Application Note

Usage of Temperature sensor and measurement of VDDD in TDA5240, TDA5235 and TDA5225

Version 1.1
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Preface to Temperature and VDDD measurement procedure:
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In front of the AD converter there is a multiplexer. The default value of the ADC-MUX is RSSI (register ADCINSEL: 000 for RSSI; 001 for Temperature; 010 for VDDD/2).
After switching ADC-MUX to a value other than RSSI in SLEEP Mode, the internal references are activated and this ADC start-up lasts 100µs. So after this ADC start-up time the readout measurements may begin.
The chip stays in this mode until reconfiguration of register ADCINSEL to setting RSSI.
However, it is recommended to measure temperature during SLEEP mode (This is also valid for VDDD).

The ADC has a width of 10 bit, but only the upper 8 bits need to be used. So only the register ADCRESH needs to be readout.

Typical the ADC refresh rate is 3.7 µs.
Time duration between two ADC readouts has to be at least 3.7 µs, so this is already achieved due to the maximum SPI rate (16 bit for SPI command and address last 8µs at an SPI rate of 2MBit/s).
The EOC bit (end of conversion) indicates a successful conversion additionally.

Repetition of the readout measurement for several times is for averaging purpose.

The input voltage of the ADC is in the range of 1 .. 2 V. Therefore VDDD/2 (= 1.65 V typical) is used to monitor VDDD. The given equation (see below) re-calculates VDDD (3.3V typical) from ADC values.

Temperature procedure:

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Calculation of temperature from ADC value:

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The used temperature sensor is generating a voltage proportional to absolute temperature. This voltage is converted into a digital value by the ADC. The function TEMP=function(ADC-value) can be idealized by a straight line.

Depending on the required tolerance the following options are recommended:

Linear interpolation (generic data) - uncalibrated:

$$TEMP = k \cdot x + d$$

k … temperature coefficient
d … offset

Note1: The statistically evaluated parameters k and d (k = 0.873648 ; d = - 94.815) can be applied.
Note2: Alternatively for slightly smaller tolerances, the parameters k and d can to be evaluated on at least 1 device (e.g.: per silicon lot) using at least 2 temperature points during module verification. The emerging equation system with 2 equations can be resolved then for the parameters k and d.

Expected tolerance: +/- 23 degC for temperature range -40 … 105degC (3 sigma)

Linear interpolation (1st order calibration):

$$TEMP = k \cdot (x - cal) + d$$

k … temperature coefficient (is already evaluated statistically)
d … offset (is already evaluated statistically)
cal … calibration value (see section "Recommended calibration procedure of temperature sensor"

Note: Calibration needs to be done for each device at the end of line test of the module.

Expected tolerance: +/-4.5 degC for temperature range -40 … 105degC (3 sigma)

Recommended calibration procedure of temperature sensor:

Apply a temperature of 25°C (➔ d=25; d is valid in the range of 15 … 35) and perform a temperature measurement (see Temperature measurement procedure. Repeat 10 times for averaging purpose). The resulting value is used for the offset correction (cal).

The measured value can be converted into temperature via the following formula:

Temp = k * (x – cal) + d

The parameters k and d are evaluated statistically (k = 0.873648 ; d = 25).
The given numbers can be adapted slightly to achieve better accuracy.

Temperature measurement procedure:

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* Set chip to SLEEP mode
* Set register ADCINSEL to "Temperature"
* Wait for at least 100 µs for 1st readout
* Readout ADC via register ADCRESH
* Repeat the readout process 10-times and create average value "x"

The ADC value x can be inserted into one of the equations described in section "Calculation of temperature from ADC value".

VDDD procedure:

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Recommended calibration procedure of VDDD sensor:

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Calibration of the sensor has to be done before usage.

* In case of a 3.3V application
  + Apply 3.3V for VDD5V, VDDA and VDDD (d=3.3V)
* In case of a 5V application
  + Apply 5V for VDD5V
  + Measure VDDD (d = measured VDDD; Note: Valid range of d = 3.0 … 3.4V for the given values)
* Set chip to SLEEP mode
* Set register ADCINSEL to "VDDD/2"
* Wait for at least 100 µs for 1st readout
* Readout ADC via register ADCRESH
* Repeat the readout process 10-times and create average value “cal” (value for the offset correction)

VDDD measurement procedure:

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This is similar to the temperature measurement procedure, but now "VDDD/2" has to be used in register ADCINSEL.

* Set chip to SLEEP mode
* Set register ADCINSEL to "VDDD/2"
* Wait for at least 100 µs for 1st readout
* Readout ADC via register ADCRESH
* Repeat the readout process 10-times and create average value “x”

The measured value can be converted into VDDD via the following formula:

$$VDDD = k * (x - cal) + d$$

The parameter k and d are evaluated statistically (k = 0.0084865; d = 3.3V or result of VDDD measurement during calibration, depending on 3.3V or 5V application).
Value x is the averaged register value of ADCRESH determined during VDDD measurement
The given numbers can be adapted slightly to achieve better accuracy.

Expected tolerance for 1-point calibration:

+/-25mV for temperature range -40 … 105degC (3 sigma)

Note: Calibration needs to be done for each device at the end of line test of the module.

Information:
Expected tolerance when uncalibrated (uses cal = 183): +/-200mV for temperature range -40 … 105degC (3 sigma)

History:
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<u>Changes in v1.1:</u>
 * Logo updated
 * Temperature range at 1-point calibration extended to +15°C .. +35°C
 * Any comment on B11 silicon deleted, as this is already outdated