Conclusions

This dissertation has carried out a complete analysis of sensor interface development methodologies proposing an evolution of the Platform Based Design Flow with the ISIF platform. This complex mixed-signal System On Chip, developed in collaboration with SensorDynamics AG, features a comprehensive set of high performance and fully programmable analog and digital IPs for interfacing a wide spectrum of sensor typologies. Indeed thanks to its high flexibility and performances, ISIF platform, which is integrated in a 0.35 μm BCD technology, enables a fast prototyping of sensor interfaces, letting designers perform an effective design space exploration and evaluate directly on silicon the system performances avoiding the critical and time consuming analysis required by standard platform based approach, reducing the time-to-market and improving the final ASIC performances.

Despite of its high flexibility and performances, ISIF platform presents some fundamental limits. The platform has been integrated in a leading-edge BCD integrated technology that guarantees reliability, high performances over temperature, ESD robustness and above all high gate density together with high-voltage and high-power devices. Anyway the platform has been limited to low voltage applications (3.3/5 V) since it was conceived to interface inertial MEMS sensors and MR sensors, which can be actuated and sensed with low voltage level signals. Nevertheless latest generation of MEMS and MOEMS exploited in many automotive and consumer applications require high-voltage and/or high-current capabilities. For these reasons, the Ph.D. research activity has been initially focused on the extension of the ISIF application space to water flow monitoring applications based on hot-wire MEMS anemometers, which require high-current and high-voltage levels to achieve higher sensitivity and then to the design of a new platform, the SD4K, able to interface last generation of MEMS and MOEMS.

The system study of a water flow monitoring in pipes based on a MEMS hot-wire anemometer has been presented. More in detail the design and laboratory test measurements of the high-voltage and high-
current PWM driver designed to actuate the hot-wire anemometer have been described. The proposed PWM driver is designed to work in the range of low frequencies (PWM output current up to 100 kHz) and with output currents between 50 mA and 130 mA. The presented topology exploits a feedback loop that allows fixing the output current to the desired value with high precision. Simulation and measurement results performed on a prototype designed and fabricated in a 0.35 μm Bipolar CMOS DMOS technology prove the effectiveness of the proposed solution showing a final error on the current value lower than 1.8% taking into account devices’ mismatch, supply voltage and temperature variation.

The SD4K platform designed is conceived to interface latest generation of MEMS and MOEMS devices and to realize a projection system based on an electrostatically actuated bi-dimensional scanning micromirror and on a laser-source system. Laser based video projection systems are expected to find a wide utilization for the realization of new generation automotive head up displays thanks to the recent advances of MOEMS and visible laser sources. The dissertation has described the state of the art for MOEMS sensors, particularly focusing on electrostatically actuated bi-dimensional raster scanning micromirrors that are far simpler to integrate than magnetic or piezoelectric micromirrors.

The ISIF approach applied to the development of this new platform has enabled a fast and effective evaluation of the whole sensor system achieving an optimal architectural definition. Furthermore, since ISIF platform allows the design space exploration to be carried out directly on silicon, phenomena related to the specific sensor and the optic environment have been highlighted as well, allowing to study and to apply proper counteractions. A system study has been conducted, starting from the development of an electric equivalent model of the micromirror to represent the interaction between the mechanical and electric world. The development of this model has involved FEM simulations and several laboratory measurements performed on the micromirror to evaluate its main performance parameters. All simulations have been useful to understand the behaviour of the real micromirror taking into account different actuation voltages, frequencies and temperatures. Then the description of the SD4K architecture has been presented, focusing on the main functionalities of the different sections in which the platform can be subdivided. Firstly, the analog section has been described, highlighting the performances of the output channels and the flexibility of the input channels. Secondly, the functionality of the ARM9 processor embedded in the system has been described. The powerful embedded processor allows not only a fast execution of the software routines needed by the application, but can also be used to embed an Operating System,
inserting a more user friendly software layer.

A deeper analysis of the analog section has been carried out, describing the design and simulation results of the scanning micromirror high-voltage actuation driver. The high-voltage driver and all the SD4K platform digital and analog IPs have been integrated in a 0.18 μm BCD technology supplied by STMicroelectronics. The driver output stage has a 25 V supply voltage, which allows to reach the high-voltage level required for the proper deflection of the scanning micromirror. Moreover the circuit features: a low Total Harmonic Distortion (THD) to prevent the excitation of unwanted micromirror’s higher resonating modes that would lead to malfunctions in the mechanical device; the programmability of the output common mode voltage between 5 V and 12.6 V in order to change the electrostatic torque applied to the mechanical structure and thus being able to actuate different micromirror prototypes and achieving different deflection angles. The high-voltage driver features a THD of about $4.7 \times 10^{-3}$ as estimated by Monte Carlo simulations performed on the circuit together with the previously described electrical equivalent micromirror model, which has enabled to take into account the micromirror non-linearities.
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List of Publications

The technical contributions of this dissertation have been published on international journals and conference proceedings. The complete list is reported at the end of this document. The list has been generated by University of Pisa “Anagrafe della Ricerca” official database. An up-to-date list can be accessed at the following URL:

http://arp.unipi.it/listedoc.php?lista=ALL&id=419264&ord=C
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**Atti di convegni nazionale con revisori articolo in extenso**


**Atto di convegno internazionale con revisori articolo su invito**

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