MCU ADC basic parameters-without calibration

- *Analog front -end*

3.2 ADC reference

/*Vref extreme values are he, the detailed info at voltage reference section

- Vref extreme values are normal mode, not in calibration state:

$E_{VREF\_1V8} := \left(VREF_{1V8\_max} - VREF_{1V8\_nom}\right) = 13\ mV$

$VREF_{1V8\_min} = 1.787\ V$ $VREF_{1V8\_max} = 1.813\ V$

VREF error: $\frac{VREF_{1V8\_max} - VREF_{1V8\_nom}}{LSB} = 29$ /*LSB

3.3 Input stage-sampling /*Rs, Cs-sampling parasitics

Sampling parasitics: $R_{sw} \equiv 1.2\ k\Omega$ $C_h \equiv 8\ pF$

Sampling time: $T_{sample} \equiv 75\ ns$

Conversion time: $T_{conv} \equiv 250\ ns$

Sampling loss (due to finite samplin time)

Sampling parasitic time constant: $T_{sp} := R_{sw} \cdot C_h$

Settling factor during sampling: $1 - \left(e^{-\frac{T_{sample}}{T_{sp}}}\right) = 9.996 \cdot 10^{-1}$

Sampling loss(fractional) $loss_s := \left(e^{-\frac{T_{sample}}{T_{sp}}}\right) = 0.0405\%$ /*of sampled value-prportional with the amplitude

$loss_s \frac{3.3\ V}{LSB} = 3.038$ /* 3*LSB @full scale, negligible?

Note: all of sampled sub-circuit attached by 10 -15nF so sampledcharge loss calculation is not necessary

6.8.2.3 ADC Input Model

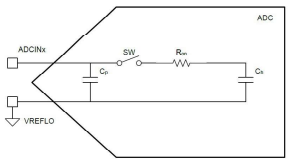


Figure 6-1. ADC Input Model

3.4 Input stage AMP-Gain and offset

Gain Error: $E_G := 5 \cdot LSB$

Offset Error: $E_O := 4 \cdot LSB$

Input leak current: $I_{leak} := 1.2\ \mu A$

- *ADC conversion parameters:*

3.5 Digitizing error params /*TUE-Total Unadjusted Error, INL, DNL

Differential Non-linearity $DNL := 1 \cdot LSB = 0.44\ mV$

Integral Non-linearity $INL := 2 \cdot LSB = 0.879\ mV$

*TUE/*TUE-Total Unadjusted Error* Not defined separately

3.6 ADC resolution-By amplitude /*count

$ADC_{bit} \equiv 12$

$ADC_{resolution} := 2^{ADC_{bit}} - 1 = 4.095 \cdot 10^3$

$LSB \equiv \frac{VREF_{1V8\_nom}}{2^{ADC_{bit}} - 1} = 0.44\ mV$ /*most ADC parameters are expressed in LSB

MCU ADC basic parameters-expressed by calibration reference

- *Analog front -end*

3.7 ADC reference

/*Vref extreme values are he, the detailed info at voltage reference section

- Vref extreme values are normal mode, not in calibration state:

$VREF_{cal\_min} = 1.638\ V$ $VREF_{cal\_max}$ $VREF_{cal\_nom} = 1.65\ V$ $E_{VREF\_cal} := (VREF_{cal\_max} - VREF_{cal\_nom}) = 12\ mV$

VREF cal error: $\frac{E_{VREF\_cal}}{LSB\_cal} = 29$ */*LSB-really large!!*

3.8 Input stage-sampling */*Rs, Cs-sampling parasitics*

/ No change, due to calibration*

Sampling parasitics: $R_{sw} = 1.2\ k\Omega$ $C_h = 8\ pF$

Sampling time: $T_{sample} = 75\ ns$

Conversion time: $T_{conv} = 250\ ns$

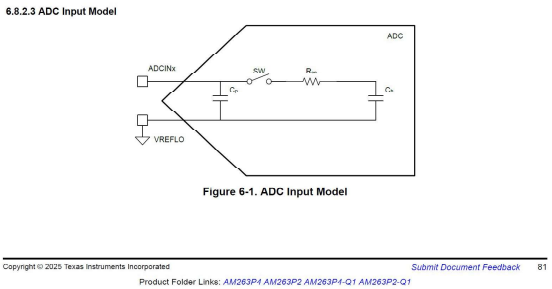
Sampling loss (due to finite samplin time)

Sampling parasitic time constant: $T_{sp} = 9.6\ ns$

Settling factor during sampling: $1 - \left(e^{-\frac{T_{sample}}{T_{sp}}}\right) = 9.996 \cdot 10^{-1}$

Sampling loss(fractional) $loss_s := \left(e^{-\frac{T_{sample}}{T_{sp}}}\right) = 0.0405\%$ */*of sampled value·prportional with the amplitude*

$loss_s \frac{3.3\ V}{LSB\_cal} = 3.314$ */* 3*LSB @full scale, negligible?*



Note: all of sampled sub-circuit attached by 10 -15nF so sampledcharge loss calculation is not necessary

3.9 Input stage AMP-Gain and offset

Gain Error: $E_{G\_cal} := 0 \cdot LSB\_cal$

Offset Error: $E_{O\_cal} := 0 \cdot LSB\_cal$

Input leak current: $I_{leak} := 1.2\ \mu A$

- *ADC conversion parameters:*

*/*TUE-Total Unadjusted Error, INL, DNL*

3.10 Digitizing error params

Differential Non-linearity $DNL\_cal := 1 \cdot LSB\_cal$

Integral Non-linearity $INL\_cal := 2 \cdot LSB\_cal$

*TUE/*TUE-Total Unadjusted Error* Not defined separately

3.11 ADC resolution-By amplitude

$ADC_{bit} = 12$

$ADC_{resolution} = 4.095 \cdot 10^3$

$LSB\_cal \equiv \frac{VREF_{cal\_nom}}{2^{ADC_{bit}} - 1} = 0.403\ mV$ */*most ADC parameters are expressed in LSB*

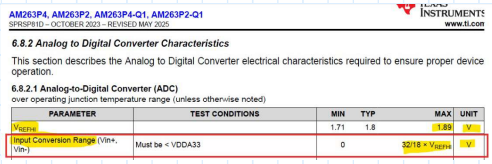
4.MCU ADC working range and accuracy calculations

Home

4.2 ADC Input voltage range:

$VREF_{1V8\_min} = 1.787\ V$ $VREF_{1V8\_max} = 1.813\ V$

$V\_in_{ADC\_max} \equiv \frac{32}{18} \cdot VREF_{1V8\_min} = 3.178\ V$



AM263P4, AM263P2, AM263P4-Q1, AM263P2-Q1
SPRSP81D – OCTOBER 2023 – REVISED MAY 2025
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6.8.2 Analog to Digital Converter Characteristics

This section describes the Analog to Digital Converter electrical characteristics required to ensure proper device operation.

6.8.2.1 Analog-to-Digital Converter (ADC)
over operating junction temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{REFHI}		1.71	1.8	1.89	V
Input Conversion Range (Vin+, Vin-)	Must be < VDDA33	0		32/18 × V_{REFHI}	V

Limit max: Result:

Limit max:

$V_{3V3\_LV\_nom} = 3.3\ V$ $V\_in_{ADC\_max} = 3.178\ V$

Note: in case of 3.3V , ADC input voltage range can be failed

4.3. Final accuracy:

MCU ADC accuracy without offset calibration

VREF error: $E_{VREF\_1V8} = 12.6\ mV$ $\frac{E_{VREF\_1V8}}{LSB} = 28.665$

Integral Non-linearity $INL = 0.879\ mV$ $\frac{INL}{LSB} = 2$ $\frac{DNL}{LSB} = 1$

Differential Non-linearity $DNL = 0.44\ mV$

Gain Error: $E_G = 2.198\ mV$ $\frac{E_G}{LSB} = 5$

Offset Error: $E_O = 1.758\ mV$ $\frac{E_O}{LSB} = 4$

$E_{ADC\_TOTAL} := \sqrt{E_{VREF\_1V8}{}^2 + INL^2 + DNL^2 + E_G{}^2 + E_O{}^2} = 12.948\ mV$

$\frac{E_{ADC\_TOTAL}}{LSB} = 29$ /*LSB

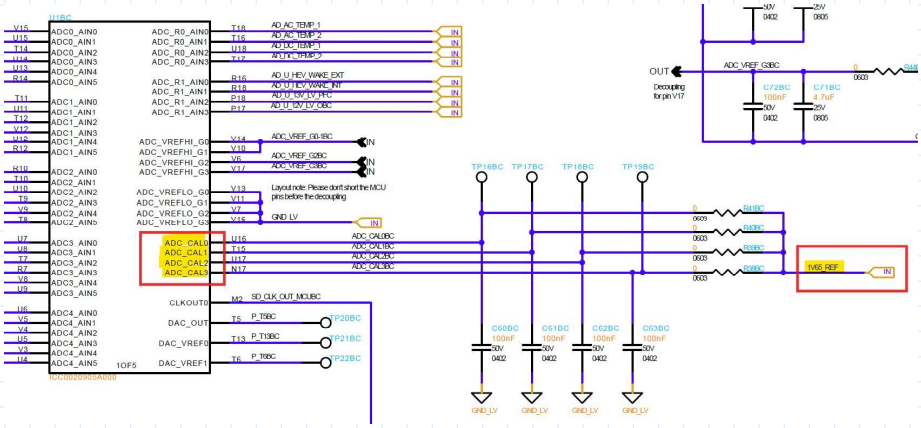
+Calculate leakage current for external circuit analysis

5.MCU ADC accuracy after calibration

Calibration procedure isof MCU ADC within the board is not clear for the author at this moment

Home

Supposing calibration will be executed on room temperature 25C

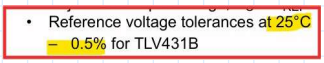


OPERATIONAL VOLTAGE REFERENCE TOLERANCE:

$tol_{VREF\_1V8} = 0.7\%$

CALIBRATION VOLTAGE REFERENCE TOLERANCE:

$tol_{SH\_REG} = 0.7\%$



+Calculate leakage current for external circuit analysis

6.SUMMARY

WITHOUT CALIBRATION:

$$\frac{E_{ADC\_TOTAL}}{LSB} = 29$$ /*LSB

WITH CALIBRATION:

$$\frac{E_{ADC\_CAL\_TOTAL}}{LSB} = ?$$ /*LSB

+Calculate leakage current for external circuit analysis

FOR SUPPORT TEAM:

PLEASE DESCRIBE THE CALIBRATION PROCEDURE AND PARAMETERS!

HELP ME TO FIND THE ADC ACCURACY AFTER THE CALIBRATION!