other accelerometer MEMS on the market. Infineon is the only one to have developed a specific pressure sensor and accelerometer in the same die for the TPMS market.

This full reverse costing study has been conducted to provide insight into the technology data, supply chain, manufacturing cost, and selling price of the five studied TPMS. Also included is a detailed comparative physical analysis with process descriptions, and a comparative manufacturing cost analysis between the five TPMS. Moreover, a teardown, bill of materials, and cost/selling price estimation of each TPMS has been made available.

COMPLETE TEARDOWN WITH:

- Detailed optical and SEM pictures
- Comparison among the TPMS
- Precise measurements
- Materials analysis
- Comparison of the different technologies
- Manufacturing process flow
- Supply chain evaluation
- Manufacturing cost analysis

Title: TPMS Comparison 2021
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Technical and Cost Comparison of the Five TPMS

AUTHORS

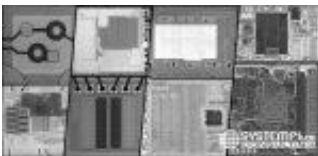


Sylvain Hallereau has been Project Manager at System Plus Consulting since 2000. He is in charge of costing analyses for Integrated Circuits, Power semiconductors and LEDs. He has significant experience in the modeling of manufacturing costs for electronics components, Sylvain holds a Master degree in Microelectronics from the University of Nantes, France.



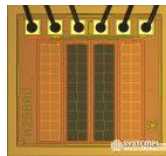
Véronique Le Troadec has joined System Plus Consulting as a laboratory engineer. Coming from Atmel Nantes, she has extensive knowledge in failure analysis of components and in deprocessing of integrated circuits.

RELATED ANALYSES



MEMS Pressure Sensor Comparison 2018

Structure and costing comparison of 34 MEMS pressure sensors from 18 different manufacturers in consumer, automotive and industrial applications.
May 2018



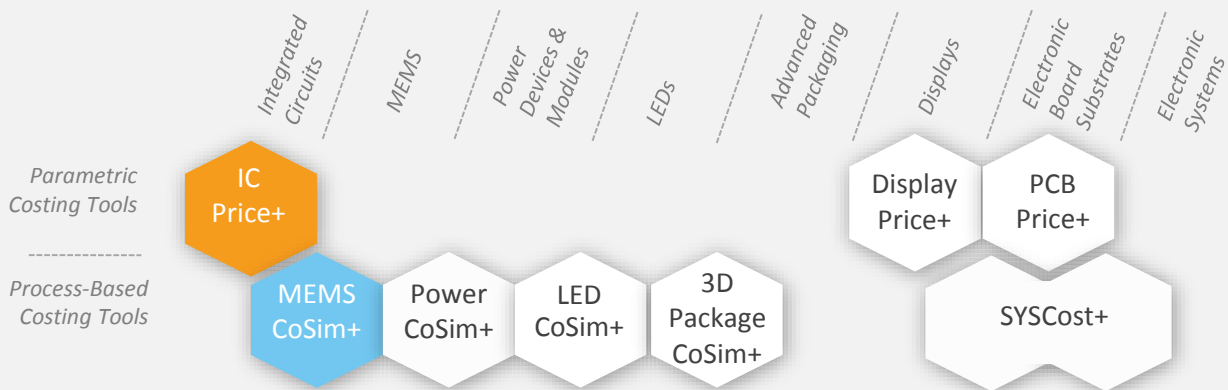
Sensor

The first barometric sensor from Infineon for the consumer market is targeting altitude, GPS, indoor and weather forecasting applications in portable devices.
February 2017



The MEMS market will grow due to new opportunities in audio for microphones, microspeakers and inertial MEMS, AR/VR for optical MEMS, and other emerging applications.
July 2021

COSTING TOOLS



Our analysis is performed with our costing tools IC Price+ and MEMS CoSim+.

System Plus Consulting offers powerful costing tools to evaluate the production cost and selling price from single chip to complex structures.

IC Price+

The tool performs the necessary cost simulation of any Integrated Circuit: ASICs, microcontrollers, DSP, memories, smartpower...

MEMS CoSim+

Cost simulation tool to evaluate the cost of any MEMS process or device.

ABOUT SYSTEM PLUS CONSULTING

WHAT IS A REVERSE COSTING®?

Reverse Costing® is the process of disassembling a device (or a system) in order to identify its technology and calculate its manufacturing cost, using in-house models and tools.



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System Plus Consulting is specialized in the cost analysis of electronics from semiconductor devices to electronic systems. A complete range of services and costing tools to provide in-depth production cost studies and to estimate the objective selling price of a product is available.

Our services:

- **STRUCTURE & PROCESS ANALYSES**
- **TEARDOWNS**
- **CUSTOM ANALYSES**
- **COSTING SERVICES**
- **COSTING TOOLS**
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TERMS AND CONDITIONS OF SALES

1. INTRODUCTION

The present terms and conditions apply to the offers, sales and deliveries of services managed by System Plus Consulting except in the case of a particular written agreement.

Buyer must note that placing an order means an agreement without any restriction with these terms and conditions.

2. PRICES

Prices of the purchased services are those which are in force on the date the order is placed. Prices are in Euros and worked out without taxes. Consequently, the taxes and possible added costs agreed when the order is placed will be charged on these initial prices.

System Plus Consulting may change its prices whenever the company thinks it necessary. However, the company commits itself in invoicing at the prices in force on the date the order is placed.

3. REBATES and DISCOUNTS

The quoted prices already include the rebates and discounts that System Plus Consulting could have granted according to the number of orders placed by the Buyer, or other specific conditions. No discount is granted in case of early payment.

4. TERMS OF PAYMENT

System Plus Consulting delivered services are to be paid within 30 days end of month by bank transfer except in the case of a particular written agreement.

If the payment does not reach System Plus Consulting on the deadline, the Buyer has to pay System Plus Consulting a penalty for late payment the amount of which is three times the legal interest rate. The legal interest rate is the current one on the delivery date. This penalty is worked out on the unpaid invoice amount, starting from the invoice deadline. This penalty is sent without previous notice.

When payment terms are over 30 days end of month, the Buyer has to pay a deposit which amount is 10% of the total invoice amount when placing his order.

5. OWNERSHIP

System Plus Consulting remains sole owner of the delivered services until total payment of the invoice.

6. DELIVERIES

The delivery schedule on the purchase order is given for information only and cannot be strictly guaranteed. Consequently any reasonable delay in the delivery of services will not allow the buyer to claim for damages or to cancel the order.

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The transport costs and risks are fully born by the Buyer. Should the customer wish to ensure the goods against lost or damage on the base of their real value, he must imperatively point it out to System Plus Consulting when the shipment takes place. Without any specific requirement, insurance terms for the return of goods will be the carrier current ones (reimbursement based on good weight instead of the real value).

8. FORCE MAJEURE

System Plus Consulting responsibility will not be involved in non execution or late delivery of one of its duties described in the current terms and conditions if these are the result of a force majeure case. Therefore, the force majeure includes all external event unpredictable and irresistible as defined by the article 1148 of the French Code Civil?

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As a rule, all information handed by customers to system Plus Consulting are considered as strictly confidential.

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The Buyer is responsible for the use and interpretations he makes of the reports delivered by System Plus Consulting. Consequently, System Plus Consulting responsibility can in no case be called into question for any direct or indirect damage, financial or otherwise, that may result from the use of the results of our analysis or results obtained using one of our costing tools.

11. APPLICABLE LAW

Any dispute that may arise about the interpretation or execution of the current terms and conditions shall be resolved applying the French law.

If the dispute cannot be settled out-of-court, the competent Court will be the Tribunal de Commerce de Nantes.