On-Chip Fuzzy Temperature Control

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TÜV CERT

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Charakteristics

The on-chip fuzzy temperature control can be applied in completely integrated adaptive fuzzy microsystems containing sensors, actors and processing circuits.

For temperature sensitive analog circuits or sensor arrays a chip area with constant temperature is desirable which could not satisfactorily be achieved with the hitherto used modelling of the temperature distribution on the chip. The reasons for this lie in the impossibility of an exact mathematical model of the system, in inexact and erroneous signals and in the high measurement effort.

- **High stability and small error tolerance**

- **fuzzy controllers are more cost-effectively to implement than PID controllers**

- **easy-to-understand system description, no complicated mathematical model**

The test chip (fig. 2) contains a fast on-chip temperature control based on a fuzzy control algorithm and specially designed temperature sensors and heating transistors.

The chip functions can be controlled by an externally applied 8-bit command code. Modes are divided in parameter setting, normal operation, memory manipulation and testing.

During normal operation the chip works as a fuzzy controller. The internal control loop is closed and the chip area is adjusted to the previously programmed target temperature.

More than one temperature sensor is included in the calculation of the heater signal to improve the controller quality.

In the parameter mode the target temperature may be programmed and the sensors may be selected. Memory manipulations allow the modification of internal memory containing the fuzzy system definition.

During test mode it is among other things possible to access the current chip temperature.

- **ensure a homogeneous temperature in the whole range (± 0,3 %)**

- **fast control response to distortions (200 µs)**

- **fast switching between different fixed temperatures**

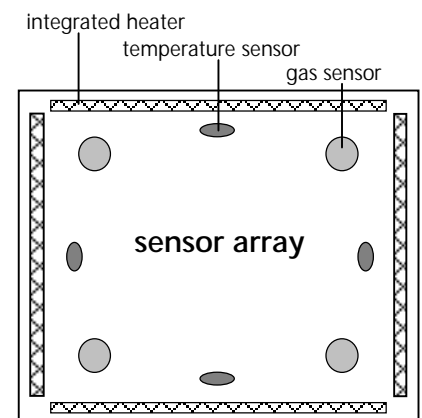- **optimal tracking of temperature curves (± 1 %)**

Fig. 1:   Application of a temperature controlled area in gas sensorics

Technical characteristics

- temperature range:
  0 C ... 100 C

- supply voltage:
  4,5 V... 5,5 V

- supply current:
  0,9 A (all four heaters)

- clock rate:
  10 MHz

- word width:
  8 bit

- temperature-controlled area:
  3 x 3 mm^2

- PGA case: IPK 68F1-8753, 68 pins

Applications

Several temperature-controlled areas separated from each other may be integrated on the same chip for user-specific sensor application in heated temperature-controlled on-chip environments (fig. 1)

- **reduction of measurement time by better controller dynamics**

- **high working temperatures because of minimized overshoot**

- **improvement of properties of systems with not so high-grade sensors**

In the application »gas sensor system« differing sensor geometries and varying temperature conductances of the media to be measured influence the response time of the control loop.

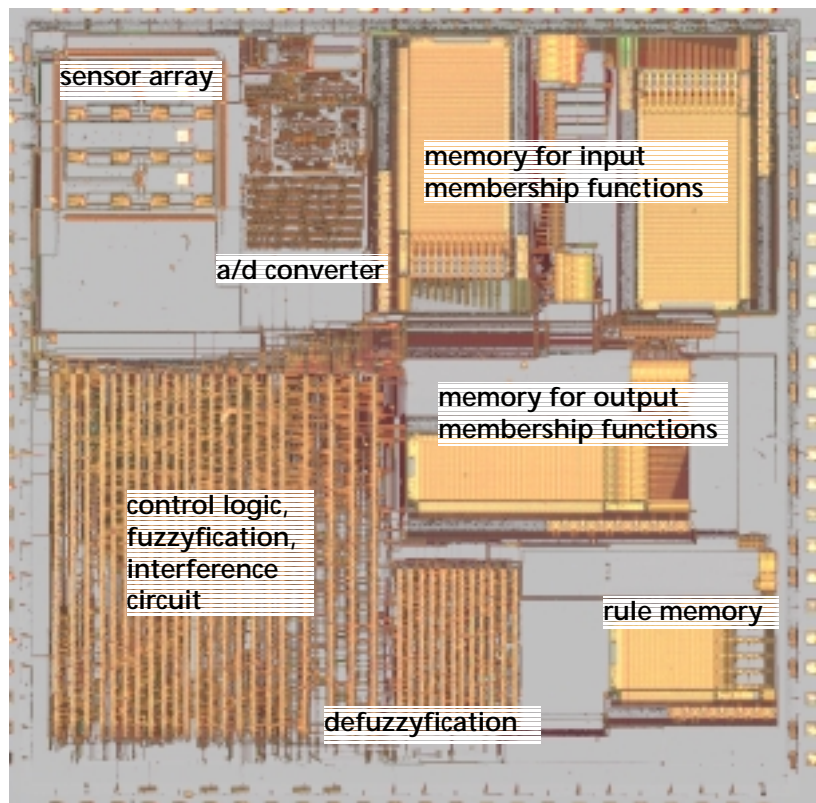By the excellent dynamic behaviour of the Fuzzy Logic controller the target temperature can be reached in short time. The temperature can be used as an additional feature during gas classification.

Fig. 2: Layout for the test chip