

# Reference current and voltage source with temperature sensor

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## SPECIFICATION

### 1 FEATURES

- TSMC CMOS 65 nm
- Output voltage 1.12 V
- Temperature-compensated voltage in wide temperature range
- Low current consumption
- Temperature sensor
- Small area
- Supported foundries: TSMC, UMC, Global Foundries, SMIC

### 2 APPLICATION

Generated reference voltage can be used for both analog and digital blocks. Main applications are:

- Supply voltage stabilization systems
- Comparison and detection systems
- System-on-chip for different purposes
- Measurement and calibration systems
- Technological research of microelectronic components
- Navigation systems

### 3 OVERVIEW

Reference current and voltage source (RS) is used to supply analog blocks. It is based on bandgap reference voltage source, forming temperature compensated voltage, and two voltage - to - current converters. First converter uses an external resistor and output current has weak temperature dependence. Second converter uses an internal resistor and output matches internal resistor temperature and process variations.

RS has an internal temperature sensor (TS). The main principle of work is digitizing output voltage of current-biased p-n junction using SAR ADC, based on R2R 10-bit DAC. Die temperature is calculated with the following expression:  $Temp = (907 - code) * 0.38 - 40$  (should be verified during evaluation). Digital controller is included in control logic. Here analog part of the block is shown.

## 4 STRUCTURE

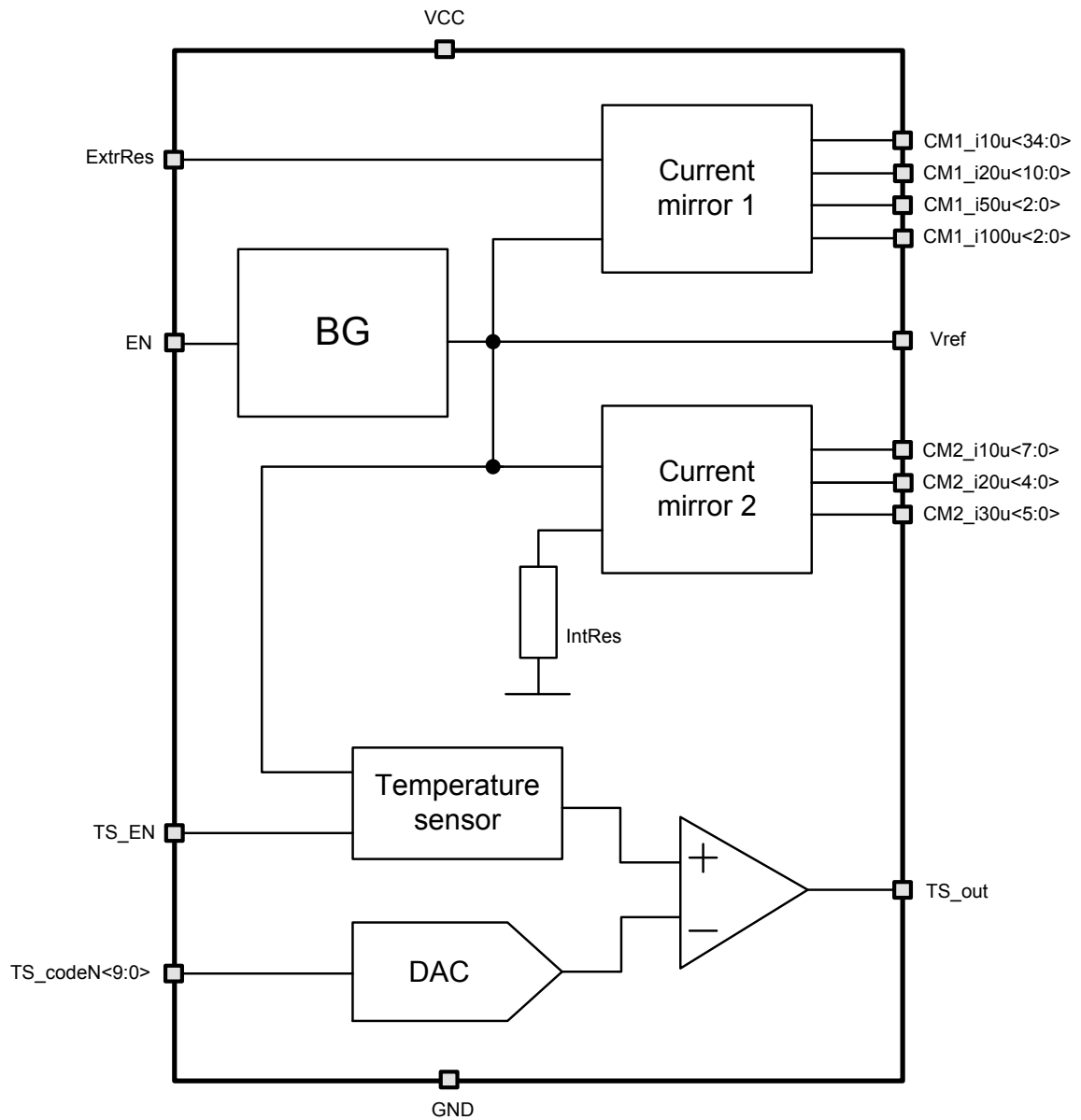


Figure 1: Reference current and voltage source with temperature sensor structure.

## 5 PIN DESCRIPTION

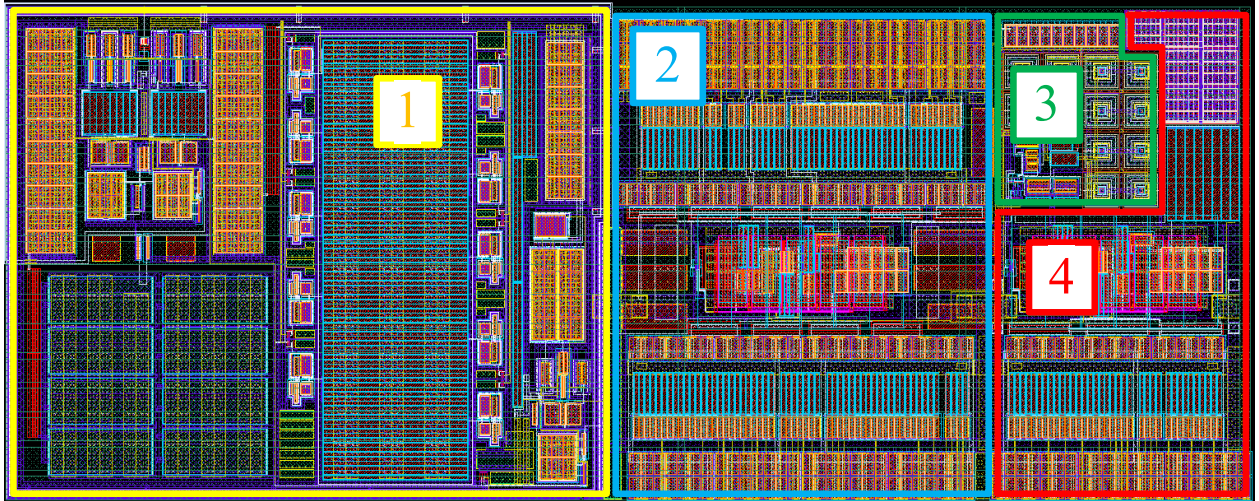
Name	Direction	Description
EN	I	RS enable
TS_EN	I	Enable temperature sensor
TS_codeN<9:0>	I	Input code of temperature
ExtrRes	I	External resistor
CM1_i10u<69:0>	O	Output reference current (10 $\mu$ A, external resistor)
CM1_i20u<12:0>	O	Output reference current (20 $\mu$ A, external resistor)
CM1_i50u<2:0>	O	Output reference current (50 $\mu$ A, external resistor)
CM1_i100u<2:0>	O	Output reference current (100 $\mu$ A, external resistor)
Vref	O	Reference voltage
CM2_i10u<7:0>	O	Output reference current (10 $\mu$ A, internal resistor)
CM2_i20u<4:0>	O	Output reference current (20 $\mu$ A, internal resistor)
CM2_i30u<5:0>	O	Output reference current (30 $\mu$ A, internal resistor)
TS_out	O	Output of temperature sensor comparator
VCC	IO	Supply voltage
GND	IO	Ground

## 6 LAYOUT DESCRIPTION

Reference source dimensions are given in the table 1.

**Table 1:** Dimensions.

Dimension	Value	Unit
Height	245	$\mu\text{m}$
Width	610	$\mu\text{m}$



**Figure 2:** Reference source layout view.

1. Temperature sensor
2. Current mirror 1
3. Bandgap reference voltage source
4. Current mirror 2

## 7 OPERATING CHARACTERISTICS

### 7.1 TECHNICAL CHARACTERISTICS

Technology \_\_\_\_\_ TSMC CMOS CRN65LP  
 Status \_\_\_\_\_ silicon proven  
 Area \_\_\_\_\_ 0.15 mm<sup>2</sup>

### 7.2 ELECTRICAL CHARACTERISTICS

The values of electrical characteristics are specified for  $V_{cc} = 2.375$  to  $2.625$  V and  $T = -40$  to  $125$  °C. Typical values are at  $V_{cc} = 2.5$  V,  $T = +25$  °C, unless otherwise specified.

Parameter	Symbol	Condition	Value			Unit
			min	typ	max	
Supply voltage	$V_{cc}$	-	2.375	2.5	2.625	V
Operating temperature range	T	-	-40	85	125	°C
Reference voltage	$V_{ref}$	-	1.103	1.121	1.135	V
Reference voltage deviation	$\Delta V_{ref}$	-	-	-	1.4	%
Output reference current	$I_{INT10u}$	Internal resistor	8.55	10	11.85	$\mu$ A
	$I_{INT20u}$		17.1	20	23.7	
	$I_{INT30u}$		25.65	30	35.55	
	$I_{EXT10u}$	External resistor	9.85	10	10.15	
	$I_{EXT20u}$		18.70	20	20.30	
	$I_{EXT50u}$		49.25	50	50.75	
	$I_{EXT100u}$		98.5	100	101.5	
TS resolution	N	-	-	0.38	-	±°C
Absolute TS accuracy	$\delta$	-	-	-	5	±°C
TS DAC resolution	K	-	-	10	-	bit
Current consumption	$I_{cc}$	-	-	200	-	$\mu$ A
Current consumption in a standby mode	$I_{stb}$	-	-	-	30	nA
Input logic-high level	$V_{IH}$	For digital inputs	$0.8V_{cc}$	-	$V_{cc}$	V
Input logic-low level	$V_{IL}$		0	-	$0.2V_{cc}$	V

## 8 TYPICAL CHARACTERISTICS

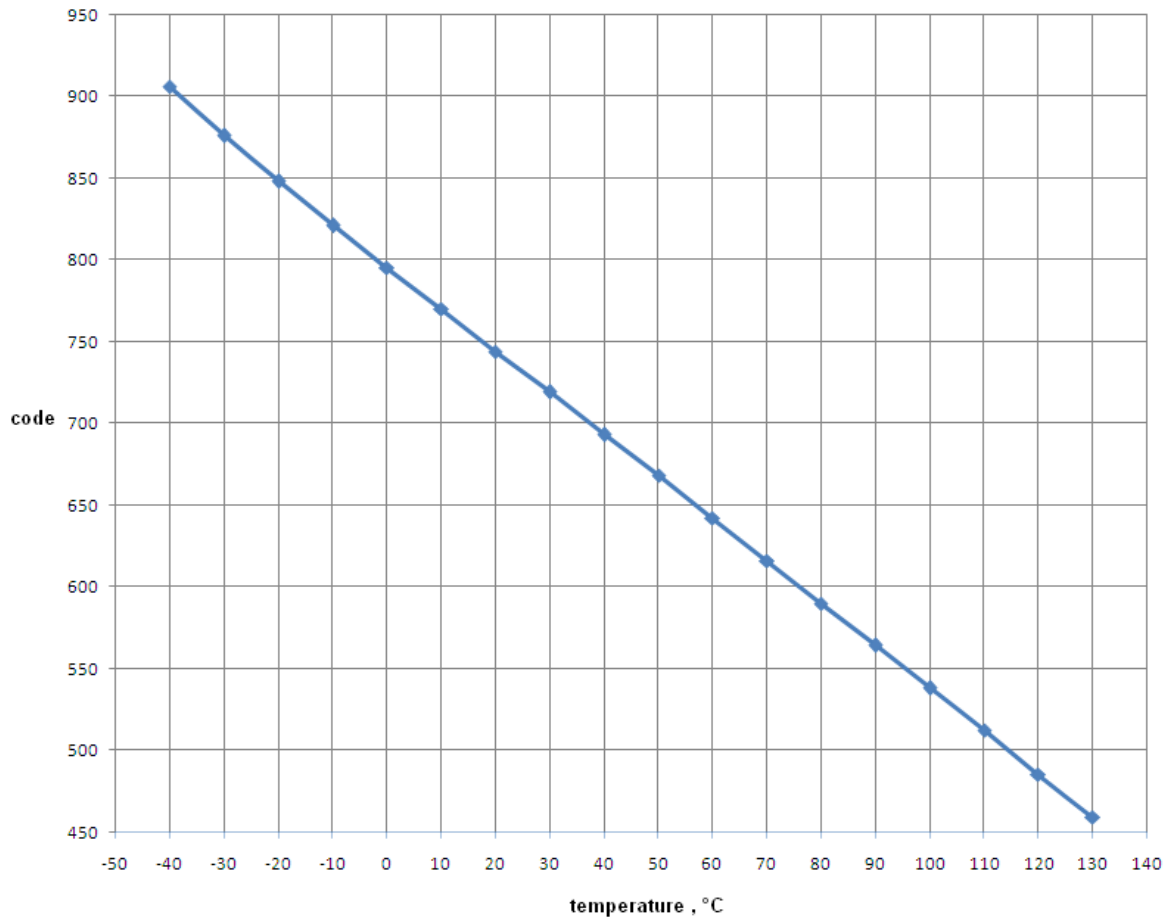


Figure 3: Code vs temperature (typical).

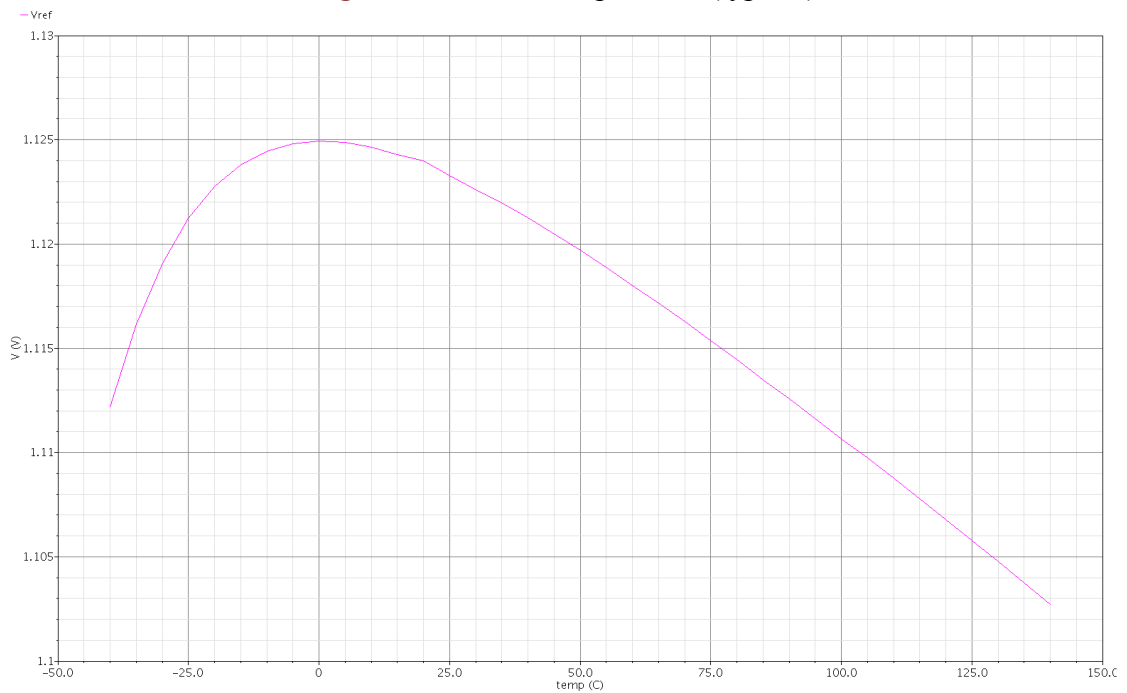


Figure 4: Reference voltage vs temperature.

## 9 DELIVERABLES

IP contents:

- Schematic or NetList
- Layout or blackbox
- Extracted view (optional)
- GDSII
- DRC, LVS, antenna report
- Test bench with saved configurations (optional)
- Documentation