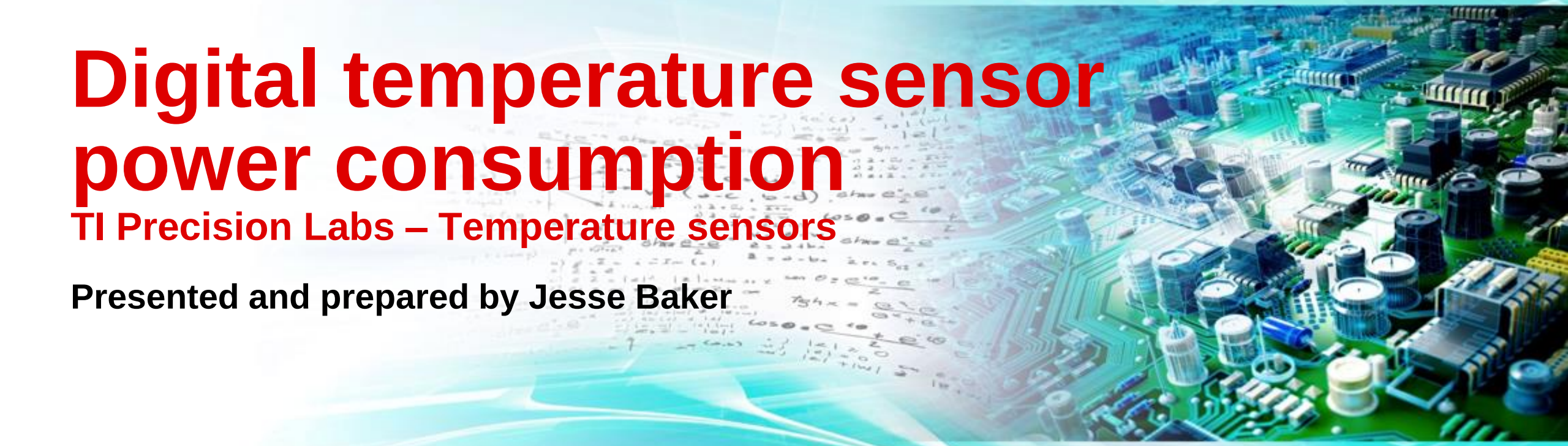
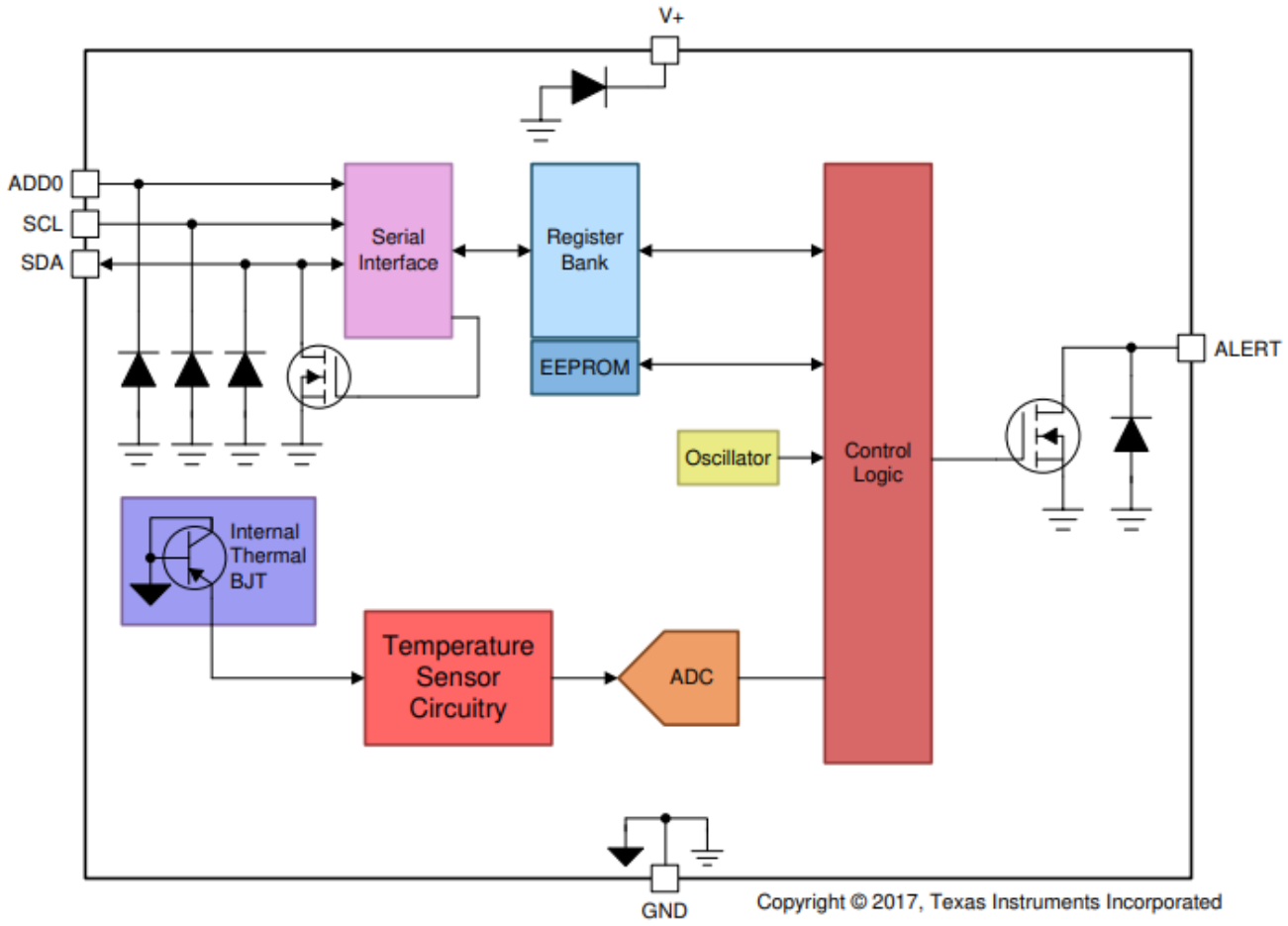
Digital temperature sensor power consumption

TI Precision Labs – Temperature sensors

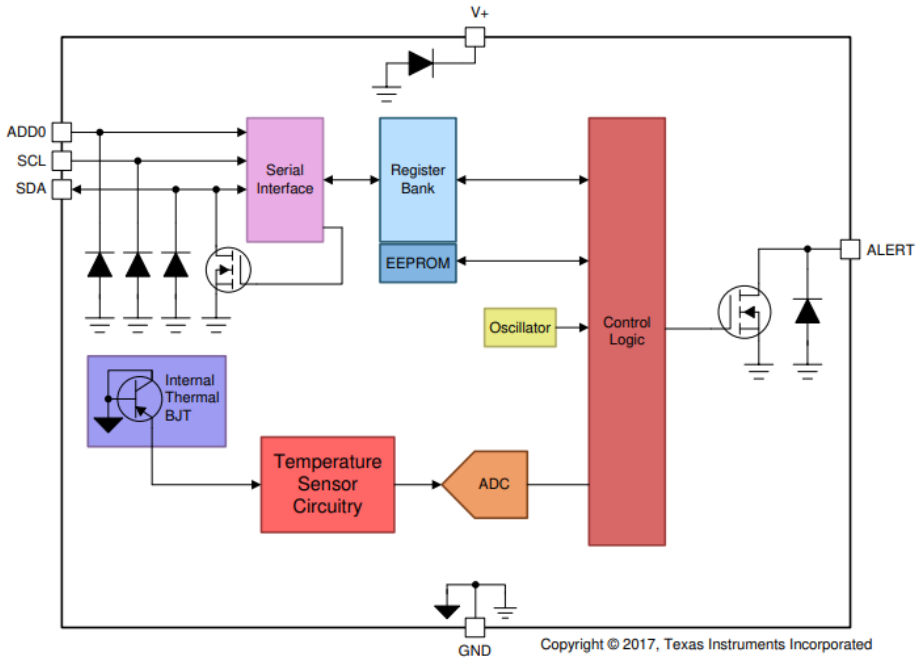


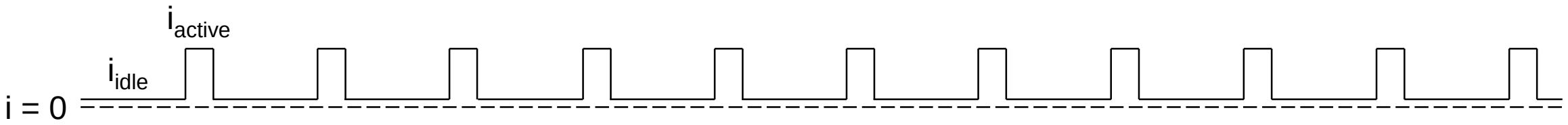
Presented and prepared by Jesse Baker

Power consumption in digital temperature sensors

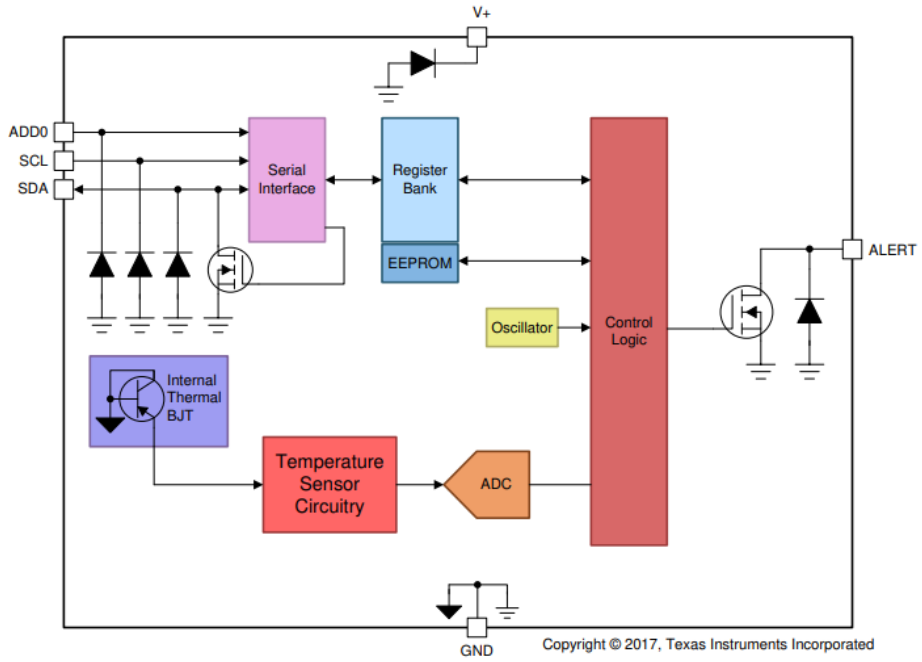


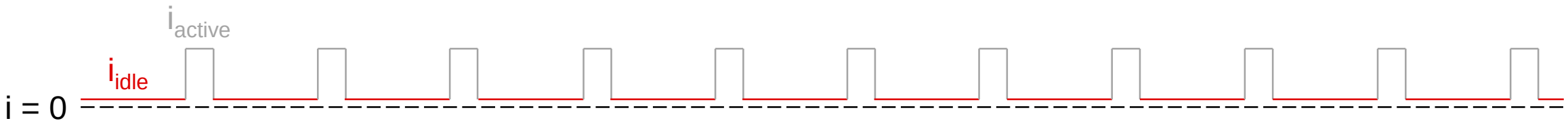
Power consumption in digital temperature sensors



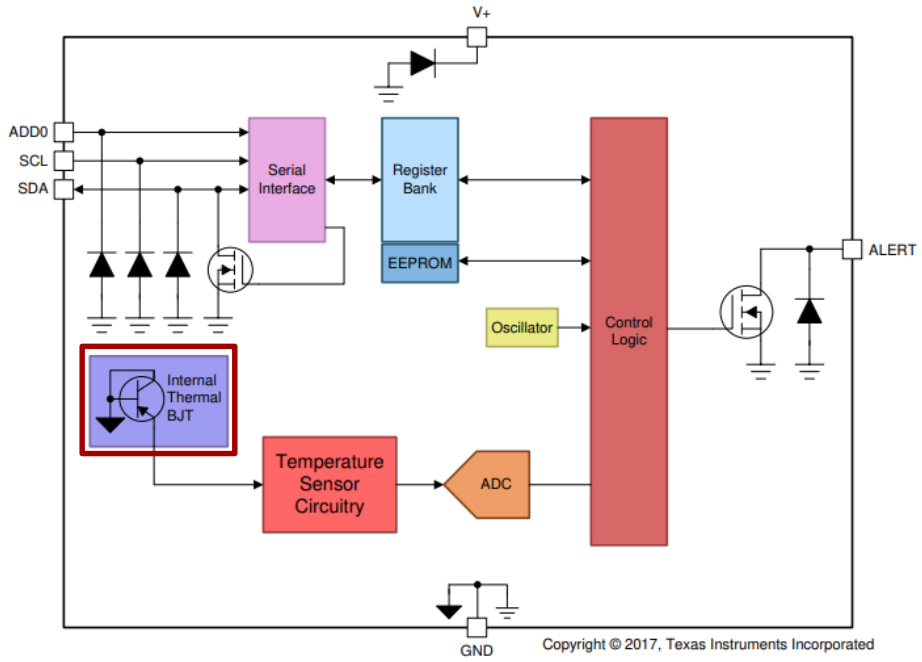


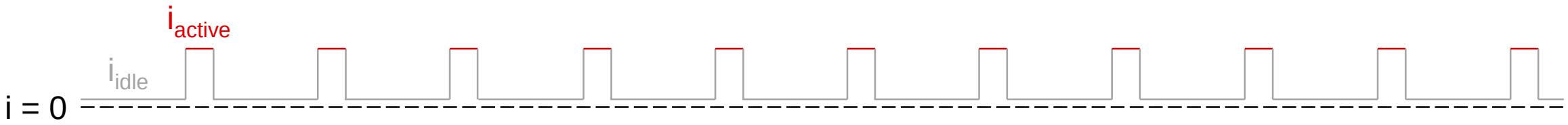
Power consumption in digital temperature sensors



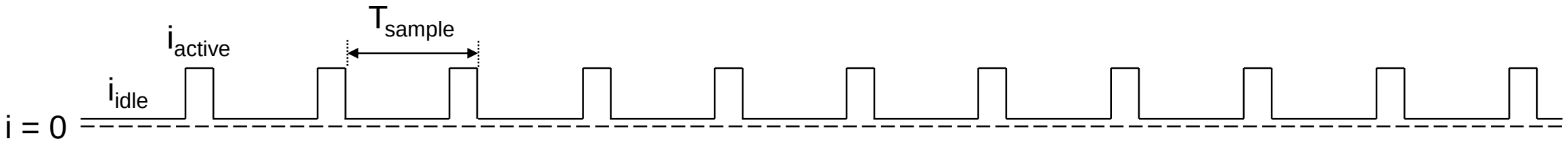


Power consumption in digital temperature sensors





Calculating sensor power consumption



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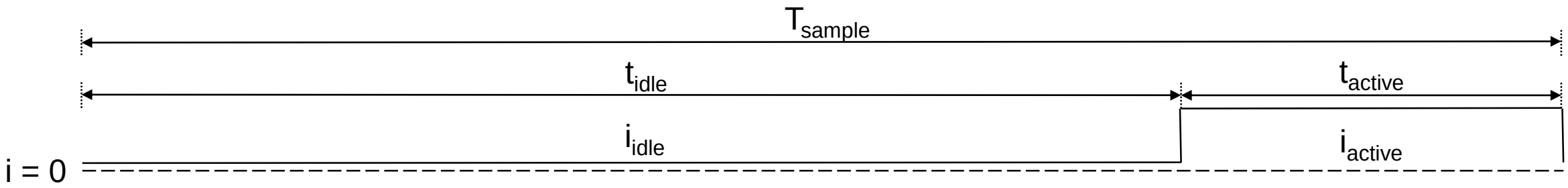

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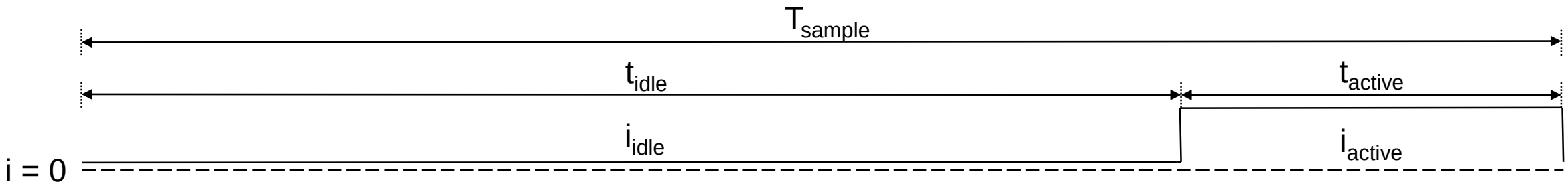
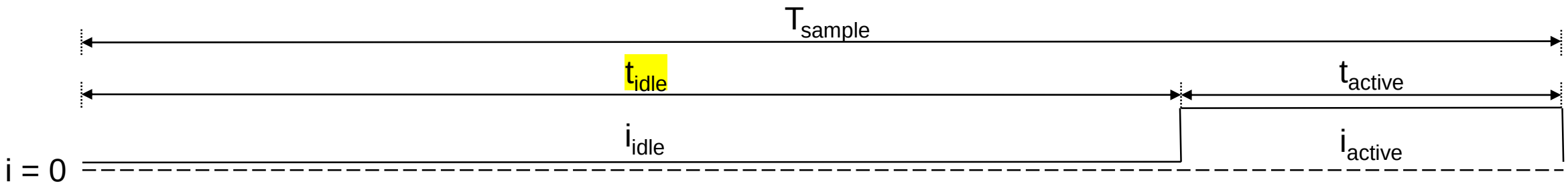


$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

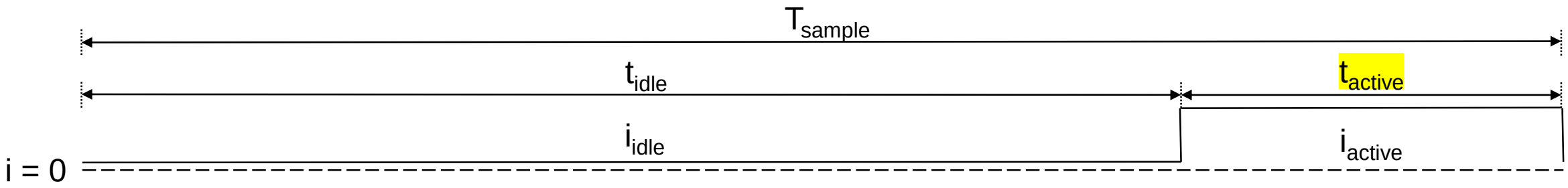
Calculating sensor power consumption



$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

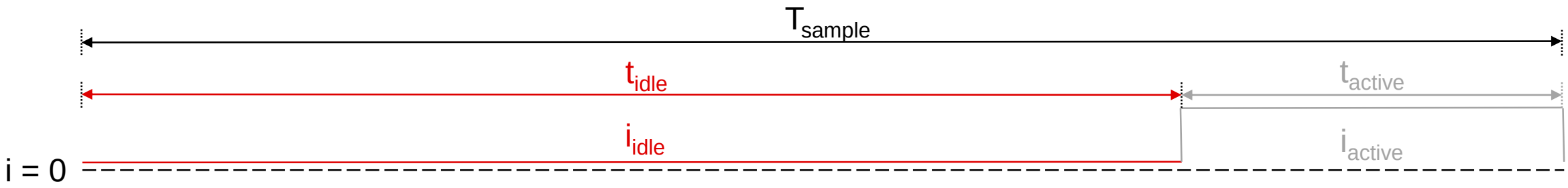
Calculating sensor power consumption



$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

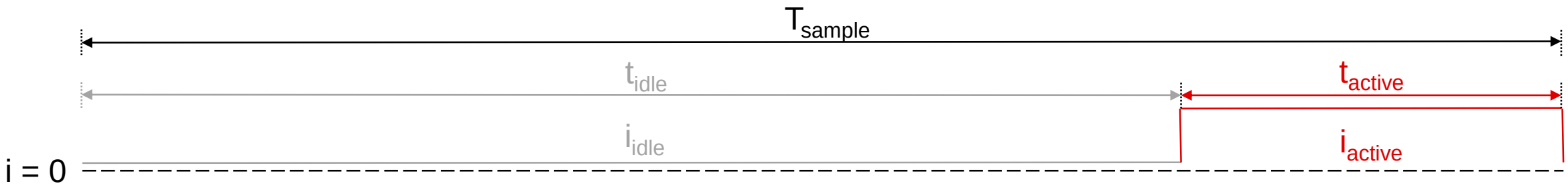
Calculating sensor power consumption



$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

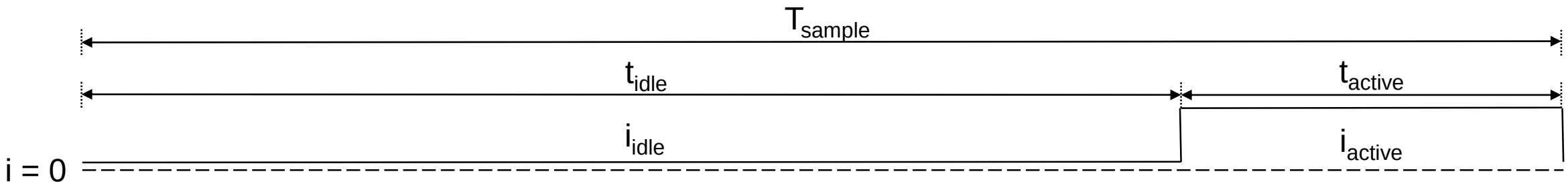
Calculating sensor power consumption



$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

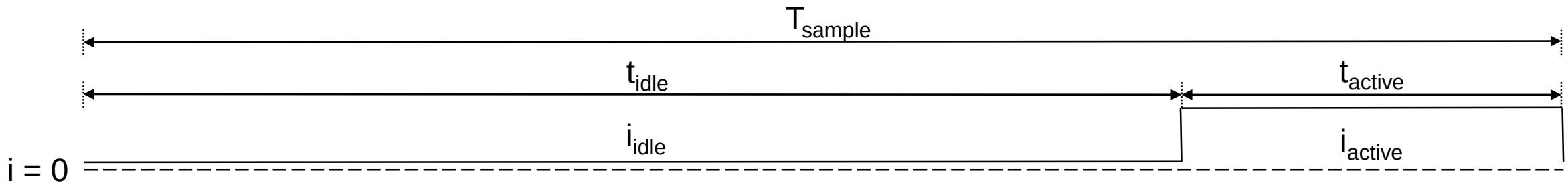
Calculating sensor power consumption



$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

Calculating sensor power consumption

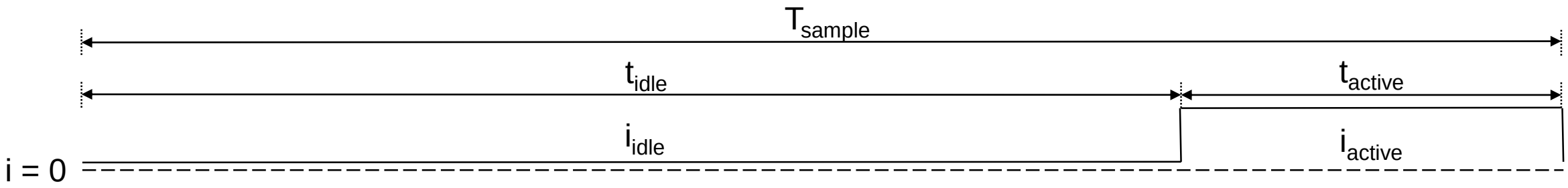


$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

	PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	POWER SUPPLY						
i_{active}	I_{Q_ACTIVE}	Quiescent current during active conversion	Active Conversion, serial bus inactive		135	220	µA
	I_Q	Quiescent current	Duty cycle 1 Hz, averaging mode off, serial bus inactive. T_A = 25 °C		3.5	5	µA
			Duty cycle 1 Hz, 8 averaging mode on, serial bus inactive. T_A = 25 °C		16	22	
			Duty cycle 1 Hz, averaging mode off, serial bus active, SCL frequency = 400 kHz		15		
i_{idle}	I_{SB}	Standby current(4)	Serial bus inactive. SCL, SDA, and ADD0 = V+. T_A = 25 °C		1.25	3.1	µA
	I_{SD}	Shutdown current	Serial bus inactive, SCL, SDA, and ADD0 = V+. T_A = 25 °C		0.15	0.5	µA
		Shutdown current	Serial bus inactive, SCL, SDA and ADD0 = V+, T_A = 150 °C			5	µA
		Shutdown current	Serial bus active, SCL frequency = 400 kHz, ADD0 = V+		17		µA

Calculating sensor power consumption



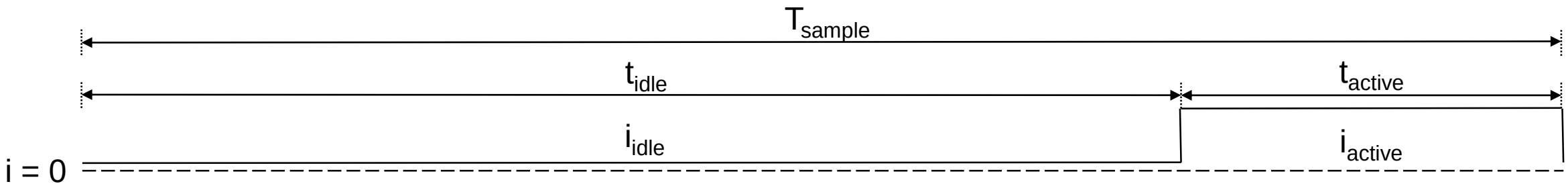
$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

t_{active}

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
TEMPERATURE TO DIGITAL CONVERTER						
	Conversion time	One-shot mode	13	15.5	17.5	ms

Calculating sensor power consumption



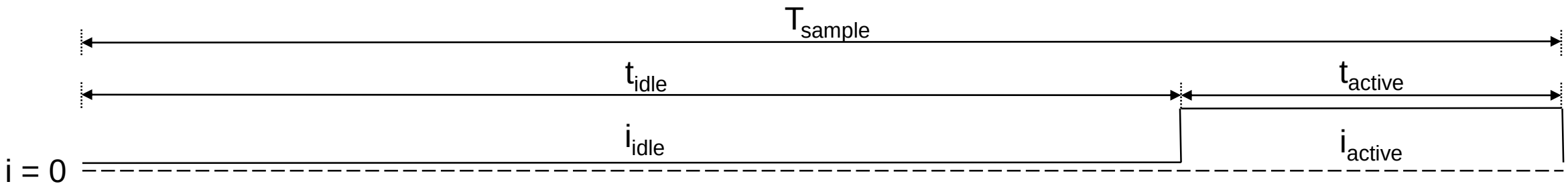
$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

BIT	FIELD	TYPE	RESET	DESCRIPTION
6:5	AVG[1:0]	R/W	01	Conversion averaging modes. Determines the number of conversion results that are collected and averaged before updating the temperature register. The average is an accumulated average and not a running average. 00: No averaging 01: 8 Averaged conversions 10: 32 averaged conversions 11: 64 averaged conversions

t_{active} = 15.5 ms

Calculating sensor power consumption



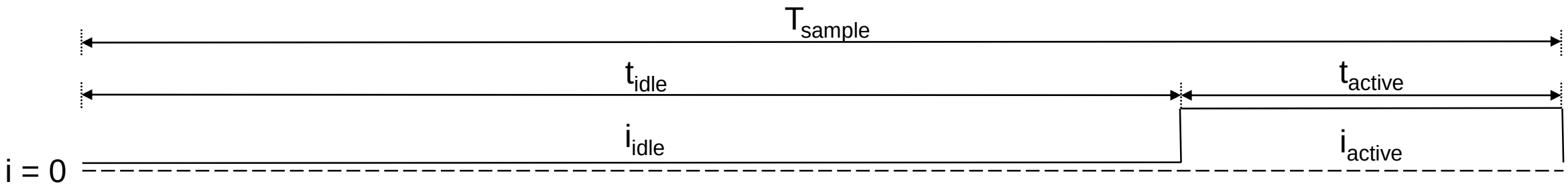
$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

BIT	FIELD	TYPE	RESET	DESCRIPTION
6:5	AVG[1:0]	R/W	01	Conversion averaging modes. Determines the number of conversion results that are collected and averaged before updating the temperature register. The average is an accumulated average and not a running average. 00: No averaging 01: 8 Averaged conversions 10: 32 averaged conversions 11: 64 averaged conversions

t_{active} = 124 ms

Calculating sensor power consumption



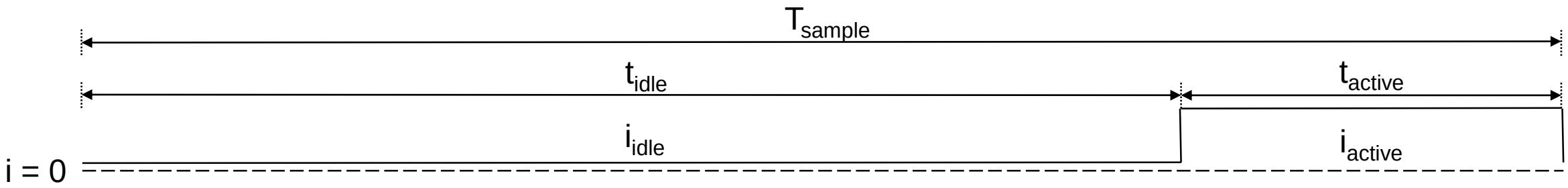
$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

BIT	FIELD	TYPE	RESET	DESCRIPTION
6:5	AVG[1:0]	R/W	01	Conversion averaging modes. Determines the number of conversion results that are collected and averaged before updating the temperature register. The average is an accumulated average and not a running average. 00: No averaging 01: 8 Averaged conversions 10: 32 averaged conversions 11: 64 averaged conversions

t_{active} = 496 ms

Calculating sensor power consumption



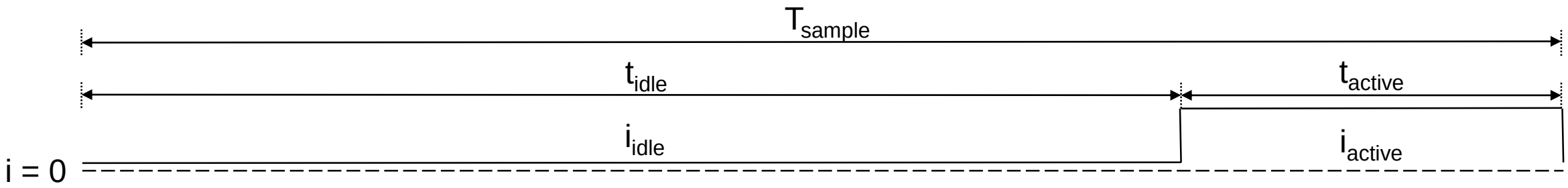
$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$

BIT	FIELD	TYPE	RESET	DESCRIPTION
6:5	AVG[1:0]	R/W	01	Conversion averaging modes. Determines the number of conversion results that are collected and averaged before updating the temperature register. The average is an accumulated average and not a running average. 00: No averaging 01: 8 Averaged conversions 10: 32 averaged conversions 11: 64 averaged conversions

t_{active} = 992 ms

Calculating sensor power consumption



$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

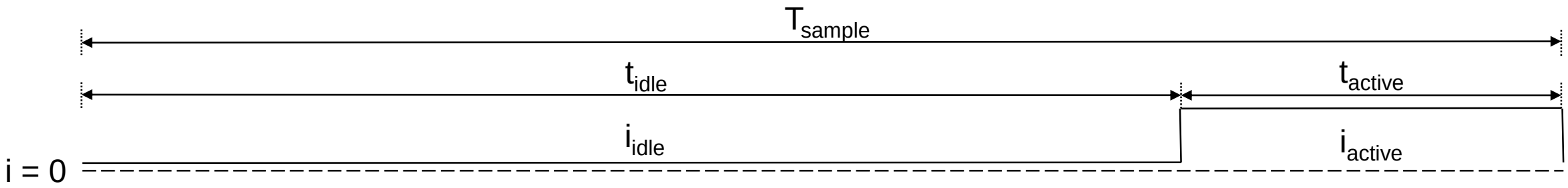
$$t_{idle} = T_{sample} - t_{active}$$

T sample

Table 7-7. Conversion Cycle Time in CC Mode

CONV[2:0]	AVG[1:0] = 00	AVG[1:0] = 01	AVG[1:0] = 10	AVG[1:0] = 11
000	15.5 ms	125 ms	500 ms	1 s
001	125 ms	125 ms	500 ms	1 s
010	250 ms	250 ms	500 ms	1 s
011	500 ms	500 ms	500 ms	1 s
100	1 s	1 s	1 s	1 s
101	4 s	4 s	4 s	4 s
110	8 s	8 s	8 s	8 s
111	16 s	16 s	16 s	16 s

Calculating sensor power consumption



$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

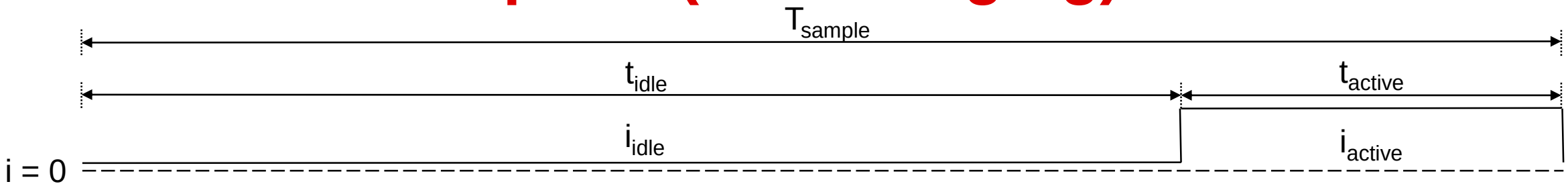
$$t_{idle} = T_{sample} - t_{active}$$

POWER SUPPLY					
I_{Q_ACTIVE}	Quiescent current during active conversion	Active Conversion, serial bus inactive	135	220	µA
I_Q	Quiescent current	Duty cycle 1 Hz, averaging mode off, serial bus inactive. T_A = 25 °C	3.5	5	µA
		Duty cycle 1 Hz, 8 averaging mode on, serial bus inactive. T_A = 25 °C	16	22	
		Duty cycle 1 Hz, averaging mode off, serial bus active, SCL frequency = 400 kHz	15		
I_{SB}	Standby current(4)	Serial bus inactive. SCL, SDA, and ADD0 = V+. T_A = 25 °C	1.25	3.1	µA
I_{SD}	Shutdown current	Serial bus inactive, SCL, SDA, and ADD0 = V+. T_A = 25 °C	0.15	0.5	µA
	Shutdown current	Serial bus inactive, SCL, SDA and ADD0 = V+, T_A = 150 °C		5	µA
	Shutdown current	Serial bus active, SCL frequency = 400 kHz, ADD0 = V+	17		µA

i_{idle}(Continuous conversion mode)

i_{idle}(One-shot mode)

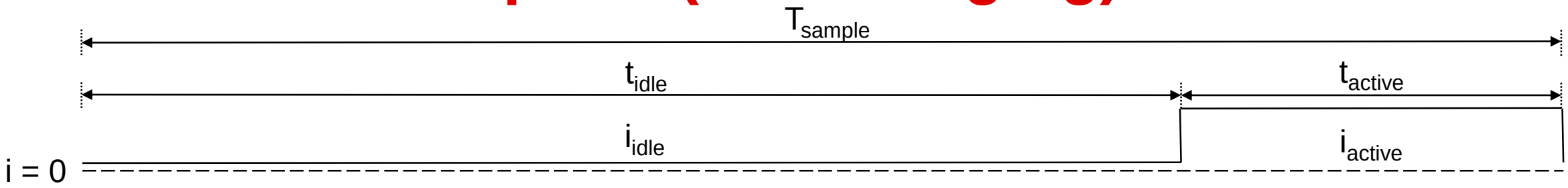
Example: Continuous conversion mode average current consumption (no averaging)



$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$
$$t_{idle} = 1s - 15.5\ ms$$
$$t_{idle} = 984.5\ ms$$

Example: Continuous conversion mode average current consumption (no averaging)

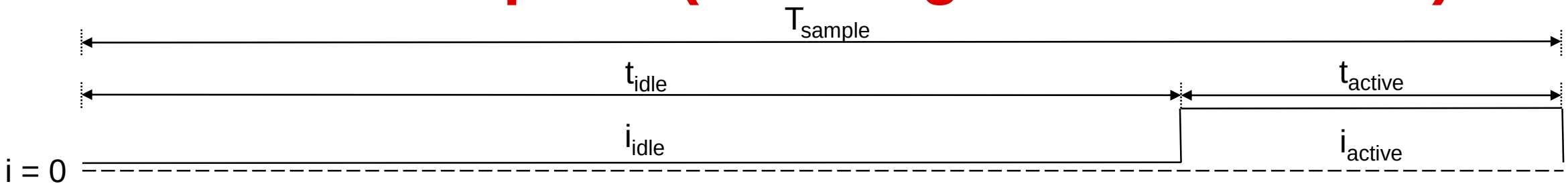


$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$
$$t_{idle} = 1s - 15.5\ ms$$
$$t_{idle} = 984.5\ ms$$

$$I_{AVG} = \frac{(984.5\ ms \times 1.25\ uA) + (15.5\ ms \times 135\ uA)}{1\ s} = 3.32\ uA \rightarrow > 2{,}750\ days\ from\ 220\ mAh\ battery$$

Example: Continuous conversion mode average current consumption (8 averaged conversions)

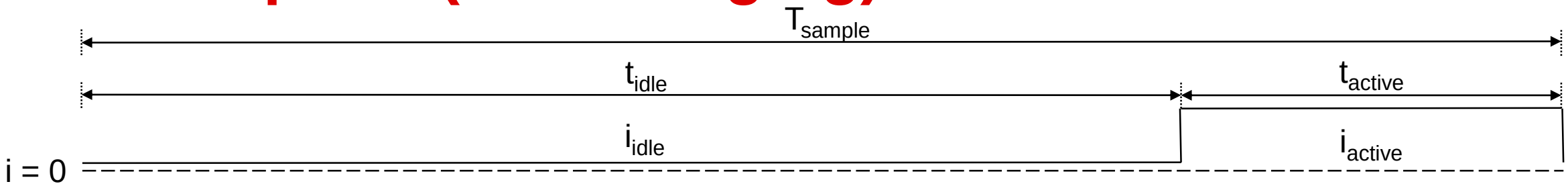


$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$
$$t_{idle} = 1s - 124\ ms$$
$$t_{idle} = 876\ ms$$

$$I_{AVG} = \frac{(876\ ms \times 1.25\ uA) + (124\ ms \times 135\ uA)}{1\ s} = 17.8\ uA \rightarrow > 510\ days\ from\ 220\ mAh\ battery$$

Example: One shot mode average current consumption (no averaging)

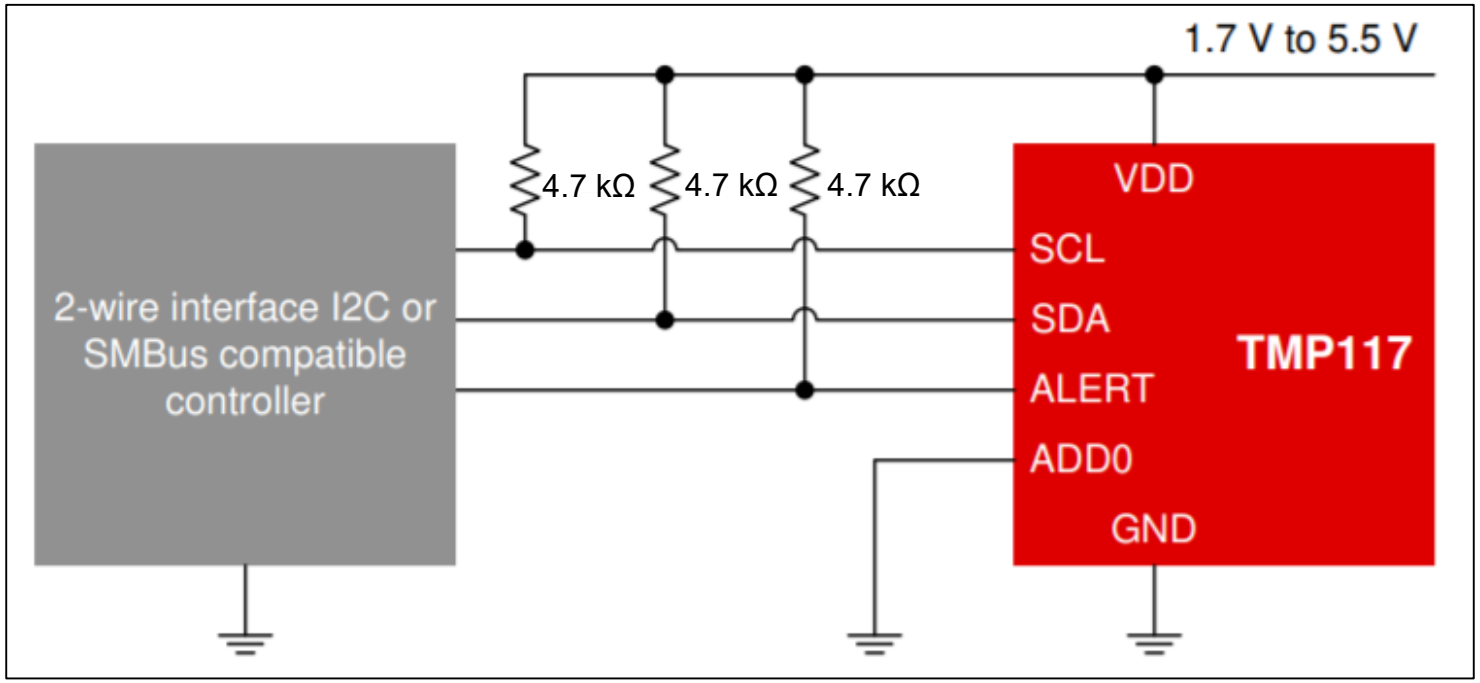


$$I_{AVG} = \frac{(t_{idle} \times i_{idle}) + (t_{active} \times i_{active})}{T_{sample}}$$

$$t_{idle} = T_{sample} - t_{active}$$
$$t_{idle} = 1s - 15.5\ ms$$
$$t_{idle} = 984.5\ ms$$

$$I_{AVG} = \frac{(984.5\ ms \times 0.15\ uA) + (15.5\ ms \times 135\ uA)}{1\ s} = 2.24\ uA \rightarrow > 4{,}000\ days\ from\ 220\ mAh\ battery$$

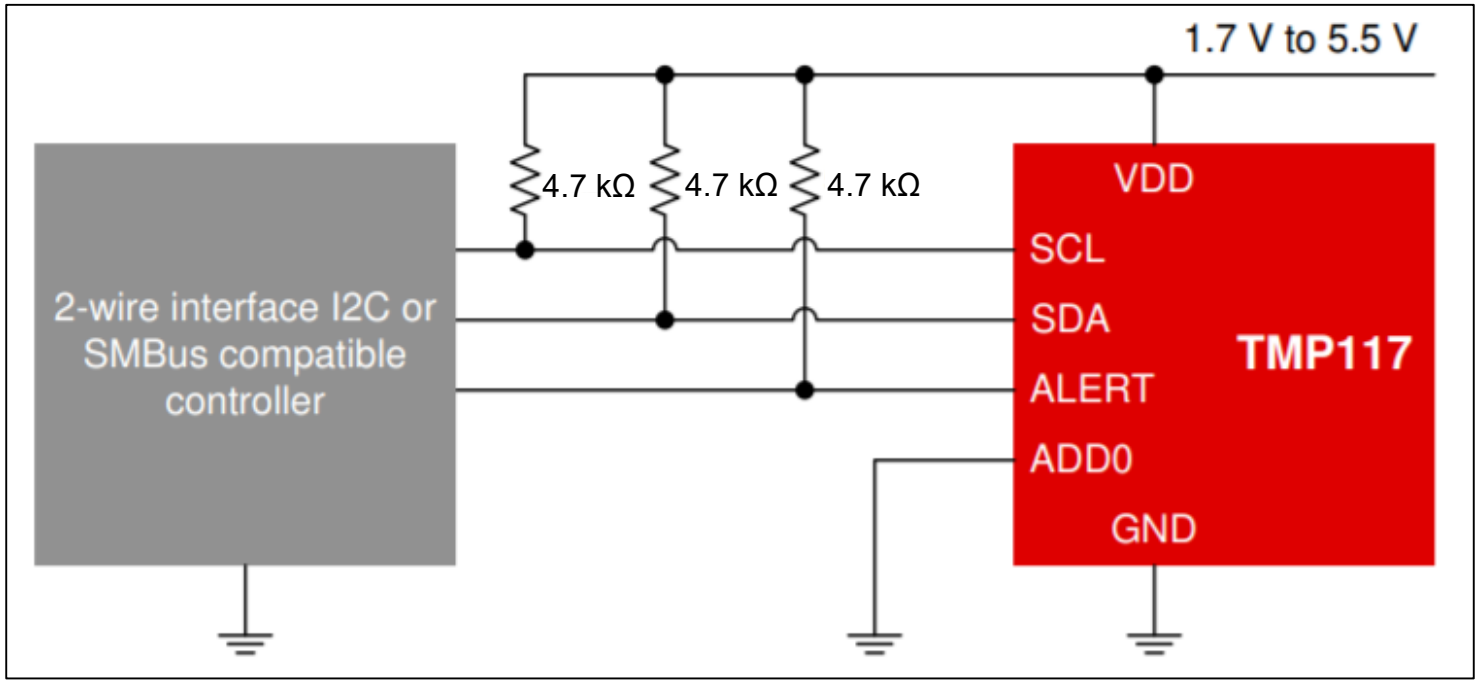
System power consumption



System power consumption

Digital temperature sensor

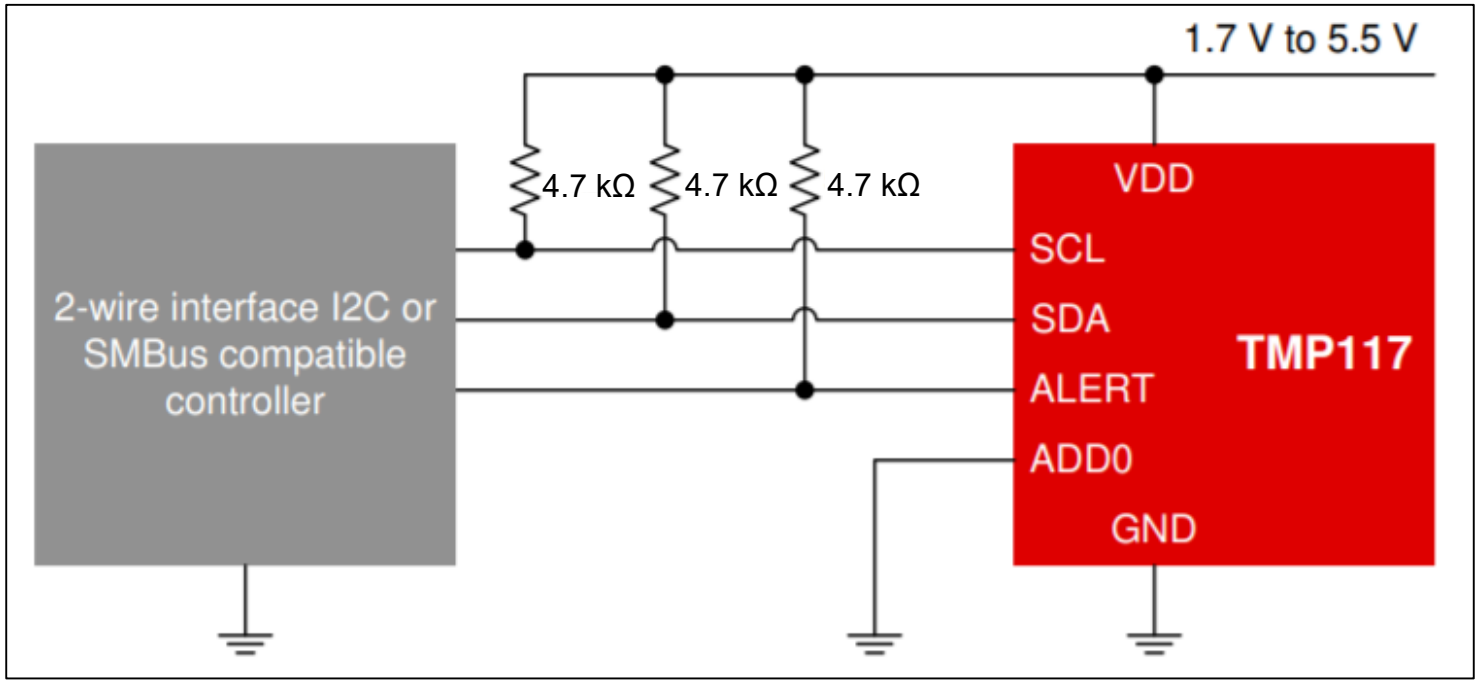
- Low sleep/standby current
- Modest active current



System power consumption

Microcontroller
- Low sleep current
- Modest standby current
- Large active current

Digital temperature sensor
- Low sleep/standby current
- Modest active current



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Digital temperature sensor
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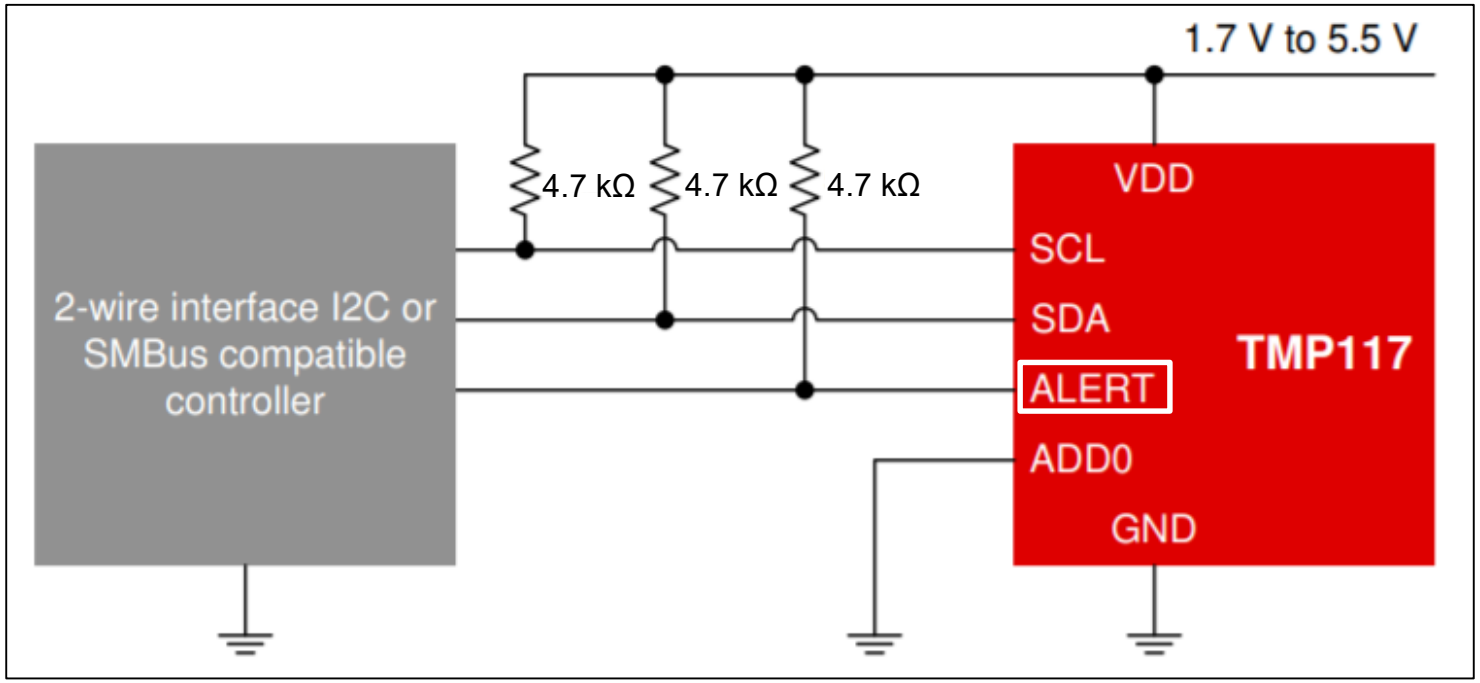

Thank you!

To find more temperature sensor resources and products, visit ti.com/temperature.