

CESIGN_TS IP

Analog Output Temperature Sensor

Features

- 3.3V analog and 1.2V digital supply voltage available
- $\pm 2^{\circ}\text{C}$ Accuracy at $-40^{\circ}\text{C} \sim 125^{\circ}\text{C}$ range with one temperature point calibration
- $\pm 5^{\circ}\text{C}$ Accuracy at $-40^{\circ}\text{C} \sim 125^{\circ}\text{C}$ range without calibration
- Linear $+6\text{mV}/^{\circ}\text{C}$ sensor gain
- $1.4\text{V} \sim 2.4\text{V}$ output at $-40^{\circ}\text{C} \sim 125^{\circ}\text{C}$ range
- Less than $20\mu\text{A}$ current consumption
- Accuracy enhanced by chopper amplifier

General Description

The CESIGN_TS IP is an integrated analog output temperature sensor that consist of temperature sensor core and calibration circuit.

Applications

- Internal temperature sensing of IC
- Temperature to analog voltage conversion
- Temperature to digital conversion with ADC over 10-bit

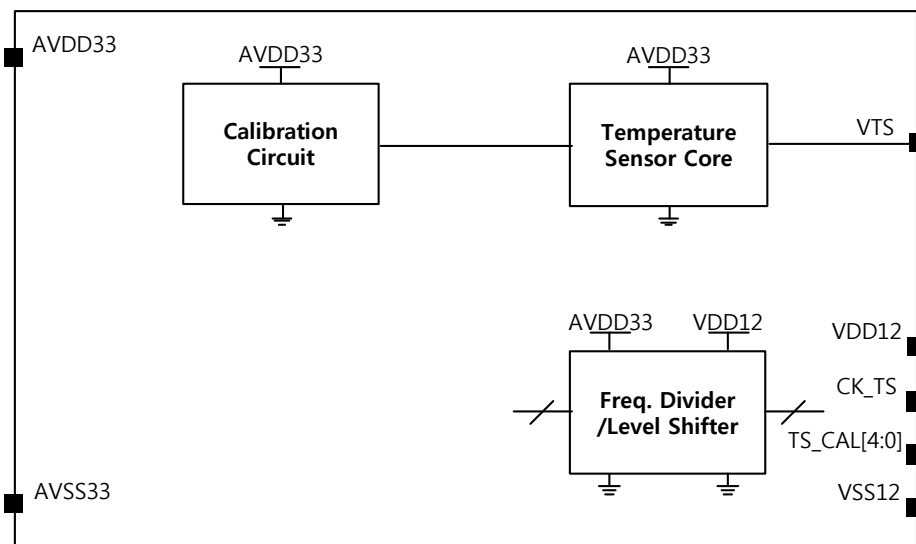


Figure 1. Functional Block Diagram

Absolute Maximum Ratings

Table 1. Absolute Maximum Ratings

Symbol	Rating	Max	Unit
AVDD33	Supply Voltage	3.6	V
T _{STG}	Storage Temperature	-40 to 125	°C

Recommended Operating Conditions

Table 2. Recommended Operating Conditions

Symbol	Rating	MIN	TYP	MAX	Unit
AVDD33	Analog Supply voltage	3.0	3.3	3.6	V
T _A	Operating Temperature Range	-40	25	125	°C

Electrical Characteristics (T.B.D.)
Table 3. Electrical Characteristics

 (Condition: Process=Typical process, AVDD33=3.3V, VDD12=1.2V, T_A=25°C unless otherwise noted)

Parameter	Condition	Values			Unit
		Min.	Typ.	Max.	
Supply Voltage	Analog power	3.0	3.3	3.6	V
	Digital power		1.2		V
Input Clock			9.0~10.3		MHz
Operating Current			20.0		uA
Accuracy1 (with 1-temp. point calibration)	T _A =-40°C, 125°C		±2.0		°C
	T _A =-40°C~125°C, Worst process	-5		+5	°C
Accuracy2 (without calibration)	T _A =-40°C, 125°C		±5.0		°C
	T _A =-40°C~125°C, Worst process	-15		+15	°C
Output Voltage (with 1-temp. point calibration)	T _A =25°C		1.8		V
	T _A =-40°C		1.4		V
	T _A =125°C		2.4		V
Sensor Gain	Average		+6.0		mV/°C
Power-on Time (refer to fig.4)	C _L =0pF		0.5	1.0	ms
Output-on Time (refer to fig.4) dependent on R _{ON_SW} , C _L	C _L =10pF		1.0		ms
IP Size			300*250		um ²

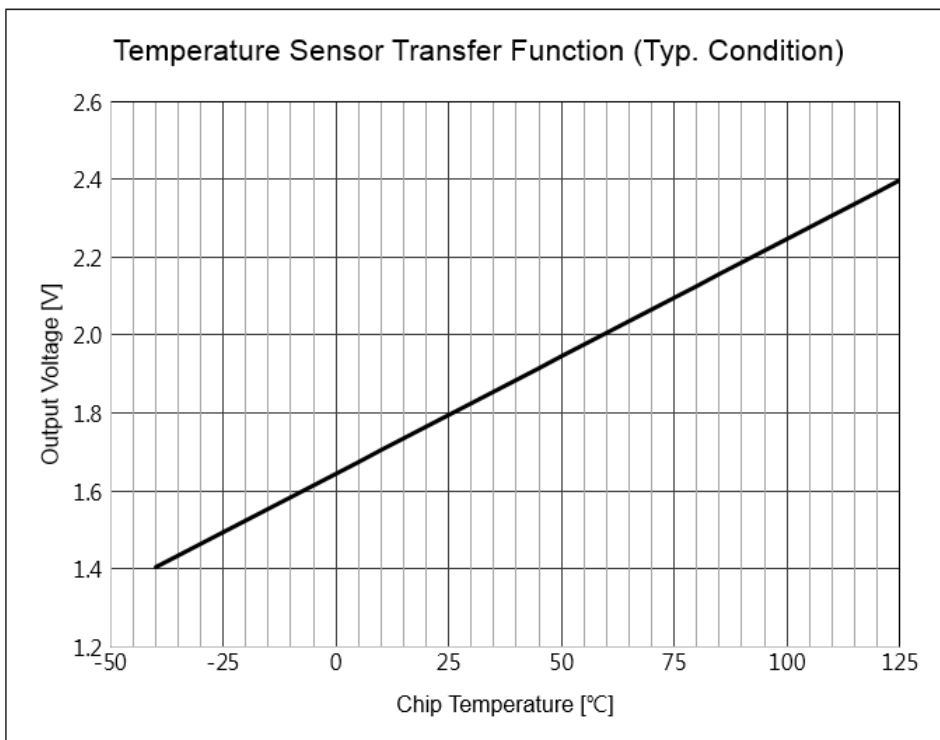


Figure 2. Output Voltage Vs. Temperature

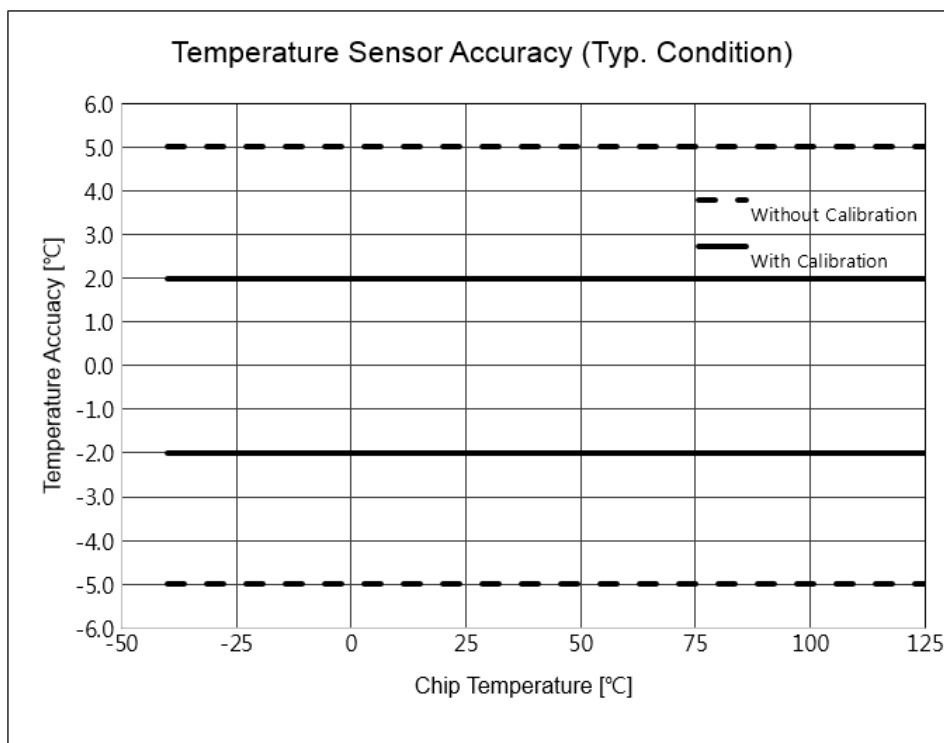


Figure 3. Accuracy Vs. Temperature

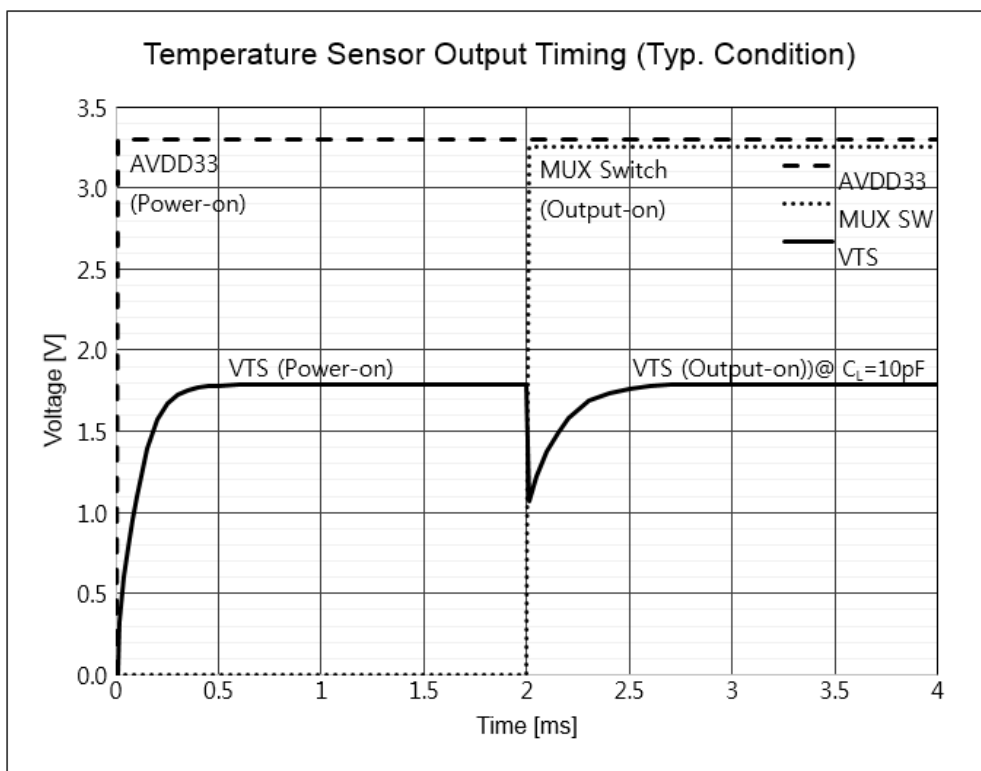
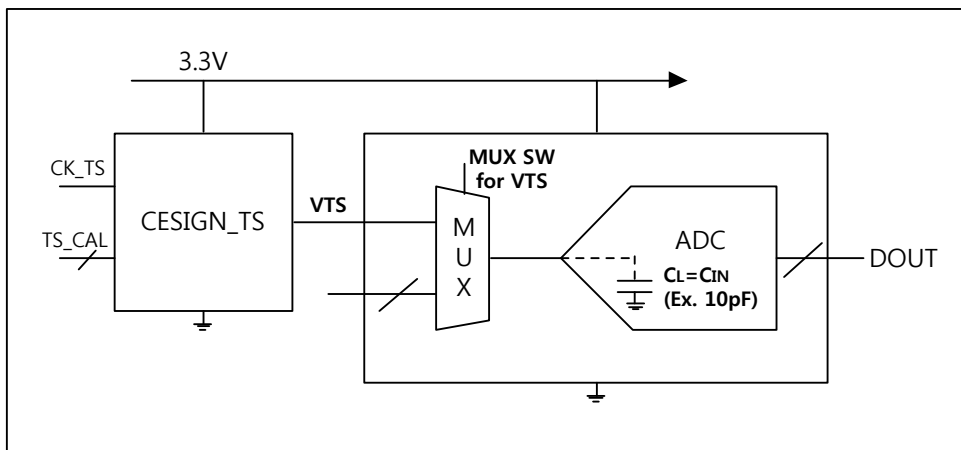


Figure 4. Power-on, Output-on Timing

Register Description

Table 4. Register Table

Register Name	DATA[7:0]								
	7	6	5	4	3	2	1	0	
TS_CALIBRATION	Reserved	Reserved	Reserved	TS_CAL[4:0]					
TS_CONTROL(Optional)	PD_TS	TS_CHOP	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	

Table 5. Descriptions of Register Table

Register Name	Descriptions
TS_CALIBRATION[7:0]	<p>[4:0]: TS_CAL = Temperature sensor calibration (Refer to Table 7) 5'b10000: +0°C calibration (default)</p>
TS_CONTROL[7:0] (Optional)	<p>[7]: PD_TS = Temperature sensor and gain amp. power-down control 1'b0: Power-on (default) 1'b1: Power-down</p> <p>[6]: TS_CHOP = Chopper enable control for temperature accuracy enhancement 1'b0: Disable 1'b1: Enable (default)</p>

Pin Description

Table 6. Pin Description

Pin No.	Pin Name	Type	Pin Position		Description
			X[um]	Y[um]	
1	AVDD33	AP	0	245	Analog power pin
2	VTS	AO	0	200	Temperature sensor output pin
3	AVSS3	AG	0	150	Analog ground pin
4	AVDD33	AP	0	32	Analog power pin
5	VSS12	DG	300	2	Digital ground pin
6	CK_TS	DI	300	5	Clock input pin for chopper amplifier
7	PD_TS	DI	300	7	Temperature sensor power-down control pin
8	TS_CHOP	DI	300	8	Chopping function enable pin
9	TS_CAL[0]	DI	300	10	Temperature sensor calibration pin
10	TS_CAL[1]	DI	300	11	Temperature sensor calibration pin
11	TS_CAL[2]	DI	300	12	Temperature sensor calibration pin
12	TS_CAL[3]	DI	300	13	Temperature sensor calibration pin
13	TS_CAL[4]	DI	300	14	Temperature sensor calibration pin
14	VDD12	DP	300	22	Digital power pin

1) D = Digital, A = Analog, I = In, O = Out, P = Power, G = Ground

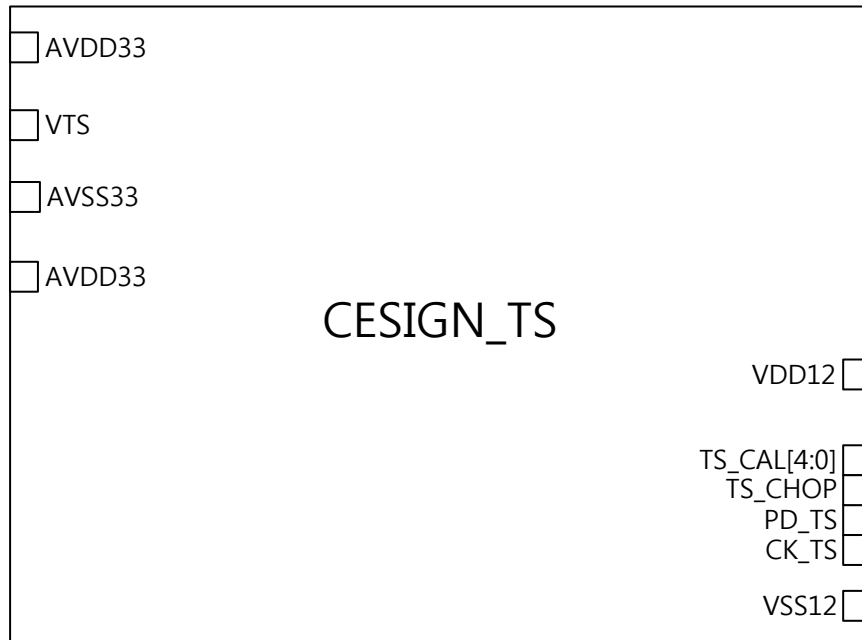


Figure 5. Pin Configuration

Temperature Calibration Information
Table 7. TS_CAL[4:0] Register Control for Temperature Calibration

Calibration Code	Calibration Range [°C]
<i>5'b11111</i>	+15
<i>5'b11110</i>	+14
<i>5'b11101</i>	+13
<i>5'b11100</i>	+12
<i>5'b11011</i>	+11
<i>5'b11010</i>	+10
<i>5'b11001</i>	+9
<i>5'b11000</i>	+8
<i>5'b10111</i>	+7
<i>5'b10110</i>	+6
<i>5'b10101</i>	+5
<i>5'b10100</i>	+4
<i>5'b10011</i>	+3
<i>5'b10010</i>	+2
<i>5'b10001</i>	+1
<i>5'b10000 (default)</i>	0
<i>5'b01111</i>	-1
<i>5'b01110</i>	-2
<i>5'b01101</i>	-3
<i>5'b01100</i>	-4
<i>5'b01011</i>	-5
<i>5'b01010</i>	-6
<i>5'b01001</i>	-7
<i>5'b01000</i>	-8
<i>5'b00111</i>	-9
<i>5'b00110</i>	-10

<i>5'b00101</i>	-11
<i>5'b00100</i>	-12
<i>5'b00011</i>	-13
<i>5'b00010</i>	-14
<i>5'b00001</i>	-15
<i>5'b00000</i>	-16

Revision History

Version	Date	Description
1.1	2016-03-11	Pin and register description updated
1.0	2016-03-10	Electrical characteristics updated
0.1	2016-02-25	Preliminary

Appendix – Application Note

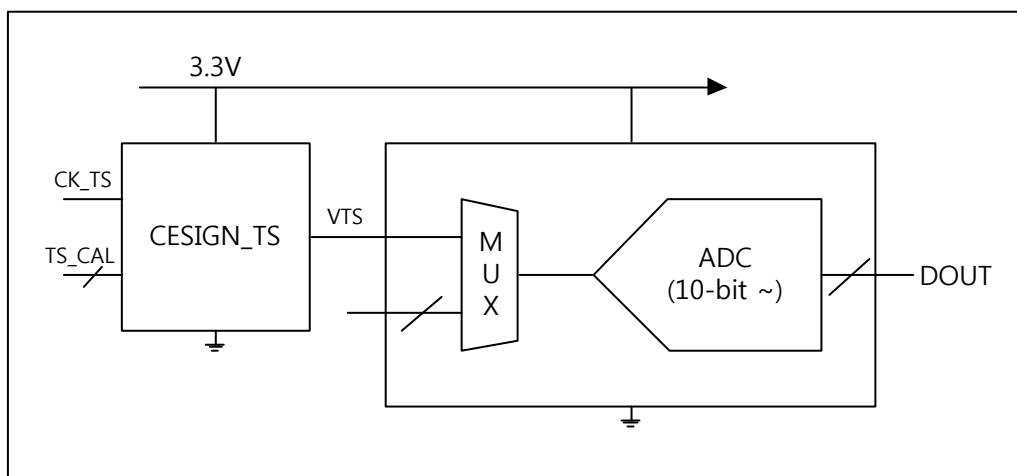


Figure 6. Typical Application Schematic for Temperature to Digital

Table 8. Electrical Characteristics Temperature Look-up Table (with 1-Temp Point Calibration)

Temperature [°C]	VTS [V]	VTS Slope [mV/°C]	D _{OUT} [Dec]
-40	1.405	+6.019	DATA_m40
-20	1.525	+6.020	DATA_m20
0	1.645	+6.023	*DATA_0
25	1.796	+6.025	*DATA_25
50	1.947	+6.026	*DATA_50
75	2.097	+6.026	DATA_75
100	2.248	+6.025	DATA_100
125	2.399	+6.021	DATA_125

*DATA_X: Please confirm the DATA_X from ADC maker for temperature conversion

Equation 1. Equation for Temperature Conversion with ADC (Over 10-bit)

$$T[°C] = A * D_{OUT} + B$$

$$A = 50 / (DATA_{50} - DATA_0)$$

$$B = 25 - (A * DATA_{25})$$

Ex) A=0.5336, B=-272.35