SimSurfing
PTC Thermistor
Performance Simulator
Operation Manual

March, 2020

Murata Manufacturing Co., Ltd.

Contents

1. About This Software
1-1. Overview

The “Chip PTC Thermistor Output Voltage Simulator” is a software that simulates output voltage - temperature properties of the PTC thermistor (PRF series) for overheat detection.

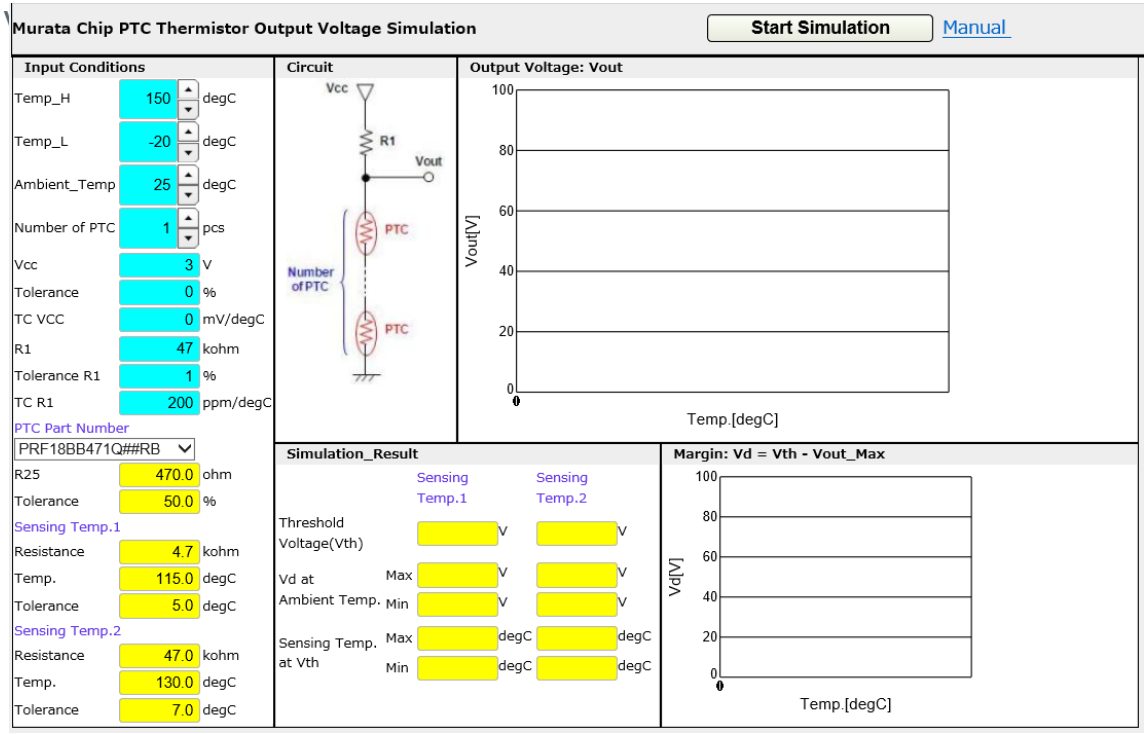
Please use it to select PTC thermistors optimal for the specified overheat detection and circuit design settings.

Operating Environment

Display Resolution: 1280×960 or more

OS: Microsoft Windows7 or higher, OS X 10.11 or higher

Browser: Internet Explorer 11, latest version of Microsoft Edge, latest version of Safari, latest



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1. About This Software
1-2. Main Functions

This simulator is a software that simulates how the output voltage Vout changes following ambient temperature changes if the fixed resistance R1 and PTC thermistors are connected serially on voltage Vcc circuits as indicated in diagram 1.

The main functions of this simulator are indicated below.

- You can select the PTC thermistor part number and amount of serially connected PTC th the circuit from 1 - 100. However, only 1 PTC thermistor can be installed.
- Enables simulation of the output voltage - temperature properties of the PTC thermistor u the temperature in the -40℃ - +160℃ range.
- Enables setting of the power voltage (Vcc), deviation, and temperature dependence of th which the PTC thermistor is installed.
- Enables setting of the resistance values, deviation, and temperature dependence of the f resistance (R1) used as voltage dividing resistance.

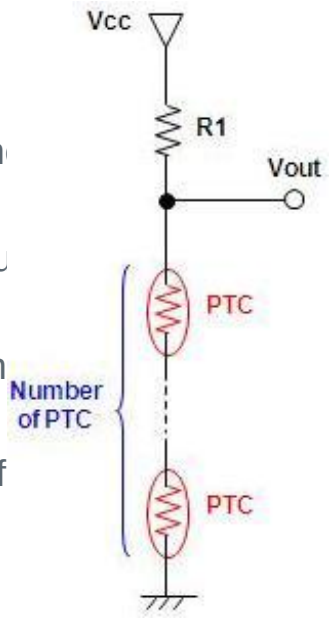

Diagram 1 Circuit Diagram

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2. Quick Operation Guide
2-1. Operation Screen Description

Description of the operation screen

Only the areas marked with blue frames in diagram 2 are areas where input is required. Areas marked with red frames are where selected PTC part number information and calculation results are automatically displayed.

1) Input simulation condition
2) Select part number of the PTC thermistor
3) Confirm the specification of the selected part number
4) Press the start simulation button
5) Confirm the simulation result

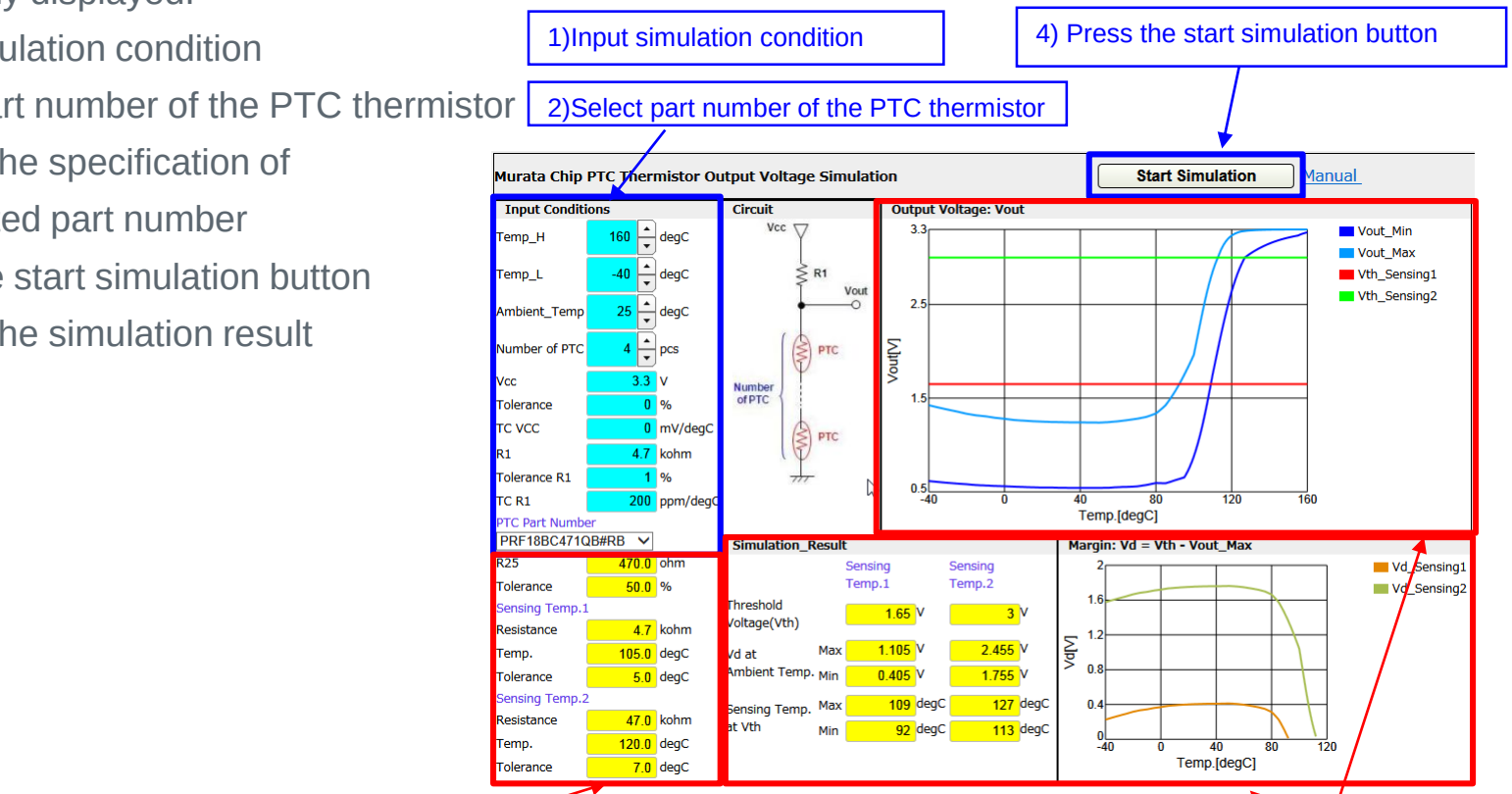
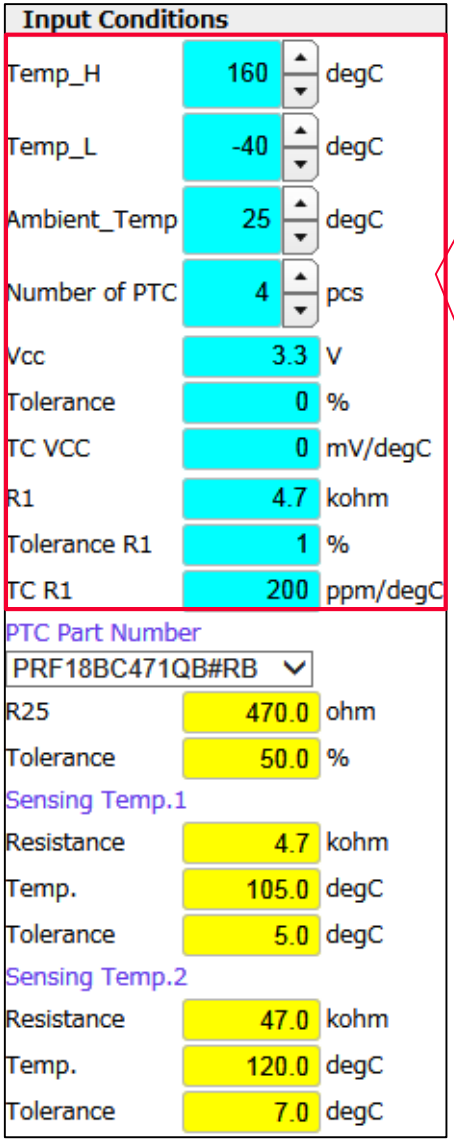


Diagram 2 Simulation Operation Screen

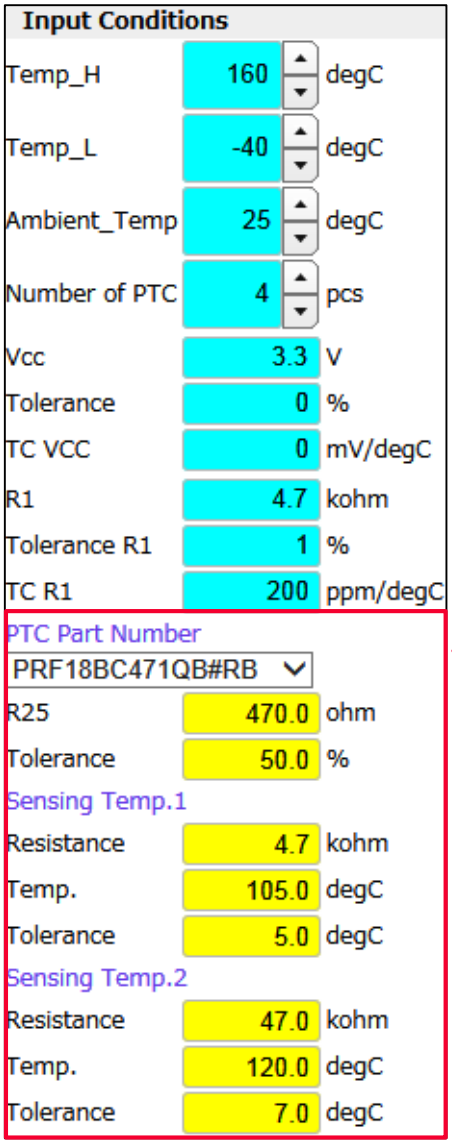
2. Quick Operation Guide
2-2. Input simulation condition



<Input simulation condition>

Phrase		Detailed Description
Temp_H		Lower limit of the simulation temperature range. Available for setting in -40℃ - 160℃.
Temp_L		Upper limit of the simulation temperature range. Available for setting in 40℃ - 160℃.
Ambient Temp.		Ambient temperature. Available for setting in 40℃ - 160℃.
Number of PTC		Can be set with 1 - 100 serially connected PTC thermistors.
Vcc	Vcc	Power voltage of the circuit
	Tolerance	Deviation of the power voltage
	TC Vcc	Temperature dependence of the power voltage
R1	R1	Resistance value of the voltage dividing resistance (fixed resistance) connected to the PTC thermistor
	Tolerance	Deviation of the fixed resistance
	TC R1	Temperature dependence of the fixed resistance

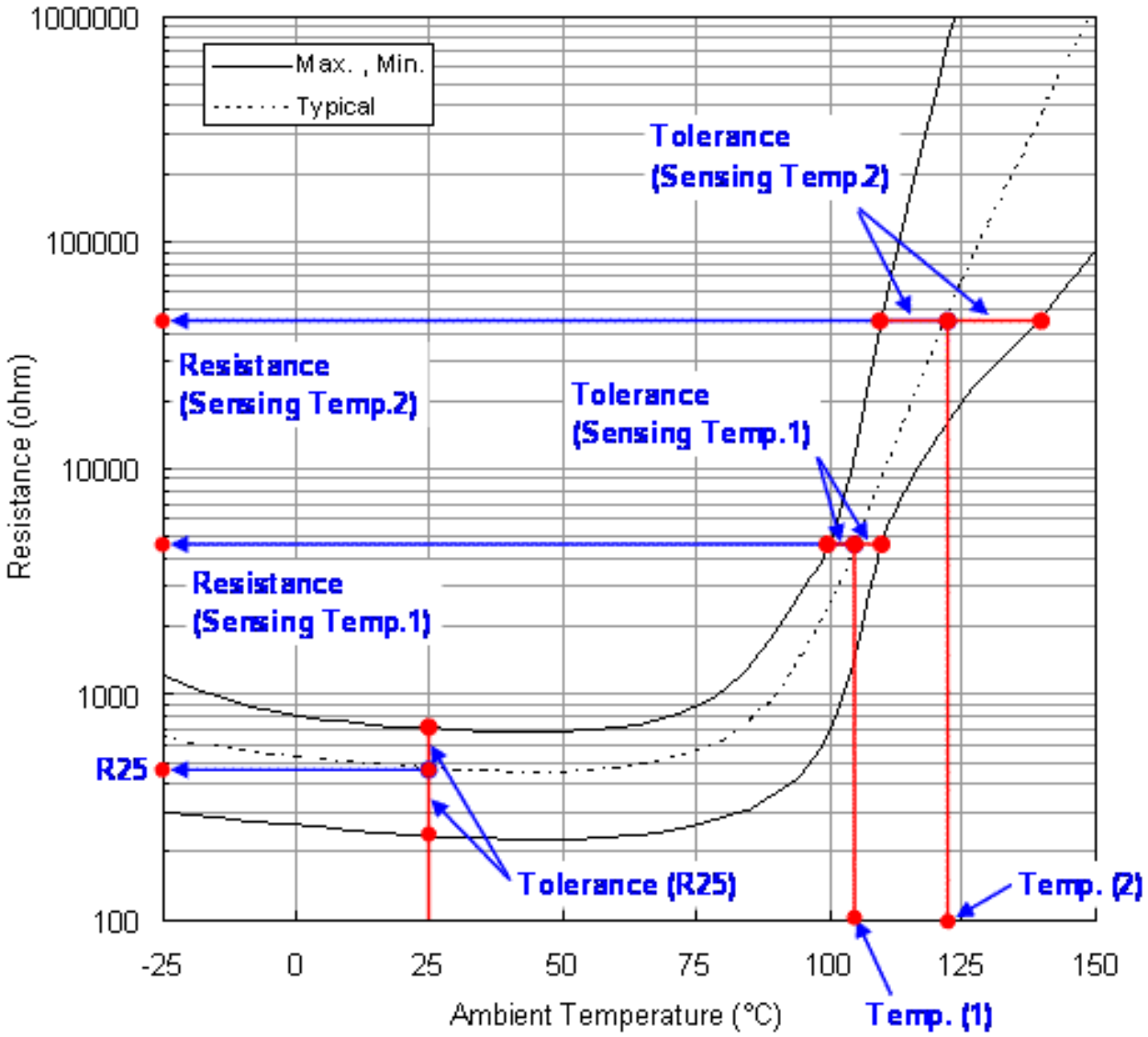
2. Quick Operation Guide
2-3. Specification Confirmation of the Selected PTC Thermistor



< Specification of the Selected PTC Thermistor >

Phrase		Detailed Description
Part Number	PTC Part Number	Product name of the PTC thermistor used during the simulation. The product name selected in the dialog box is displayed.
	R25	Resistance value when PTC thermistor is 25℃
	Tolerance	Deviation of the resistance value when PTC thermistor is 25℃
Sensing Temp.1	Sensing Temp.1	Detected Temperature 1 When the PTC thermistor reaches the specified resistance value, indicates what temperature the element temperature becomes.
	Resistance	Resistance value in Sensing Temp.1 (varies by part number)
	Temp.	Center value of detected temperature 1
	Tolerance	Deviation for the center value of detected temperature 1
Sensing Temp.2	Sensing Temp.2	Detected temperature 2 Only the PTC thermistor with 2 point guarantee of the detected temperature is displayed.
	Resistance	Resistance value in Sensing Temp.2 (varies by part number)
	Temp.	Center value of detected temperature 2
	Tolerance	Deviation for the center value of detected temperature 2

2. Quick Operation Guide
2-4. PTC Thermistor Property Diagram



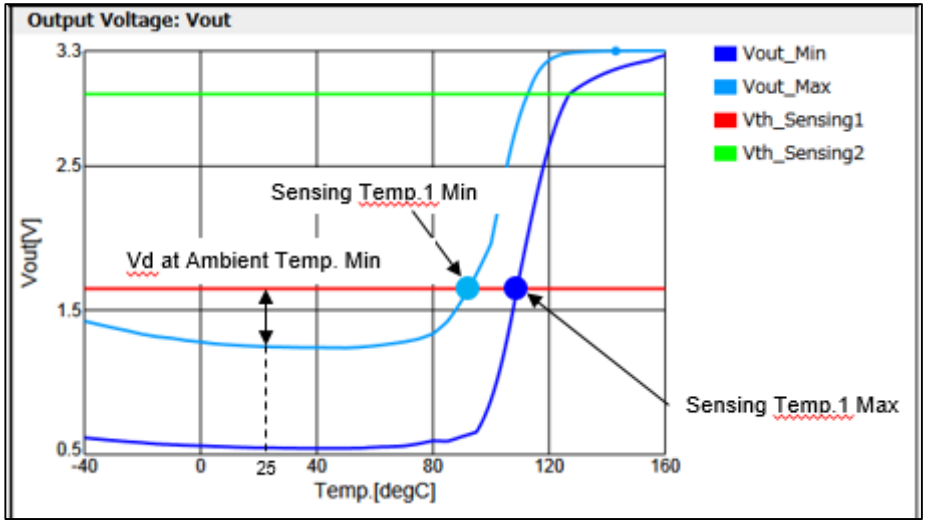
2. Quick Operation Guide
2-5. Confirm Simulation Result

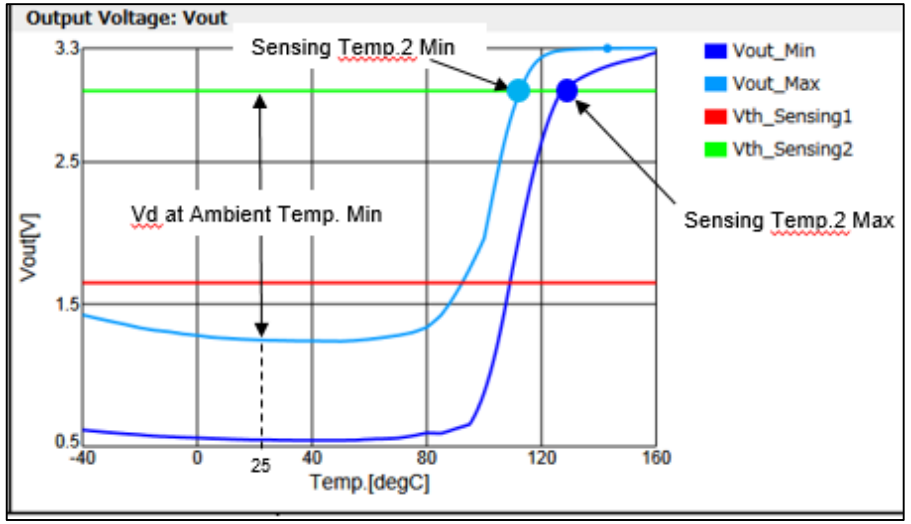
Simulation_Result

		Sensing Temp.1		Sensing Temp.2	
Threshold Voltage(Vth)		1.65	V	3	V
Vd at Ambient Temp.	Max	1.105	V	2.455	V
	Min	0.405	V	1.755	V
Sensing Temp. at Vth	Max	109	degC	127	degC
	Min	92	degC	113	degC

< Confirm Simulation Result >

Threshold Voltage(Vth)	Vth_Sensing1	Vout in Sensing Temp1
	Vth_Sensing2	Vout in Sensing Temp2
Vd	Vd at Ambient Temp.	Voltage difference of voltage Vout and Sensing Temp (Vth) in a certain temperature T
	Min	Smallest value of Vd at Ambient Temp
	Max	Largest value of Vd at Ambient Temp
SensingTemp. at Vth	Sensing Temp. at Vth	Temperature detection range when the detected voltage is Vth
	Min	Smallest value of the above
	Max	Largest value of the above



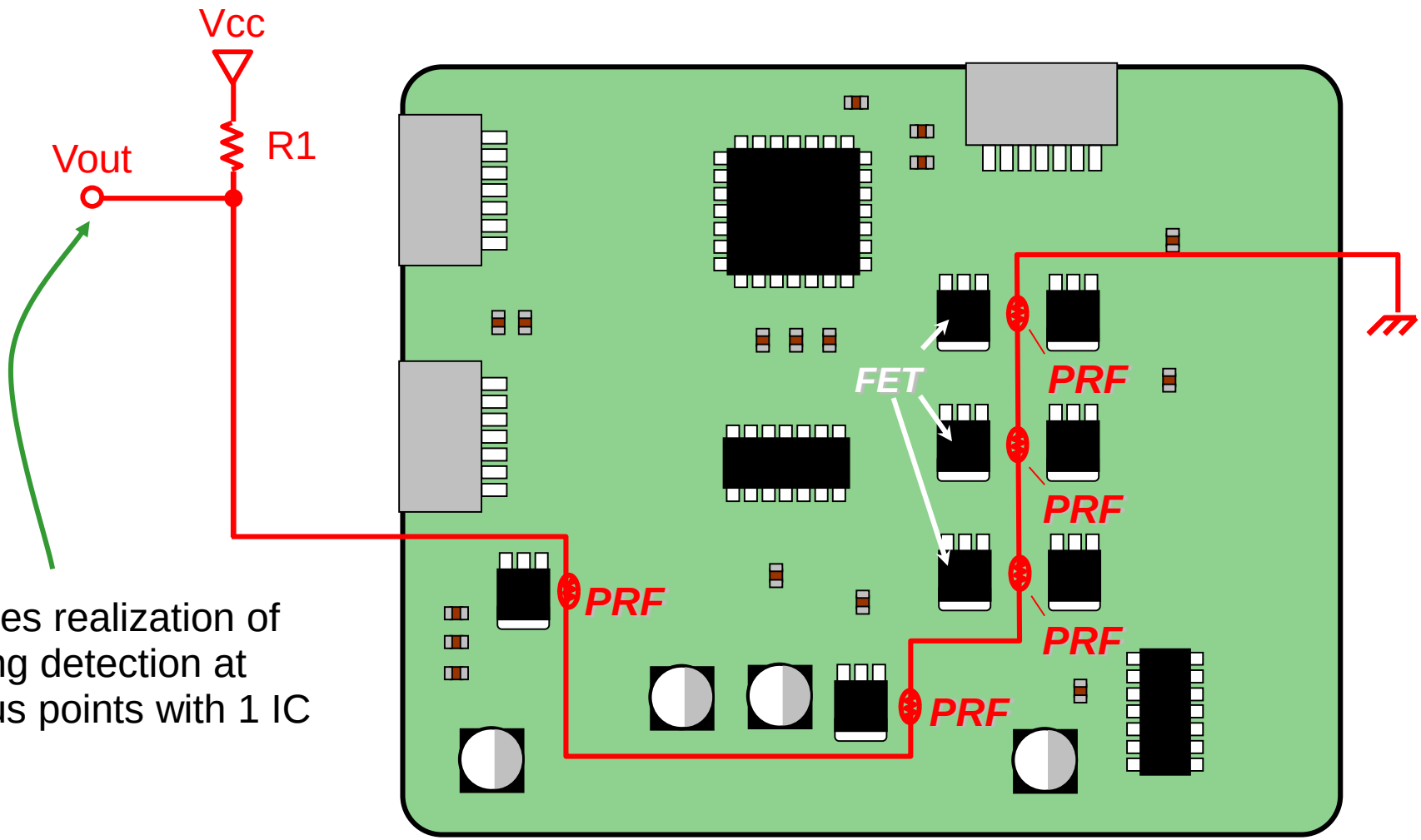


This is the end of the operation manual. To enable maximum usage of the software, techniques and detailed descriptions of operation procedures will be introduced from the next page on.

Contents

3. Software Use Examples
3-1. Heating Detection Circuit Example Using PTC

Enables design of a circuit that detects heating of multiple FETs using the PRF series as seen in the diagram below. Try the simulation using the following circuit as an example.



Enables realization of heating detection at various points with 1 IC port!

3. Software Use Examples
3-2. Design of 130℃ Heating Detection Circuit

- Design Example -
Thermistor used :PRF18BB471QB#RB
(Refer to the specification list in P22 - 23 for thermistor selection)

Circuit : right diagram
(Voltage dividing resistance + 5 PTC thermistors)

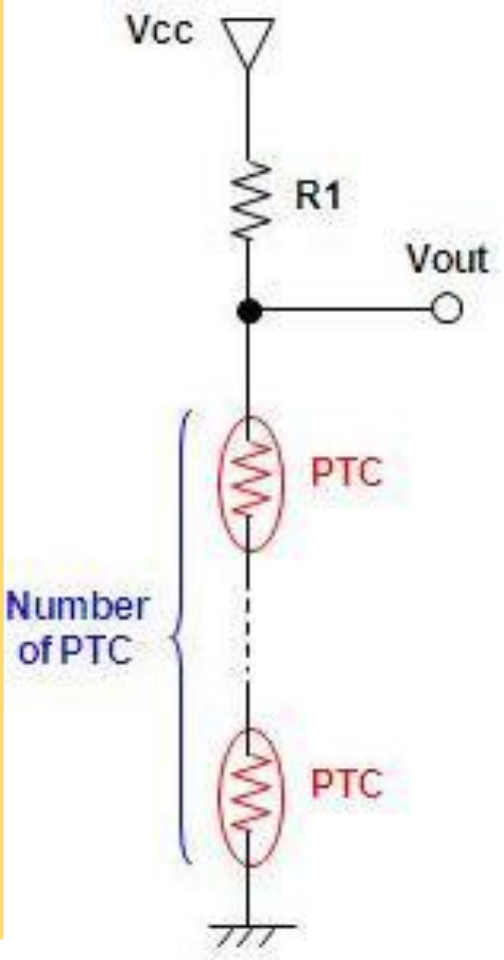
Operating temperature range :-20℃～150℃

Normal ambient temperature：25℃

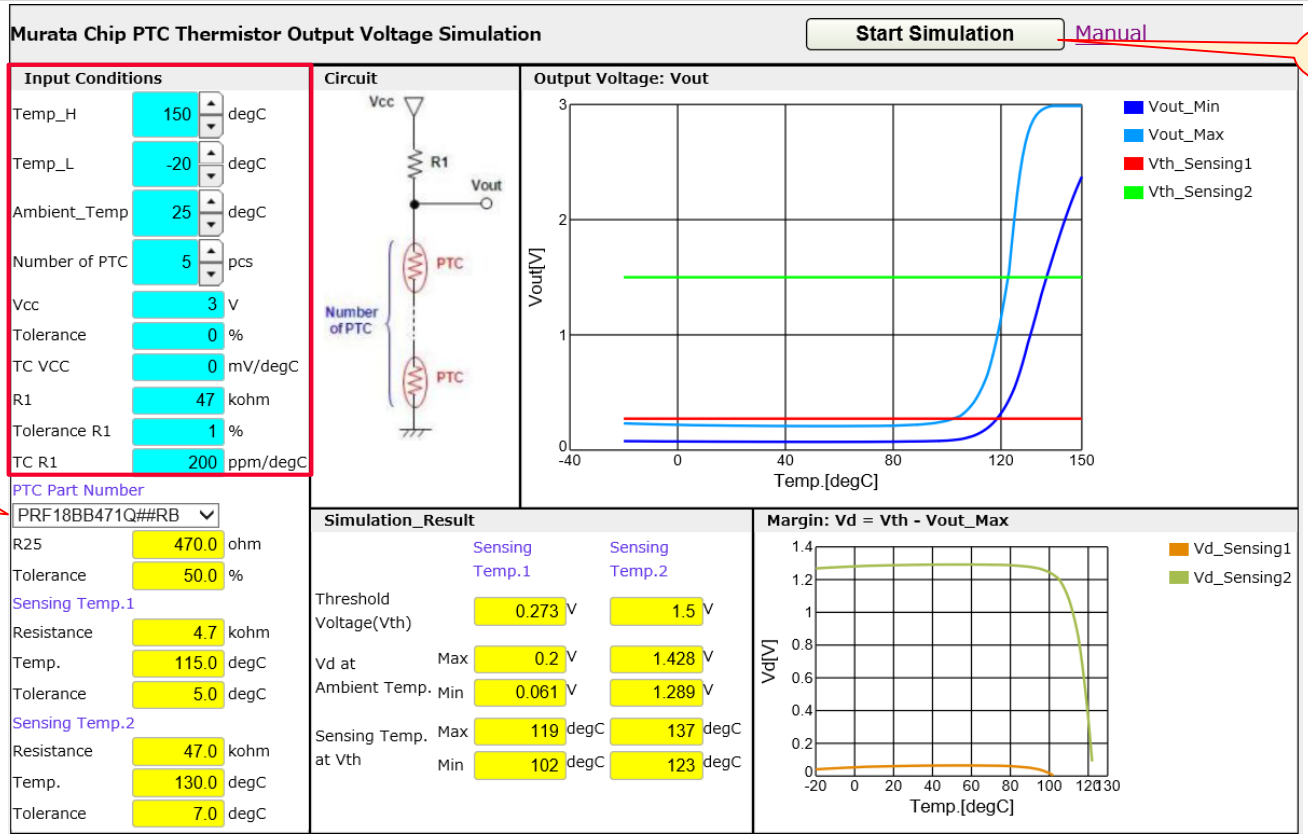
Input voltage Vin ： 3V(assuming there are no voltage fluctuation)

Resistance R1 ： Adjustable following E24 step

Circuit Conditions ：To perform heating detection in the 130℃ range
(the Vout is to fluctuate 1V between the normal state and heated state)



3. Software Use Examples
3-3. Confirming Circuit Conditions



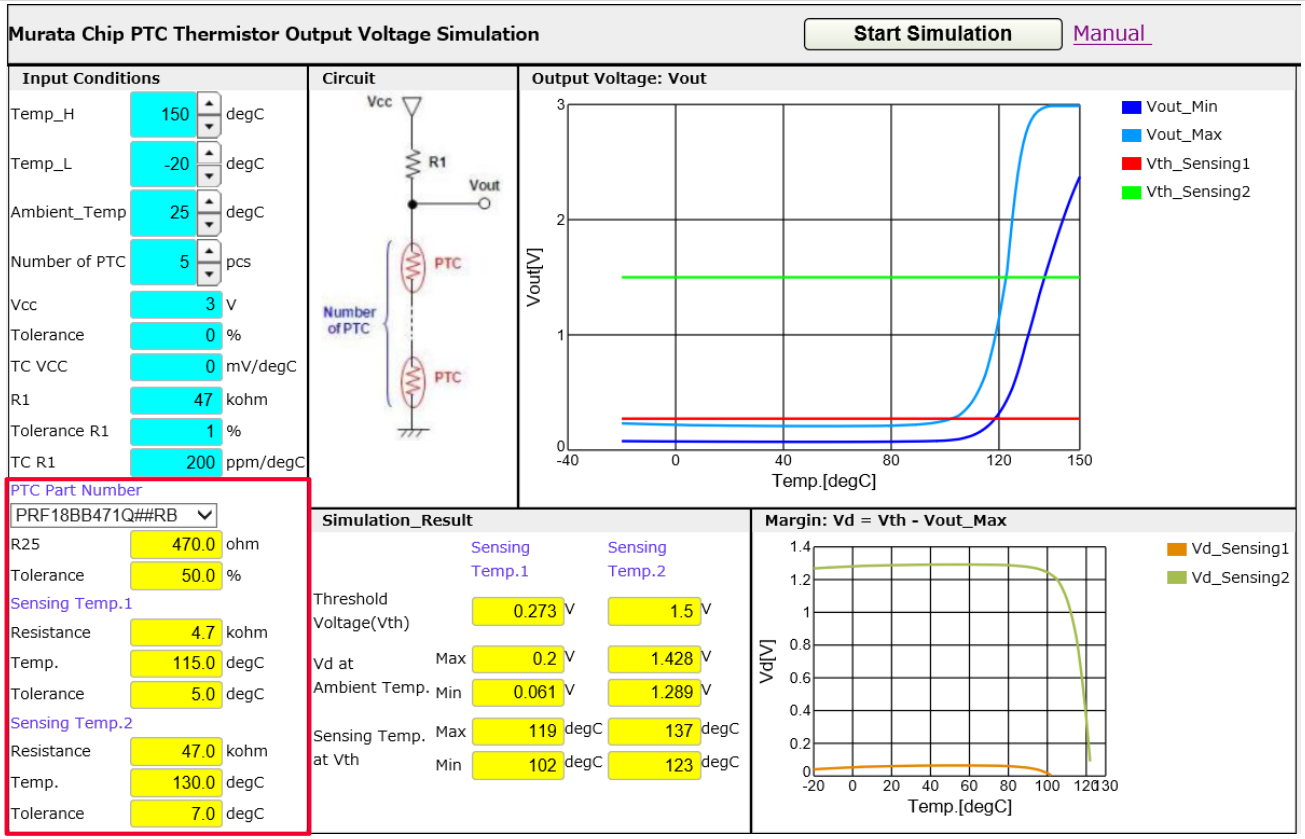
(1)

(2)

(3)

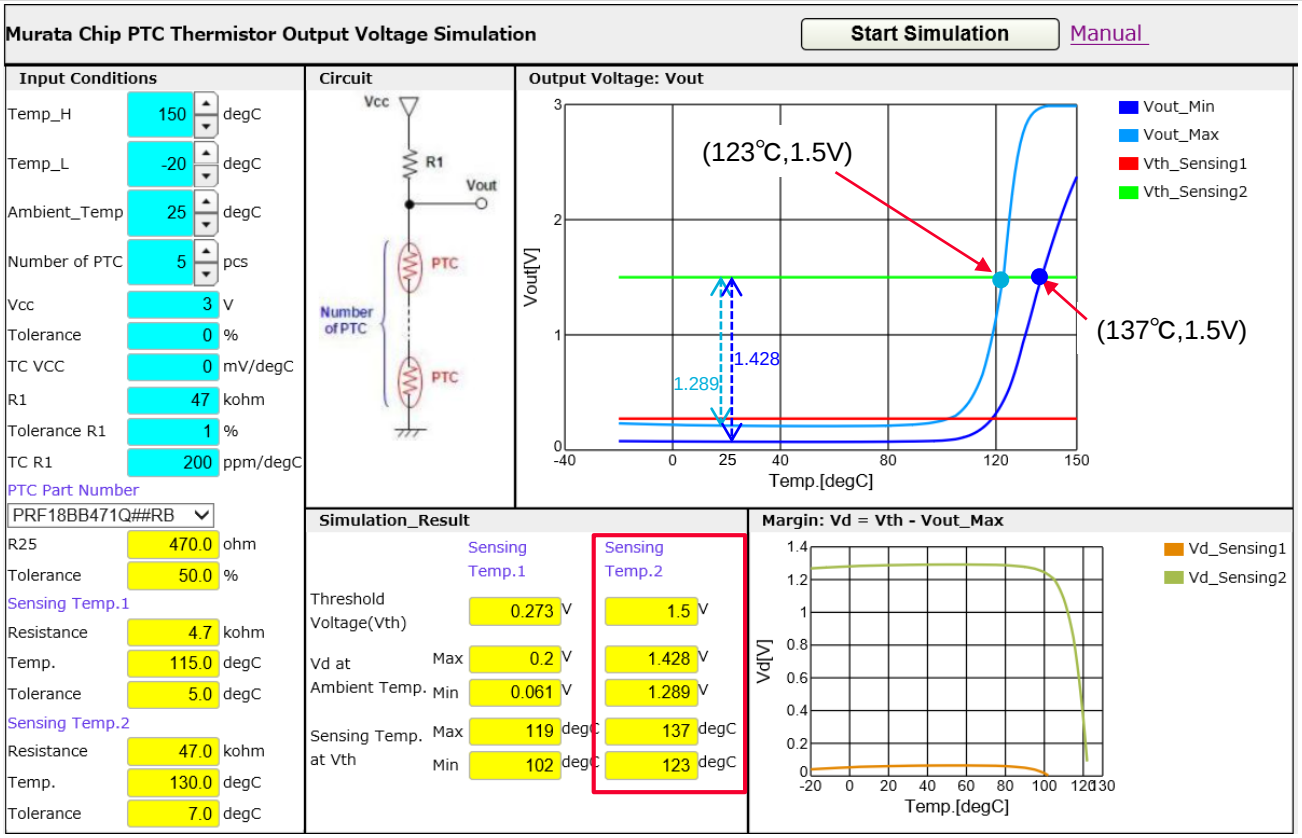
(1) Set Number of PTC to 5 pcs.
(Make adjustments later while observing simulation results for R1)
(2) The used PTC part number is PRF18BB471QB#RB.
(3) Click Start Simulation and display the result.

3. Software Use Examples
3-4. Confirm PTC Specifications



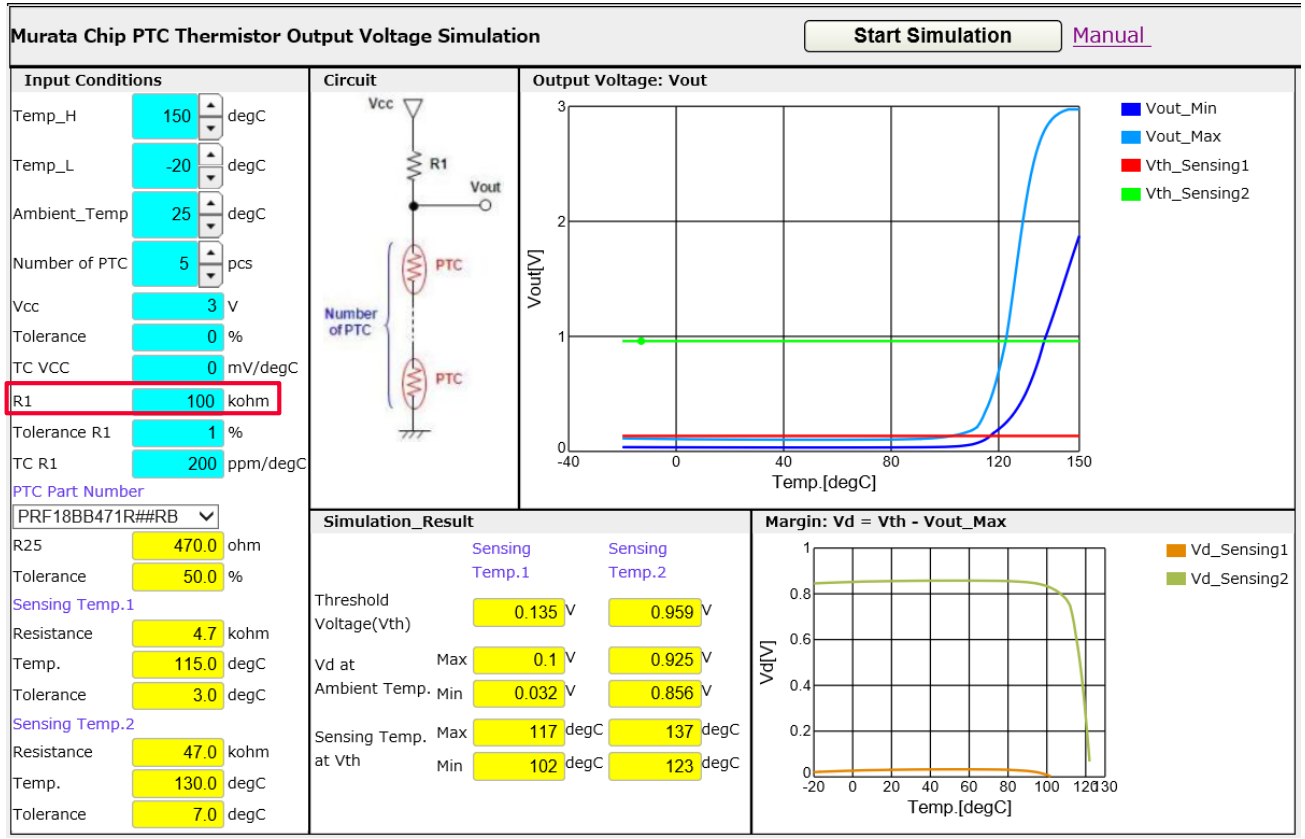
Confirm the PTC specification and confirm that the selection is correct. The selected thermistor is used to detect 115±5℃ (Sensing Temp_1) or 130±7℃ (SensingTemp_2).
Circuit design will be performed using Temp_2 here. (Temp_1 has a small temperature deviation and Temp_2 has a large voltage fluctuation.)

3. Software Use Examples
3-5. Confirm Simulation Result



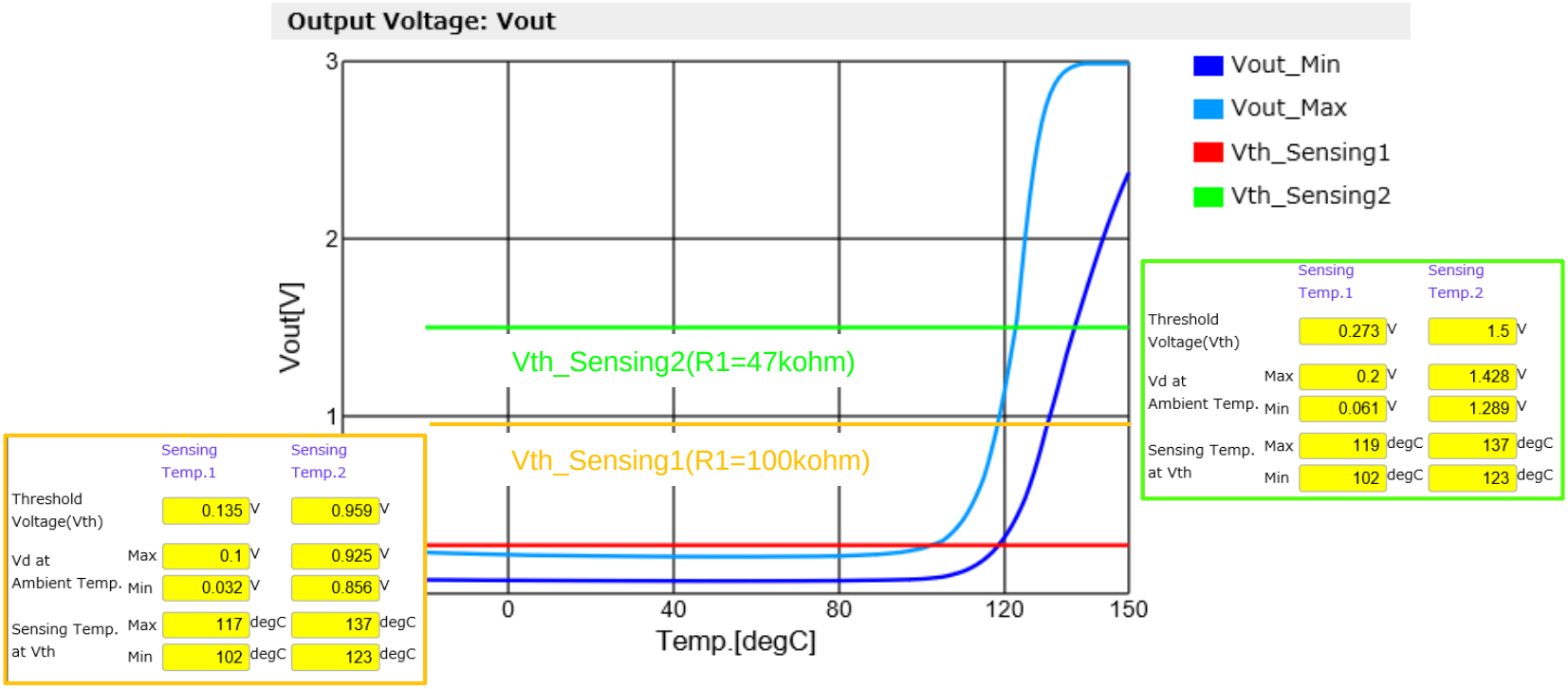
Confirm simulation results in SensingTemp_2.
You can see that Vout reaches 1.5 V while the temperature is 123 - 137℃ in the item related to Vth. Furthermore, in this simulation, you can see that Vd at ambient Temp indicates the change of Vout in 25℃ and 150℃, and there is a large gain of over 1.2 V voltage change in input voltage 3 V.
Next, confirm the relationship between R1 and the simulation result.

3. Software Use Examples
3-6. Change Fixed Resistance R1



Try the simulation again with R1 as 100 kohm.

3. Software Use Examples
3-7. Relationship Between Fixed Resistance R1 and Vth



You can see that Vth = 1.5 V when R1 = 47 kohm and Vth = 0.96 V when R1 = 100 kohm. Generally, making fixed resistance R1 larger will make Vth (Vout of detected temperature) smaller. Enables setting of desired Vout based on the type of control IC. This design condition is “Vout fluctuates by 1 V between the normal state and when heated.” Therefore, R1 is changed again and an optimal condition is searched for.

3. Software Use Examples
3-8. Optimization of Circuits

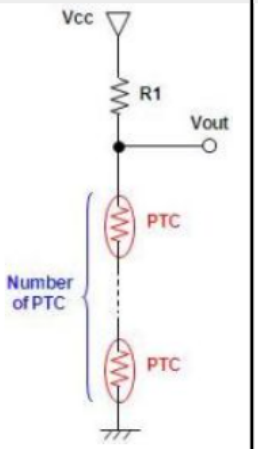
Input Conditions

Temp_H	150	degC
Temp_L	-20	degC
Ambient_Temp	25	degC
Number of PTC	5	pcs
Vcc	3	V
Tolerance	0	%
TC VCC	0	mV/degC
R1	75	kohm
Tolerance R1	1	%
TC R1	200	ppm/degC

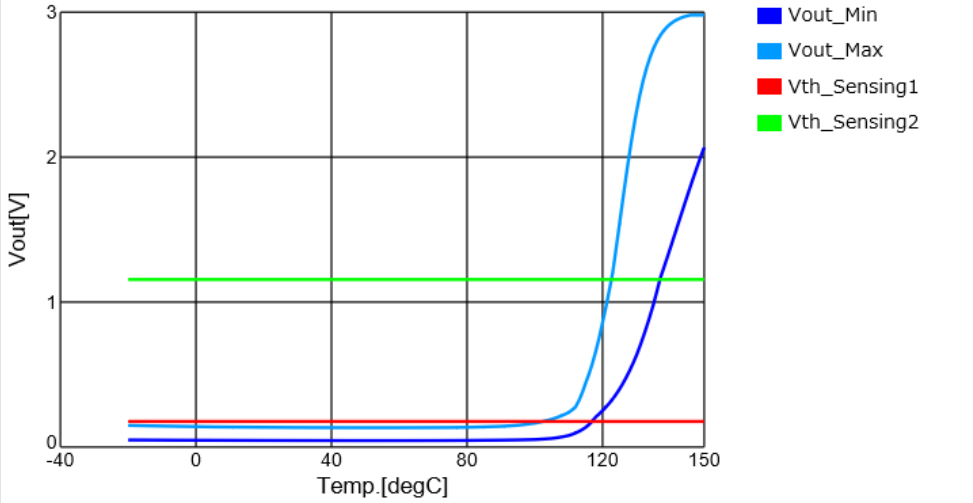
PTC Part Number: PRF18BB471R##RB

R25	470.0	ohm
Tolerance	50.0	%
Sensing Temp.1		
Resistance	4.7	kohm
Temp.	115.0	degC
Tolerance	3.0	degC
Sensing Temp.2		
Resistance	47.0	kohm
Temp.	130.0	degC
Tolerance	7.0	degC

Circuit



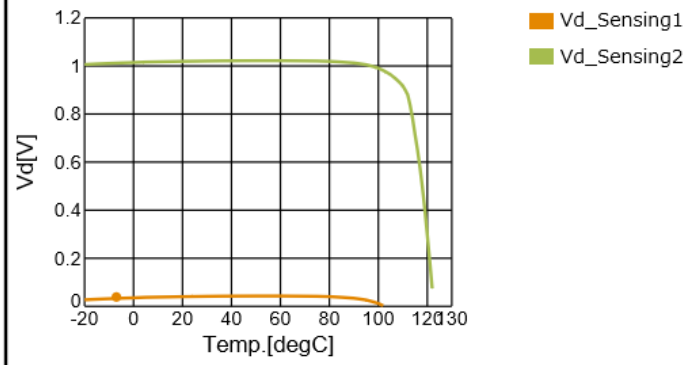
Output Voltage: Vout



Simulation_Result

		Sensing Temp.1	Sensing Temp.2
Threshold Voltage(Vth)		0.177 V	1.156 V
Vd at Ambient Temp.	Max	0.131 V	1.11 V
	Min	0.041 V	1.02 V
Sensing Temp. at Vth	Max	117 degC	137 degC
	Min	102 degC	123 degC

Margin: Vd = Vth - Vout_Max



By making R1 = 75 ohm, Vd at ambient Temp (Vout change in 25℃ - 130℃) becomes 1.02 V - 1.11 V, and achieves your desired circuit.

Contents

4. Appendix
4-1. Specifications of the PRF Series (1/2)

No.	Item	R25	Tolerance	CP	Sensing Temperature 1			Sensing Temperature 2		
		[Ω]	[%]	[°C] (Typical)	Resistance [kΩ]	Temp. [°C]	Tolerance [°C]	Resistance [kΩ]	Temp. [°C]	Tolerance [°C]
1	PRF15AR102RB#RC	1000	50	120	10	135	5	100	150	3
2	PRF15BA102RB#RC	1000	50	110	10	125	5	100	140	3
3	PRF15BB102RB#RC	1000	50	100	10	115	5	100	130	3
4	PRF15BC102RB#RC	1000	50	90	10	105	5	100	120	3
5	PRF15BD102RB#RC	1000	50	80	10	95	5	100	110	3
6	PRF15BE102RB#RC	1000	50	70	10	85	5	100	100	3
7	PRF15BF102RB#RC	1000	50	60	10	75	5	100	90	3
8	PRF15BG102RB#RC	1000	50	50	10	65	5	100	80	3
9	PRF15BB103RB#RC	10000	50	102	4700	130	3			
10	PRF15BE103RB#RC	10000	50	70	4700	100	3			
11	PRF15BG103RB#RC	10000	50	50	4700	80	3			
12	PRF18AS471QB#RB	470	50	130	4.7	145	5			
13	PRF18AR471QB#RB	470	50	120	4.7	135	5	47	150	7
14	PRF18BA471QB#RB	470	50	110	4.7	125	5	47	140	7
15	PRF18BB471QB#RB	470	50	100	4.7	115	5	47	130	7
16	PRF18BC471QB#RB	470	50	90	4.7	105	5	47	120	7
17	PRF18BD471QB#RB	470	50	80	4.7	95	5	47	110	7
18	PRF18BE471QB#RB	470	50	70	4.7	85	5	47	100	7
19	PRF18BF471QB#RB	470	50	60	4.7	75	5	47	90	7
20	PRF18BG471QB#RB	470	50	50	4.7	65	5	47	80	7
21	PRF18BB471RB#RB	470	50	100	4.7	115	3	47	130	7
22	PRF18BC471RB#RB	470	50	90	4.7	105	3	47	120	7
23	PRF18BD471RB#RB	470	50	80	4.7	95	3	47	110	7
24	PRF18BE471RB#RB	470	50	70	4.7	85	3	47	100	7
25	PRF18BF471RB#RB	470	50	70	4.7	75	3	47	90	7

4. Appendix
4-1. Specifications of the PRF Series (2/2)

No.	Item	R25	Tolerance	CP	Sensing Temperature 1			Sensing Temperature 2		
		[Ω]	[%]	[°C] (Typical)	Resistance [kΩ]	Temp. [°C]	Tolerance [°C]	Resistance [kΩ]	Temp. [°C]	Tolerance [°C]
26	PRF18BG471RB#RB	470	50	70	4.7	65	3	47	80	7
27	PRF21AS471QB#RA	470	50	130	4.7	145	5			
28	PRF21AR471QB#RA	470	50	120	4.7	135	5			
29	PRF21BA471QB#RA	470	50	110	4.7	125	5			
30	PRF21BB471QB#RA	470	50	100	4.7	115	5			
31	PRF21BC471QB#RA	470	50	90	4.7	105	5			
32	PRF21BD471QB#RA	470	50	80	4.7	95	5			
33	PRF21BE471QB#RA	470	50	70	4.7	85	5			
34	PRF18AS471QS#RB	470	50	130	4.7	145	5			
35	PRF18AR471QS#RB	470	50	120	4.7	135	5	47	150	7
36	PRF18BA471QS#RB	470	50	110	4.7	125	5	47	140	7
37	PRF18BB471QS#RB	470	50	100	4.7	115	5	47	130	7
38	PRF18BC471QS#RB	470	50	90	4.7	105	5	47	120	7
39	PRF18BD471QS#RB	470	50	80	4.7	95	5	47	110	7
40	PRF18BE471QS#RB	470	50	70	4.7	85	5	47	100	7
41	PRF18BF471QS#RB	470	50	60	4.7	75	5	47	90	7
42	PRF18BG471QS#RB	470	50	50	4.7	65	5	47	80	7
43	PRF18BB471RS#RB	470	50	100	4.7	115	3	47	130	7
44	PRF18BC471RS#RB	470	50	90	4.7	105	3	47	120	7
45	PRF18BD471RS#RB	470	50	80	4.7	95	3	47	110	7
46	PRF18BE471RS#RB	470	50	70	4.7	85	3	47	100	7
47	PRF18BF471RS#RB	470	50	70	4.7	75	3	47	90	7
48	PRF18BG471RS#RB	470	50	70	4.7	65	3	47	80	7

4. Appendix
4-2. Standard Numerical Table

E6	E24	E96
10	10	100
		102
		105
		107
	11	110
		113
		115
		118
	12	121
		124
		127
		130
	13	133
		137
		140
		143
15	15	147
		150
		154
		158
	16	162
		165
		169
		174
	18	178
		182
		187
		191
	20	196
		200
		205
		210

E6	E24	E96
22	22	215
		221
		226
		232
	24	237
		243
		249
		255
	27	261
		267
		274
		280
	30	287
		294
		301
		309
33	33	316
		324
		332
		340
	36	348
		357
		365
		374
	39	383
		392
		402
		412
	43	422
		432
		442
		453

E6	E24	E96
47	47	464
		475
		487
		499
	51	511
		523
		536
		549
	56	562
		576
		590
		604
	62	619
		634
		649
		665
68	68	681
		698
		715
		732
	75	750
		768
		787
		806
	82	825
		845
		866
		887
	91	909
		931
		953
		976