Handling Instructions

HCT01- Series

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1 Introduction

HCT01 humidity/temperature SMD sensor combines high quality, long time approved thin-film sensor technology with low energy consumption, cost-effective processing and integrated pollution filter.

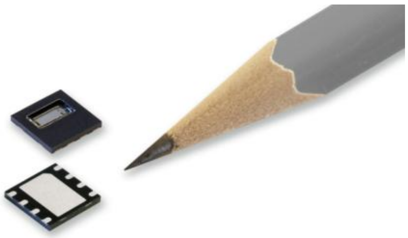


Figure 1: HCT01

This handling instruction provides the user with all relevant information to process the humidity sensor HCT01.

Further supporting material can be found under: www.epluse.com/hct01

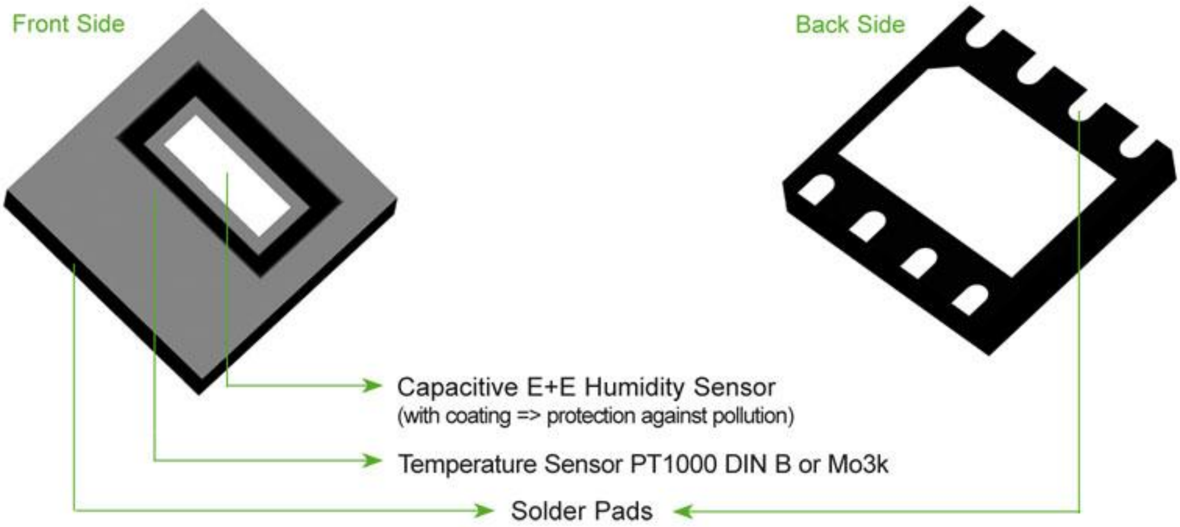


Figure 2: Front / Back side HCT01

2 Sensor information

2.1 Sensor technology

The HCT01 uses a humidity element which has approved its quality a million times in operation for many years. The customer can decide between two temperature sensors (Pt1000, Mo3000). The HCT01 is the only SMD passive humidity sensor worldwide, which is fully protected against most external pollution or emissions.

2.2 Sensor materials / protection

The HCT01 contains highly accurate thin film sensor elements. The sensor is based on a plated Cu lead-frame and *green* epoxy-based compound. The DFN housing of the humidity sensor and a polymer based environmental filter layer, on the active sensor area, provide maximum protection. Furthermore all solder contacts are protected by a thin noble metal layer. The sensor is fully RoHS and WEEE compliant.

2.3 Package

2.3.1 Dimensions

In the following figure the HCT01 is shown in three different perspectives. The detailed dimensions can be found in the table below.

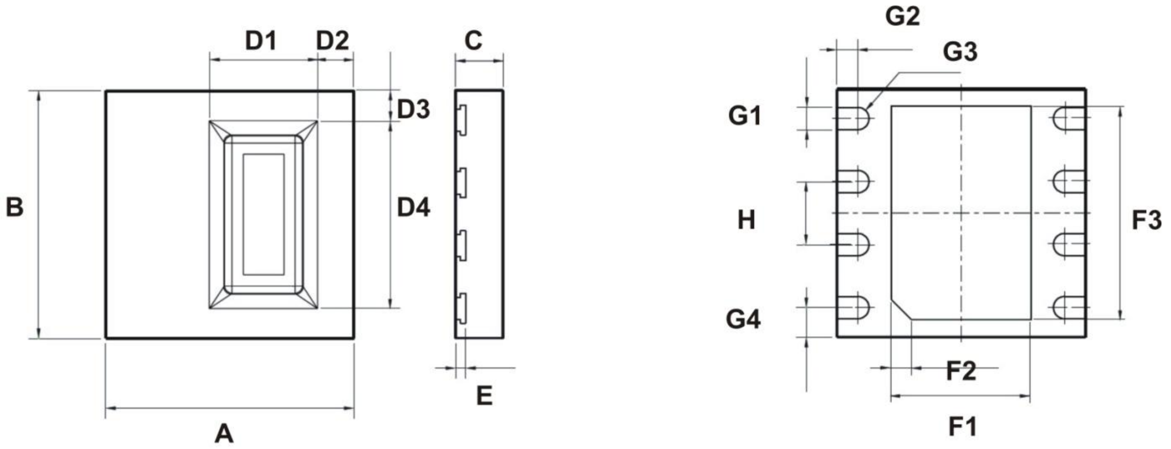


Figure 3: Top / Side / Back view HCT

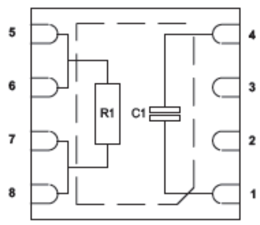
Table 1: Dimensions HCT01

Index	Item	Dimension, tolerance [mm]	Dimension, tolerance [inch]
A	Width	5,00 ±0,10	0,197±0,004
B	Length	5,00 ±0,10	0,197±0,004
C	Thickness	0,95 ±0,05	0,037±0,002
D1	Window length	2,18 BSC[1]	0,086 BSC
D2	Distance window/outer side	0,73 BSC	0,029 BSC
D3	Distance window/outer side	0,60 BSC	0,024 BSC
D4	Window width	3,80 BSC	0,150 BSC
E	Contact thickness	0,20 REF[2]	0,008 REF
F1	Die pad width	2,80 BSC	0,110 BSC
F2	Die pad chamfered edge	0,4 x 45° REF	0,16 x 45° REF
F3	Die pad length	4,31 BSC	0,170 BSC
G1	Contact pin width	0,45 BSC	0,018 BSC
G2	Distance center pin radius / outer side	0,42 BSC	0,017 BSC
G3	Pin radius	R 0,22 REF	R 0,009 REF
G4	Distance pin/out side	0,59 BSC	0,023 BSC
H	Pitch	1,27 BSC	0,050 BSC

2.3.2 Weight of HCT01

The approximate weight of the HCT01 is 85 mg.

2.3.3 Connection diagram



1	H1	Humidity +
2	NC	not connected
3	NC	not connected
4	H2	Humidity -
5	T1	Temperature
6	T1	Temperature
7	T2	Temperature
8	T2	Temperature

Figure 4: Connection diagram: Top view

2.3.4 Termination solder pads

Table 2: Termination

Layer	Material	Thickness	unit
Base (Lead frame)	Cu (purity >97%)	195-211	µm
Intermediate Layer	Ni	0.5-2.0	µm
Intermediate Layer	Pd	0.03-0.15	µm
Surface (Lead finish)	Au	0.003-0.015	µm

[1] BSC: Basic dimension. Theoretical exact values shown without tolerances.
[2] REF: Reference dimension, usually without tolerance, for information purpose only.

3 Technical data

3.1 Maximum ratings

Table 3: Maximum ratings

Parameter	Symbol	Value	Unit	Conditions
Upper limit temperature	t_{UL}	140	°C	---
Lower limit temperature	t_{LL}	-40	°C	---
Humidity working range		0..100	% RH	Details see humidity working range diagram (6.1)
Humidity sensor:				
Maximum AC supply voltage	U_{pp}	5	V	---
Maximum DC Voltage	U_{DC}	300	mV	---
Operating frequency	f	10..100	kHz	recommended
Temperature sensor:				
Maximum continuous sensor current (without relevant self heating)	I_{cont}	0,1	mA	$t_{LL} < t_A < t_{UL}$
Max. Current (still air)	I_{max}	1	mA	---
Max. U_{Charge} for ESD (HBM)	U_{charge}	250	V	MIL-STD-883 Method 3015

3.2 Characteristic Values

Table 4: Characteristic values

Parameter	Symbol	Value	Unit	conditions
Humidity sensor:				
Reference temperature	t_{Ref}	30	°C	---
Nominal or rated capacitance	C_0	70,1	pF	$t_A = t_{Ref}$
	C_{50}	82,0	pF	$t_A = t_{Ref}$
Accuracy HCT01-02	ΔRH	± 2 (3)	%	$t_A = t_{Ref}$ 30…70% RH (0…90% RH) see Graph 5
Accuracy HCT01-03	ΔRH	± 3 (4.5)	%	
HCT01-00 (non adjusted) Initial capacitance tolerance	$\Delta C_0/C_0$	± 10	%	$t_A = t_{Ref}$
Humidity coefficient	HC_0	3420	ppm/%RH	$t_A = t_{Ref}$
Initial humidity coefficient tolerance	ΔHC_0	±190	ppm/%RH	$t_A = t_{Ref}$
Parallel Resistance	$R_p \geq$	100	MΩ	$t_A = t_{Ref}$,1kHz, Upp 1V
Serial Resistance	$R_s \leq$	1200	Ω	$t_A = t_{Ref}$, 20kHz, U_{pp} 1V
Hysteresis		max. 1.85	% RH	Given under [2)]

Response time constant humidity	$t_{63} \leq$	6	s	$t_A = t_{Ref}$ (10% to 90% RH)
Adjustment temperature	t_{adj}	30 defined by user	°C	HCT01-02x, -03x HCT01-00x
Temperature dependence humidity measurement[3]	ΔC	$-0{,}00083 \cdot RH(T-t_{adj})$	pF	$-40 < t_A < 120°C$
or equivalent	ΔRH	$-0{,}0033 \cdot RH(T- t_{adj})$	%	$-40 < t_A < 120°C$
Temperature sensor (Mo3000)				
Room temperature	t_{Room}	25	°C	
Nominal resistance	R_{25}	3000	Ω	$t_A = t_{Room}$
Initial tolerance of resistance	$\Delta R_{25}/R_{25}$	0,06	%	$t_A = t_{Room}$
Accuracy	Δt	±[0.2+0.008*(t-25)]	K	see Graph 6
Self heating in still air (mounted on PCB)		0,20	K/mW	$t_A = t_{Room}$
Temperature sensor (Pt1000)				
Nominal resistance	R_0	1000	Ω	$t_A = 0°C$
Accuracy according IEC 751		DIN B		see Graph 6
For both types:				
Response time constant temperature	$t_{63} \leq$	6	s	$t_A = t_{Room}$
				v = 4 m/s

In the following graphs the relative humidity and temperature accuracy of the HCT01 are shown:

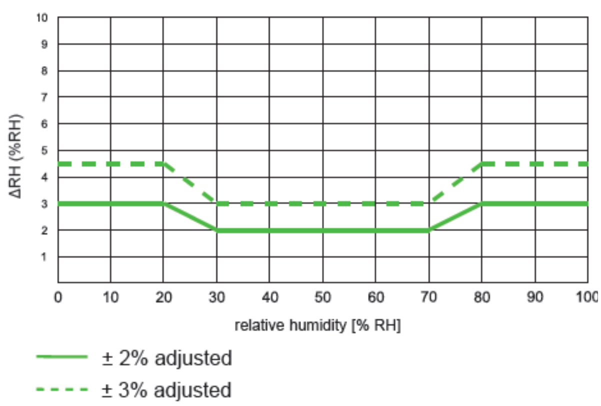


Figure 6: Relative humidity accuracy

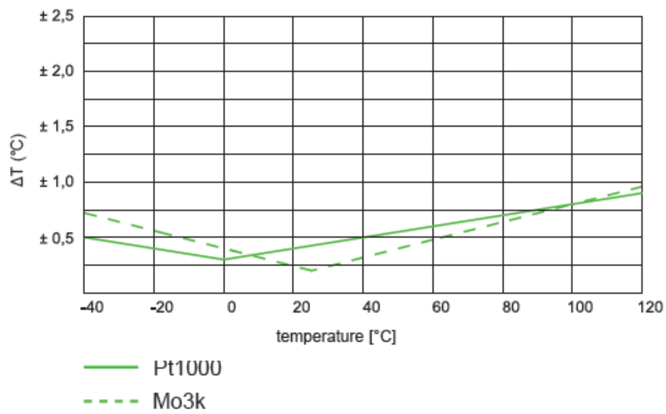


Figure 5: Temperature accuracy

3 1) More detailed model for compensation temperature dependence on request.
2) For hysteresis measurement the following procedure is used after basic treatment:
0% RH 1h, 15% 2h, 35% 2h, 55% 2h, 75% 2h, 95% 1h, 75% 2h, 55% 2h, 35% 2h, 15% 1h, hysteresis is defined as maximum difference between measurements at the same humidity up and down branch.

3.3 Temperature compensation

3.3.1 Additional misreading (%RH) caused by a temperature change without compensation

Table 5: Humidity misreading caused by an operating temperature different to standard temperature without compensation. For example T_{adj} = 25°C

%RH																					
100	-22	-18	-15	-12	-8	-5	-2	0	2	5	8	12	15	18	22	25	28	32	35	38	
95	-21	-17	-14	-11	-8	-5	-2	0	2	5	8	11	14	17	21	24	27	30	33	36	
90	-19	-16	-13	-10	-7	-4	-1	0	1	4	7	10	13	16	19	22	25	28	31	34	
85	-18	-16	-13	-10	-7	-4	-1	0	1	4	7	10	13	16	18	21	24	27	30	32	
80	-17	-15	-12	-9	-7	-4	-1	0	1	4	7	9	12	15	17	20	23	25	28	31	
75	-16	-14	-11	-9	-6	-4	-1	0	1	4	6	9	11	14	16	19	21	24	26	29	
70	-15	-13	-10	-8	-6	-3	-1	0	1	3	6	8	10	13	15	17	20	22	24	27	
65	-14	-12	-10	-8	-5	-3	-1	0	1	3	5	8	10	12	14	16	18	21	23	25	
60	-13	-11	-9	-7	-5	-3	-1	0	1	3	5	7	9	11	13	15	17	19	21	23	
55	-12	-10	-8	-6	-5	-3	-1	0	1	3	5	6	8	10	12	14	16	17	19	21	
50	-11	-9	-7	-6	-4	-2	-1	0	1	2	4	6	7	9	11	12	14	16	17	19	
45	-10	-8	-7	-5	-4	-2	-1	0	1	2	4	5	7	8	10	11	13	14	16	17	
40	-9	-7	-6	-5	-3	-2	-1	0	1	2	3	5	6	7	9	10	11	13	14	15	
35	-8	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	8	9	10	11	12	13	
30	-6	-5	-4	-3	-2	-1	0	0	0	1	2	3	4	5	6	7	8	9	10	11	
25	-5	-5	-4	-3	-2	-1	0	0	0	1	2	3	4	5	5	6	7	8	9	10	
20	-4	-4	-3	-2	-2	-1	0	0	0	1	2	2	3	4	4	5	6	6	7	8	
15	-3	-3	-2	-2	-1	-1	0	0	0	1	1	2	2	3	3	4	4	5	5	6	
10	-2	-2	-1	-1	-1	0	0	0	0	0	1	1	1	2	2	2	3	3	3	4	
5	-1	-1	-1	-1	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	-40	**-30**	**-20**	**-10**	**0**	**10**	**20**	**25**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**°C**

3.3.2 Additional misreading (%RH) caused by a temperature change with (linear) compensation

Linear model of temperature dependence: dC = -0,00083*RH(T-30°C) [pF]

Table 6: Temperature change with (linear) compensation (remaining systematic error)

%RH																					
100	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
95	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
90	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
85	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
80	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
75	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
70	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
65	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
60	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
55	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
50	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
45	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
40	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
35	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
30	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
25	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
20	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
15	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
10	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
5	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
0	0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4	0,6	0,9	1,2	1,6	2,1	
	-40	-30	-20	-10	0	10	20	25	30	40	50	60	70	80	90	100	110	120	130	140	°C

For example T_{adj}=25°C, compensation linear model

More detailed temperature dependence model (for better compensation) on request.

4 Characteristic curves

4.1 Working range

The working range is shown with regard to the humidity / temperature limits.

Although the sensors would not fail when operated outside the working range, the sensor is specified only within. In applications with high humidity at high temperatures the time factor shall be considered.

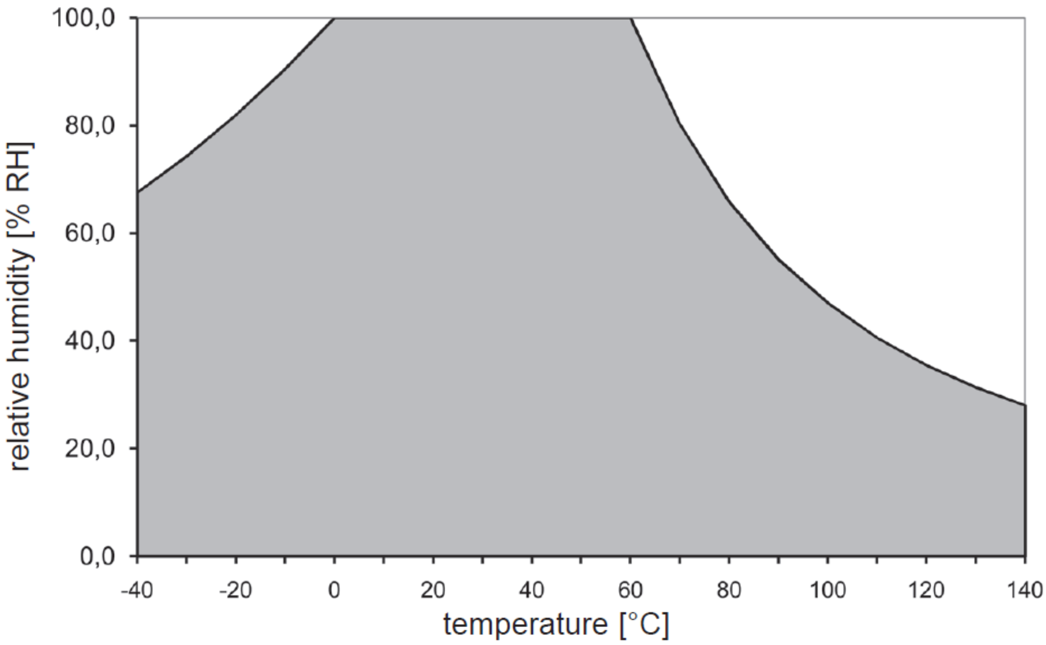


Figure 7: Working range

4.2 Characteristics humidity element

The average increase of capacitance over the working range is approximately 25 pF. For the range of 0–98% RH linear approximation is possible, errors will be lower than < ± 1.5% RH.

The sensor characteristic is determined by the following linear formula:

$C(U_w) = C_0 * [1+HC_0 * U_w]$

$C_0 = 70.1$ pF

with $HC_0 = 3420 \pm 190$ ppm /% RH

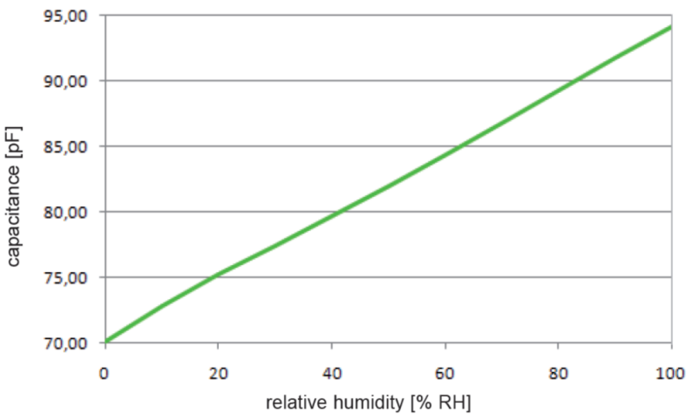


Figure 8: Characteristics humidity element

For high accuracy requirements, the sensitivity is determined by the following polynomial:

$C(U_w) = C0*[1+ HC_0* U_w +k(U_w)]$ U_w …. relative humidity

C_0…. capacitance of sensor at 0%rH

$k(U_w) = A1* U_w + A2* U_w^{1.5} + A3* U_w^{2} + A4* U_w^{2.5}$

$A1 = 2,6657*10^{-3}$ $A3 = 1,1272*10^{-4}$

$A2 = -9,6134*10^{-4}$ $A4 = -4.3*10^{-6}$

4.2.1 Humidity Table RH[%]→C[pF] (t_A=30°C)

Table 7: Humidity table

	0	1	2	3	4	5	6	7	8	9
0	70,08	70,44	70,77	71,07	71,36	71,64	71,90	72,16	72,41	72,66
10	72,90	73,14	73,38	73,61	73,84	74,07	74,30	74,53	74,75	74,98
20	75,20	75,42	75,64	75,87	76,09	76,31	76,53	76,76	76,98	77,20
30	77,42	77,65	77,87	78,09	78,32	78,54	78,77	79,00	79,22	79,45
40	79,68	79,91	80,14	80,37	80,60	80,83	81,06	81,30	81,53	81,76
50	82,00	82,24	82,47	82,71	82,95	83,19	83,42	83,66	83,90	84,14
60	84,39	84,63	84,87	85,11	85,36	85,60	85,84	86,09	86,33	86,58
70	86,82	87,07	87,31	87,56	87,81	88,05	88,30	88,55	88,80	89,04
80	89,29	89,54	89,79	90,03	90,28	90,53	90,77	91,02	91,27	91,52
90	91,76	92,01	92,25	92,50	92,75	92,99	93,23	93,48	93,72	93,97

4.2.2 Relative Version of the Humidity Table RH[%]→C[pF] (t_A=30°C)

$C(U_w) = C_0 * k_{rel}(U_w)$

Table 8: Relative humidity table

	0	1	2	3	4	5	6	7	8	9
0	1,000	1,005	1,010	1,014	1,018	1,022	1,026	1,030	1,033	1,037
10	1,040	1,044	1,047	1,050	1,054	1,057	1,060	1,064	1,067	1,070
20	1,073	1,076	1,079	1,083	1,086	1,089	1,092	1,095	1,098	1,102
30	1,105	1,108	1,111	1,114	1,118	1,121	1,124	1,127	1,131	1,134
40	1,137	1,140	1,144	1,147	1,150	1,153	1,157	1,160	1,163	1,167
50	1,170	1,174	1,177	1,180	1,184	1,187	1,190	1,194	1,197	1,201
60	1,204	1,208	1,211	1,215	1,218	1,222	1,225	1,228	1,232	1,235
70	1,239	1,242	1,246	1,250	1,253	1,257	1,260	1,264	1,267	1,271
80	1,274	1,278	1,281	1,285	1,288	1,292	1,295	1,299	1,302	1,306
90	1,309	1,313	1,316	1,320	1,323	1,327	1,330	1,334	1,337	1,341

4.2.3 Humidity Table C[pF] →RH[%] (t_A=30°C)

Table 9: Humidity table C[pf]

	60	70	80	90	100
0		-0,19	41,40	82,87	124,94
0,5		1,17	43,57	84,89	127,24
1		2,76	45,73	86,91	129,58
1,5		4,50	47,87	88,94	
2		6,37	50,00	90,97	
2,5		8,34	52,12	93,00	
3		10,40	54,22	95,04	
3,5		12,51	56,32	97,09	
4		14,68	58,40	99,14	
4,5		16,88	60,47	101,20	
5	-19,79	19,11	62,54	103,28	
5,5	-17,56	21,35	64,59	105,36	
6	-15,35	23,60	66,64	107,46	
6,5	-13,17	25,85	68,68	109,58	
7	-11,04	28,10	70,72	111,71	
7,5	-8,96	30,35	72,75	113,86	
8	-6,96	32,58	74,78	116,02	
8,5	-5,06	34,80	76,80	118,21	
9	-3,28	37,02	78,83	120,43	
9,5	-1,63	39,21	80,85	122,67	

Values below 0% and above 100% will be corrected by succeeding temperature compensation.

Example:

- Calibration temperature 30°C
- Reading 95,5 pF → "105,4 %RH", measuring temperature 0°C
- Temperature misreading due to temperature dependence
  ΔRH = -0,0033*RH(T-30°C) [%RH]
- Temperature correction ΔRH = + 0,0033*RH(T-30°C) [%RH]
- Corrected value: 105,4 + 0,0033*105,4*(0-30) %RH=105,4–10,4 %RH= 95,0 %RH including correction.

4.3 Temperature sensor Mo3000 / PT1000 comparison

The following diagram shows the accuracy of the available resistive temperature sensors for the HCT01.

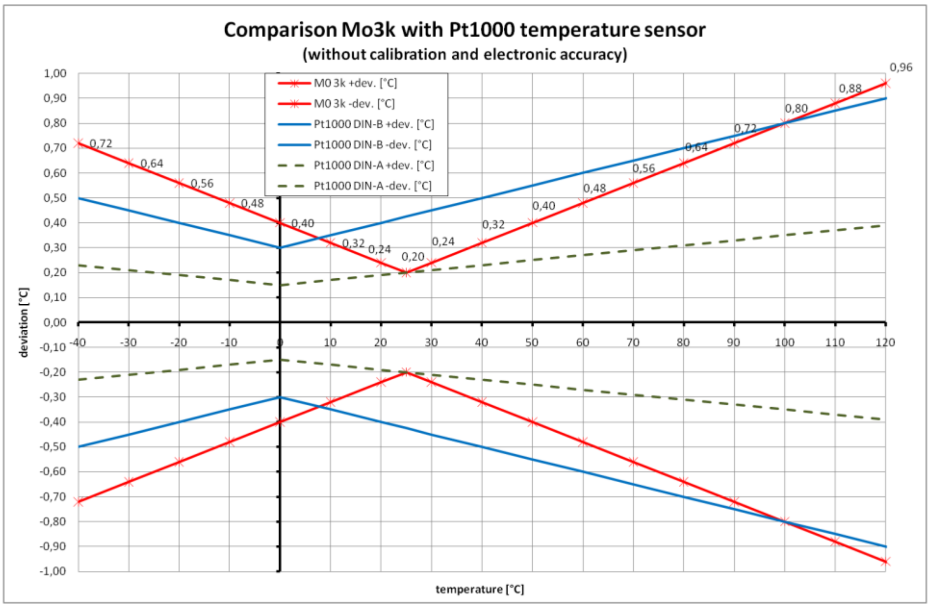


Figure 9: Temperature sensor Mo3000 / PT1000 comparison

4.4 Characteristics temperature element Mo3000

The characteristic curve of the temperature sensor element can be calculated as follows:

$$R = R_0 * (1 + \alpha * t * (1 + \beta * (t/100 - 1)))$$

α [1/K] = Tk [ppm/K] $*10^{-6}$

R_0 = 2785,88 Ohm

Tk = 3100 ppm/K

β = 0,011

t … Temperature

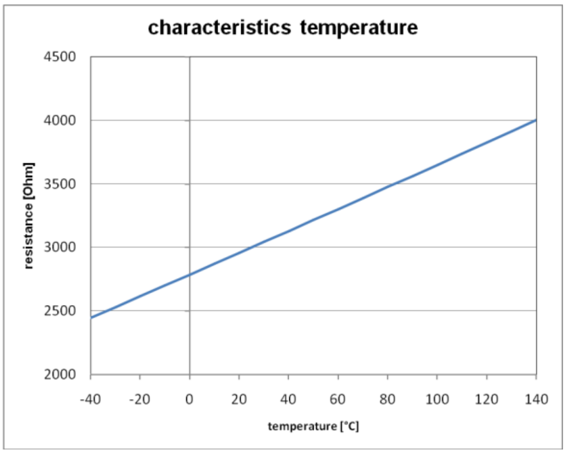


Figure 10: Characteristics temperature element Mo3000

Alternatively, the following function can be used:

$R = R_0 * (1 + A * t + B * t^2)$ with

R_0 = 2785,88 Ohm

B = $3,41*10^{-7}$

A = 0,0030659

t = Temperature in °C

The coefficients of the functions can be transformed according to:

$A = \alpha * (1 - \beta)$
$B = \alpha * \beta / 100$

$\alpha = A + B*100$
$\beta = B / \alpha * 100$

4.4.1 Temperature Table Mo3000

T→R [°C]→[Ω]

Table 10: Temperature Table Mo3000

	0	1	2	3	4	5	6	7	8	9
-40	2445,8	2454,2	2462,7	2471,2	2479,6	2488,1	2496,6	2505,1	2513,5	2522,0
-30	2530,5	2539,0	2547,5	2556,0	2564,5	2572,9	2581,4	2589,9	2598,4	2606,9
-20	2615,4	2623,9	2632,4	2641,0	2649,5	2658,0	2666,5	2675,0	2683,5	2692,0
-10	2700,6	2709,1	2717,6	2726,1	2734,7	2743,2	2751,7	2760,3	2768,8	2777,3
0	2785,9	2794,4	2803,0	2811,5	2820,1	2828,6	2837,2	2845,7	2854,3	2862,8
10	2871,4	2879,9	2888,5	2897,1	2905,6	2914,2	2922,8	2931,4	2939,9	2948,5
20	2957,1	2965,7	2974,2	2982,8	2991,4	3000,0	3008,6	3017,2	3025,8	3034,4
30	3043,0	3051,6	3060,2	3068,8	3077,4	3086,0	3094,6	3103,2	3111,8	3120,4
40	3129,0	3137,7	3146,3	3154,9	3163,5	3172,2	3180,8	3189,4	3198,0	3206,7
50	3215,3	3224,0	3232,6	3241,2	3249,9	3258,5	3267,2	3275,8	3284,5	3293,1
60	3301,8	3310,4	3319,1	3327,7	3336,4	3345,1	3353,7	3362,4	3371,1	3379,7
70	3388,4	3397,1	3405,8	3414,5	3423,1	3431,8	3440,5	3449,2	3457,9	3466,6
80	3475,3	3484,0	3492,6	3501,3	3510,0	3518,7	3527,5	3536,2	3544,9	3553,6
90	3562,3	3571,0	3579,7	3588,4	3597,1	3605,9	3614,6	3623,3	3632,0	3640,8
100	3649,5	3658,2	3667,0	3675,7	3684,4	3693,2	3701,9	3710,7	3719,4	3728,2
110	3736,9	3745,7	3754,4	3763,2	3771,9	3780,7	3789,4	3798,2	3807,0	3815,7
120	3824,5	3833,3	3842,0	3850,8	3859,6	3868,4	3877,2	3885,9	3894,7	3903,5
130	3912,3	3921,1	3929,9	3938,7	3947,5	3956,3	3965,1	3973,9	3982,7	3991,5

R→T [Ω]→[°C]

Table 11: Reverse temperature table Mo3000

	0	10	20	30	40	50	60	70	80	90
2400	-45,4	-44,2	-43,0	-41,9	-40,7	-39,5	-38,3	-37,1	-36,0	-34,8
2500	-33,6	-32,4	-31,2	-30,1	-28,9	-27,7	-26,5	-25,3	-24,2	-23,0
2600	-21,8	-20,6	-19,5	-18,3	-17,1	-15,9	-14,8	-13,6	-12,4	-11,2
2700	-10,1	-8,9	-7,7	-6,5	-5,4	-4,2	-3,0	-1,9	-0,7	0,5
2800	1,7	2,8	4,0	5,2	6,3	7,5	8,7	9,8	11,0	12,2
2900	13,3	14,5	15,7	16,8	18,0	19,2	20,3	21,5	22,7	23,8
3000	25,0	26,2	27,3	28,5	29,7	30,8	32,0	33,1	34,3	35,5
3100	36,6	37,8	38,9	40,1	41,3	42,4	43,6	44,7	45,9	47,1
3200	48,2	49,4	50,5	51,7	52,9	54,0	55,2	56,3	57,5	58,6
3300	59,8	61,0	62,1	63,3	64,4	65,6	66,7	67,9	69,0	70,2
3400	71,3	72,5	73,6	74,8	75,9	77,1	78,2	79,4	80,5	81,7
3500	82,8	84,0	85,1	86,3	87,4	88,6	89,7	90,9	92,0	93,2
3600	94,3	95,5	96,6	97,8	98,9	100,1	101,2	102,3	103,5	104,6
3700	105,8	106,9	108,1	109,2	110,4	111,5	112,6	113,8	114,9	116,1
3800	117,2	118,3	119,5	120,6	121,8	122,9	124,0	125,2	126,3	127,5
3900	128,6	129,7	130,9	132,0	133,2	134,3	135,4	136,6	137,7	138,8
4000	140,0	141,1	142,2	143,4	144,5	145,6	146,8	147,9	149,0	150,2

4.5 Characteristics temperature element Pt1000

For HCT01 with Pt1000 temperature sensor element the standard parameters according to DIN IEC 751 (EN 60751 July 96) IST 90 can be used:

$R = R_0 * (1 + \alpha * t * (1 + \beta * (t/100 - 1)))$ with

$\alpha = 3850.55$ [ppm/°C] $\beta = -1.499786E-2$

or $R = R_0 * (1 + A * t + B * t^2)$ with

A = 3.9083E-3   B = -5.775E-7

4.5.1 Temperature Table Pt1000

Table 12: Temperature Table Pt1000: T→R [°C]→[Ω]

	0	1	2	3	4	5	6	7	8	9
-40	842,7	846,7	850,7	854,6	858,6	862,5	866,5	870,4	874,3	878,3
-30	882,2	886,2	890,1	894,1	898,0	901,9	905,9	909,8	913,7	917,7
-20	921,6	925,5	929,5	933,4	937,3	941,2	945,2	949,1	953,0	956,9
-10	960,9	964,8	968,7	972,6	976,5	980,4	984,4	988,3	992,2	996,1
0	1000,0	1003,9	1007,8	1011,7	1015,6	1019,5	1023,4	1027,3	1031,2	1035,1
10	1039,0	1042,9	1046,8	1050,7	1054,6	1058,5	1062,4	1066,3	1070,2	1074,0
20	1077,9	1081,8	1085,7	1089,6	1093,5	1097,3	1101,2	1105,1	1109,0	1112,9
30	1116,7	1120,6	1124,5	1128,3	1132,2	1136,1	1140,0	1143,8	1147,7	1151,5
40	1155,4	1159,3	1163,1	1167,0	1170,8	1174,7	1178,6	1182,4	1186,3	1190,1
50	1194,0	1197,8	1201,7	1205,5	1209,4	1213,2	1217,1	1220,9	1224,7	1228,6
60	1232,4	1236,3	1240,1	1243,9	1247,8	1251,6	1255,4	1259,3	1263,1	1266,9
70	1270,8	1274,6	1278,4	1282,2	1286,1	1289,9	1293,7	1297,5	1301,3	1305,2
80	1309,0	1312,8	1316,6	1320,4	1324,2	1328,0	1331,8	1335,7	1339,5	1343,3
90	1347,1	1350,9	1354,7	1358,5	1362,3	1366,1	1369,9	1373,7	1377,5	1381,3
100	1385,1	1388,8	1392,6	1396,4	1400,2	1404,0	1407,8	1411,6	1415,4	1419,1
110	1422,9	1426,7	1430,5	1434,3	1438,0	1441,8	1445,6	1449,4	1453,1	1456,9
120	1460,7	1464,4	1468,2	1472,0	1475,7	1479,5	1483,3	1487,0	1490,8	1494,6
130	1498,3	1502,1	1505,8	1509,6	1513,3	1517,1	1520,8	1524,6	1528,3	1532,1

Table 13: Reverse temperature table PT1000: R→T [Ω]→[°C]

	800	900	1000	1100	1200	1300	1400	1500
0	-50,8	-25,5	0,0	25,7	51,6	77,7	103,9	130,4
5	-49,5	-24,2	1,3	27,0	52,9	79,0	105,3	131,8
10	-48,3	-23,0	2,6	28,3	54,2	80,3	106,6	133,1
15	-47,0	-21,7	3,8	29,6	55,5	81,6	107,9	134,4
20	-45,7	-20,4	5,1	30,8	56,8	82,9	109,2	135,8
25	-44,5	-19,1	6,4	32,1	58,1	84,2	110,5	137,1
30	-43,2	-17,9	7,7	33,4	59,4	85,5	111,9	138,4
35	-42,0	-16,6	9,0	34,7	60,7	86,8	113,2	139,8
40	-40,7	-15,3	10,3	36,0	62,0	88,1	114,5	141,1
45	-39,4	-14,0	11,5	37,3	63,3	89,5	115,8	142,4
50	-38,2	-12,8	12,8	38,6	64,6	90,8	117,2	143,8
55	-36,9	-11,5	14,1	39,9	65,9	92,1	118,5	145,1
60	-35,6	-10,2	15,4	41,2	67,2	93,4	119,8	146,5
65	-34,4	-8,9	16,7	42,5	68,5	94,7	121,1	147,8
70	-33,1	-7,7	18,0	43,8	69,8	96,0	122,5	149,1
75	-31,8	-6,4	19,2	45,1	71,1	97,3	123,8	150,5
80	-30,6	-5,1	20,5	46,4	72,4	98,7	125,1	151,8
85	-29,3	-3,8	21,8	47,7	73,7	100,0	126,5	153,1
90	-28,0	-2,6	23,1	49,0	75,0	101,3	127,8	154,5
95	-26,8	-1,3	24,4	50,3	76,3	102,6	129,1	155,8

5 Processing information

5.1 Storage instructions

The HCT01 is a highly accurate temperature and humidity sensor. Therefore the storage instructions must be followed precisely in order to guarantee specification. Pursuant to IPC/JEDEC J-STD-020D.1[4] the Moisture Sensitivity Level (MSL) is 2, which guarantees one-year storage of the sensor package. High concentrations and long exposure times to chemical vapors can influence the characteristic of the sensor.

It is advisable to keep the sensor in the original manufacturing packaging. If it is necessary to remove the packaging, ESD trays made from PS (Polystyrol) are recommended, keeping the storage temperature in the range of 0 – 55°C. In addition sealed ESD bags are recommended. In Chapter 5.4 "Handling instructions" supplementary details will be provided for transportation.

5.2 Soldering instructions

The copper based lead frame is plated with a thin stack of Ni/Pd/Au layers. For mechanical as well as electrical connection the pads have to be soldered to the PCB. Furthermore, it is recommended to solder the exposed die pad to the PCB, too.

Except for the exposed die pad, the lands should be 0,05 mm larger than the package pads and 0,2 mm longer at the outward side. Additional information is given in Figure 11 as well as in Figure 12. The land pattern can be downloaded from www.epluse.com/hct01

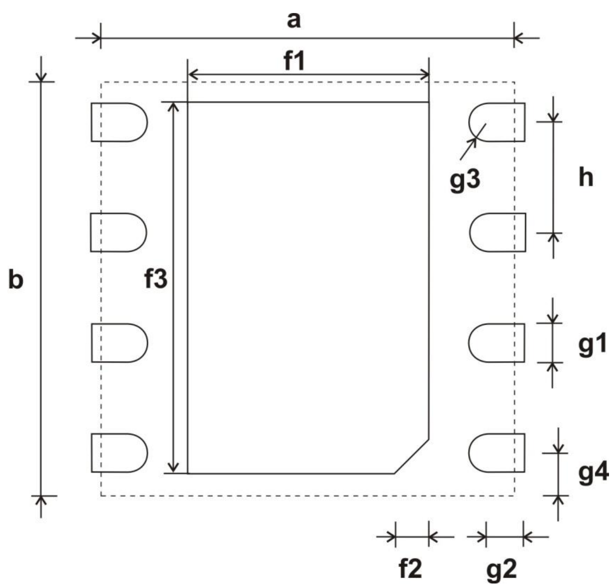


Figure 11: Suggested land pattern

4 Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices

Suggested land pattern for connecting the package pads to the PCB. It is recommended to connect the center pad (die pad) to the PCB. The outer dimension of the HCT01 package is indicated by the dotted line.

Table 14: Physical dimensions of the land pattern corresponding to Figure 11.

Index	Item	Dimension [mm]	Dimension [in]
a	length	5,0	0,197
b	width	5,0	0,197
f1	die pad length	2,80	0,110
f2	projected length of the chamfered edge	0,40	0,016
f3	die pad width	4,30	0,169
g1	pin width	0,550	0,022
g2	pin length without radius	0,620	0,024
g3	pin radius	0,275	0,011
g4	distance edge – pin (mirror plane)	0,595	0,023
h	pitch	1,270	0,050
k	pad oversize	0,20	0,008

For soldering, a lead-free, air-, and nitrogen-reflow-solderable no-clean type 3 solder paste, which meets the requirements of the RoHS Directive 2002/95/EC Art. 4, as well as the standards by J-STD-004, is recommended. As an example, the solder paste EnviroMark^{TM} 907 from Kester is one of these candidates, exceeding the reliability standards required by J-STD-004. Graph 14 shows the typical soldering profile for the soldering paste.

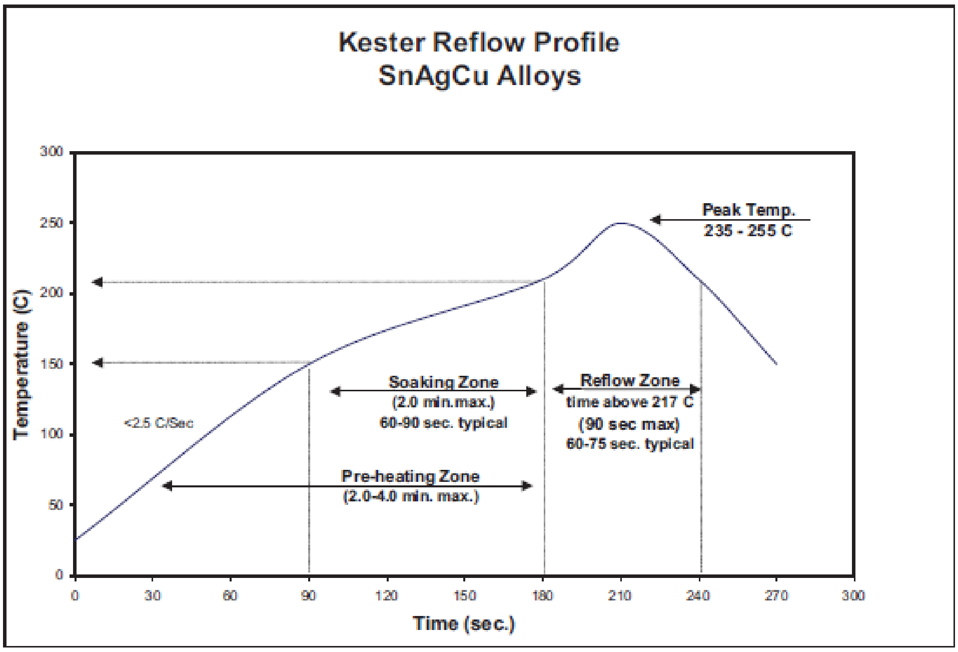


Figure 12: Recommended reflow profile using a standard reflow soldering oven.

Note that the sensor package itself is qualified to withstand the profile given in JEDEC J-STD-020D for Pb - free soldering with a peak temperature of 260°C and a time in the critical zone above (T_{peak} - 5°C) of up to 40 seconds. The packages passed the tests according to: AEC Q200-REV C, method 005[5], IEC 60068-2-20 test Ta method 1[6], IEC 60068-2-58, item 5[7], MIL-202 M210[8], IEC 60068-2-21 Ue_2 and Ue_3[9], respectively.

5.3 Post reflow treatment

We strongly recommend high humidity storage of the boards including the sensor packages after reflow soldering. A storage process of 16-24 hours at 80±10% RH (room temperature) is advisable for rehydration. Adjustment of boards (e.g. using HCT01-00 untrimmed) should be done after a short further rest (>1 hour) at room conditions.

5.4 Handling instructions

5.4.1 Handling Information

During the whole transportation process it should be avoided to expose the sensor to high concentrations of chemical solvents for longer time periods. Otherwise the "Reconditioning procedure (5.4.4)" must be followed.

5.4.2 Recommended packaging materials

The best packaging is the original manufacturer packaging. If the sensor has to be removed from this packaging ESD trays made from PS (Polystyrol) or sealed ESD bags are recommended.

5.4.3 Forbidden packaging materials

Out-gassing materials:

- Foams (e.g.: Type MOS 2200)
- Glues
- adhesive tapes and
- foils

are strictly forbidden and may change the characteristic of the sensor.

[5] PASSIVE COMPONENT Board Flex / Terminal Bond Strength Test
[6] Basic environmental testing procedures, Part 2: Tests, Test T: Soldering
7 Environmental testing – Part 2-58: Tests – Test Td: Test methods for solder ability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)
8 Resistance to soldering heat
9 Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices

5.4.4 Reconditioning procedure

After exposure to extreme conditions or chemical solvents or storage time of several months, the sensor characteristic curve may offset. Exposure to higher temperature will reset the contamination offset (reflow soldering process or e.g. 110°C, 5-7h). After returning to room temperature a humidity exposure to 80±10% RH for 16-24 hours completes the reconditioning process.

5.5 Traceability information

5.5.1 Marking Code

On request there is a laser marked Data-Matrix-Code on the front side of the HCT01, below the active area window, to individually track the sensor element.

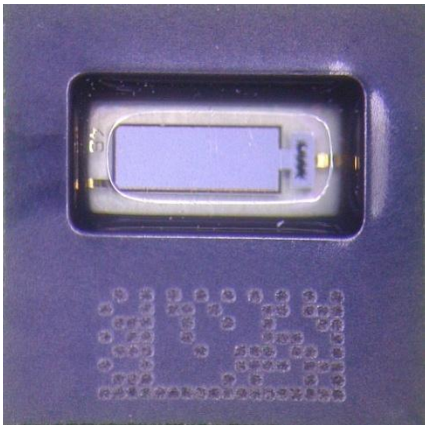


Figure 13: Data matrix code

5.5.2 Reel Label

HCT01-02 TR1

310063_111006101

Menge: 100

Figure 14: Standard reel label

5.6 Shipping details

The HTC-01 is provided in tape & reel packaging according to IEC 60286-3[10] and sealed into antistatic ESD bags. Typical HCT01 packages per reel are 200 / 1000 / 2500 pieces. In the drawing detailed packaging dimensions are given:

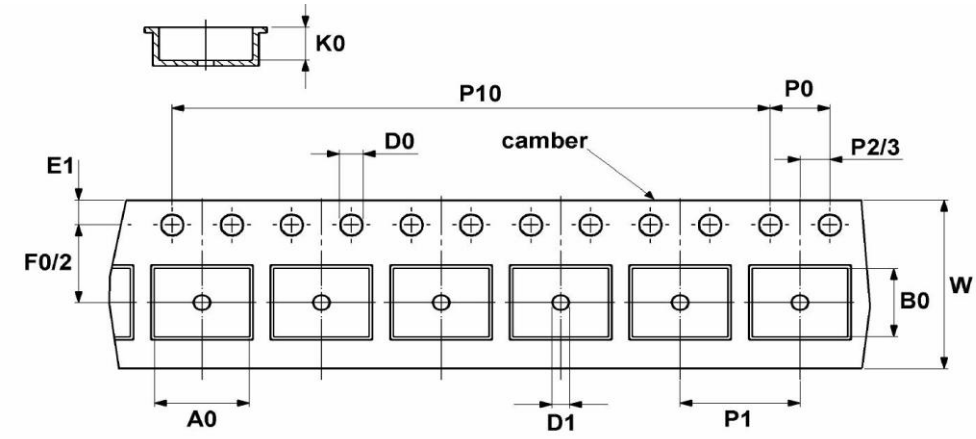


Figure 15: Embossed carrier configuration

Table 15: Metric dimensions of embossed tape

Index	Item	Dimension, tolerance
P10	10 x transporting hole	40,00 ±0,20
	camber = 1,0 / 250 check line	
	camber cross winding = 2,0 / 250 check line	
D0	transportation hole	1,50 +0,10
P0	transportation hole	4,00 ±0,10
P2	distance transport hole/cavity	2,00 ±0,05
P3	distance transport hole/hole	2,00 ±0,05
W	tape width	12,00 ±0,10
E1	distance transport hole/outer side	1,75 ±0,10
F0	distance transport hole/cavity	5,50 ±0,05
F2	distance transport hole/hole	5,50 ±0,05
A0	cavity	5,25 ±0,05
B0	cavity	5,25 ±0,05
P1	distance cavity/cavity	8,00 ±0,10
D1	hole in cavity	1,50 ±0,10
K0	deepness of cavity inside	1,15 ±0,05
T	thickness of tape	0,25 ±0,05

[10] Packaging of components for automatic handling – Part 3: Packaging of surface mount components on continuous tapes

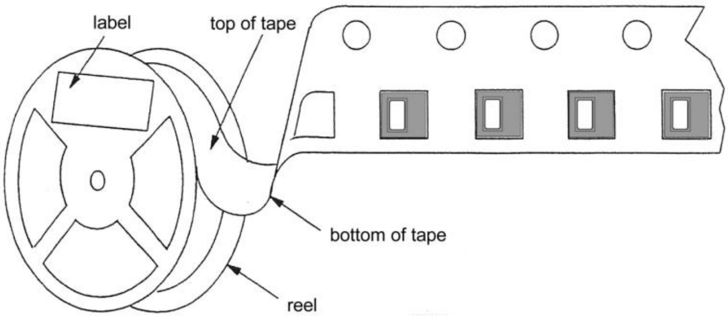


Figure 16: Orientation of sensor packages in tape

6 Environmental durability

HCT01 sensor series were successfully tested to a multitude of environmental tests according to AEC-Q200, AEC-Q100 and other applicable standards.

The table below gives a digest of these tests

Table 16: Environmental durability tests

Test	Conditions	Result
Electrical Duration	140°C , 2000h, pulsed operation of samples (IEC 60068-2-2)	Within specifications: |ΔC/C| < 0,75% (at 0%RH, 50%RH and 85%RH) ; |ΔR25/R25| < 0,06%; |ΔTk/Tk| < 0,4 %
ESD (MM+HBM)	MM (AEC Q100, Nr. 3 Rev.E), HBM (AEC Q200, Nr.2)	Component classification: MM: Class M2 HBM Class 1A
Low temperature exposure	-40°C, 250h (IEC 60068-2-1)	Within specifications: |ΔC/C| < 0,75% (at 0%RH, 50%RH and 85%RH) ; |ΔR25/R25| < 0,06%; |ΔTk/Tk| < 0,4 %
High temperature exposure	140°C, 2000h (AEC Q200 Nr.3)	Within specifications: |ΔC/C| < 0,75% (at 0%RH, 50%RH and 85%RH) ; |ΔR25/R25| < 0,06%; |ΔTk/Tk| < 0,4 %
Rapid change of temperature	T-shock, 1000 cycles (AEC Q200 Nr.16)	Within specifications: |ΔC/C| < 0,75% (at 0%RH, 50%RH and 85%RH) ; |ΔR25/R25| < 0,06%; |ΔTk/Tk| < 0,4 %
Temperature Cycling	-40/140°, 5°/min (JESD22 JA-104)	Within specifications: |ΔC/C| < 0,75% (at 0%RH, 50%RH and 85%RH) ; |ΔR25/R25| < 0,06%; |ΔTk/Tk| < 0,4 %
Moisture test 1	40°/93%RH, 1344h (AEC Q200 Nr.7)	Within specifications: |ΔC/C| < 1,5% (at 0%RH, 50%RH and 85%RH) ;

		|ΔR25/R25| < 0,06%; |ΔTk/Tk| < 0,4 %
Moisture test 2	85°/85%RH, 1000 h	Within specifications: |ΔC/C| < 1,5% (at 0%RH, 50%RH and 85%RH) ; |ΔR25/R25| < 0,06%; |ΔTk/Tk| < 0,4 %
Substrate bending test	AEC Q200-005	Qualified
Bond tests	AEC Q100 test C1&C2	Qualified
Terminal strength	AEC-Q200 test 22	Qualified

6.1 Test procedure

E+E standard measurement for the humidity sensor element is done according to the following procedure:
Basic treatment 2 hours at 150°C, followed by 24 hours at 30%RH and 80±5% RH. Measurement at T_{ref}=30%RH, measuring points at the following humidities: 0% RH, 15%, 25% 35%, 45%, 50%, 55%, 65%, 75%, 85%, 95%, 85%, 75%, 65%, 55%, 50%, 45%, 35%, 25%, 15% , dwell time 1 hour for each humidity.

Standard failure criteria for environmental tests:

Humidity sensor: ΔC/C @ 0%, 50% and 85%RH <0,75% and for high humidity tests (moisture test 1 & 2) 1,5% respectively.

Temperature sensor Mo3k: |ΔR25/R25| < 0,06%; |ΔTk/Tk| < 0,4 %

7 Circuits

Depending on accuracy requirements and existing electronics, various cost-effective evaluation circuits are available.

The following diagram provides a general overview of the possible solutions.

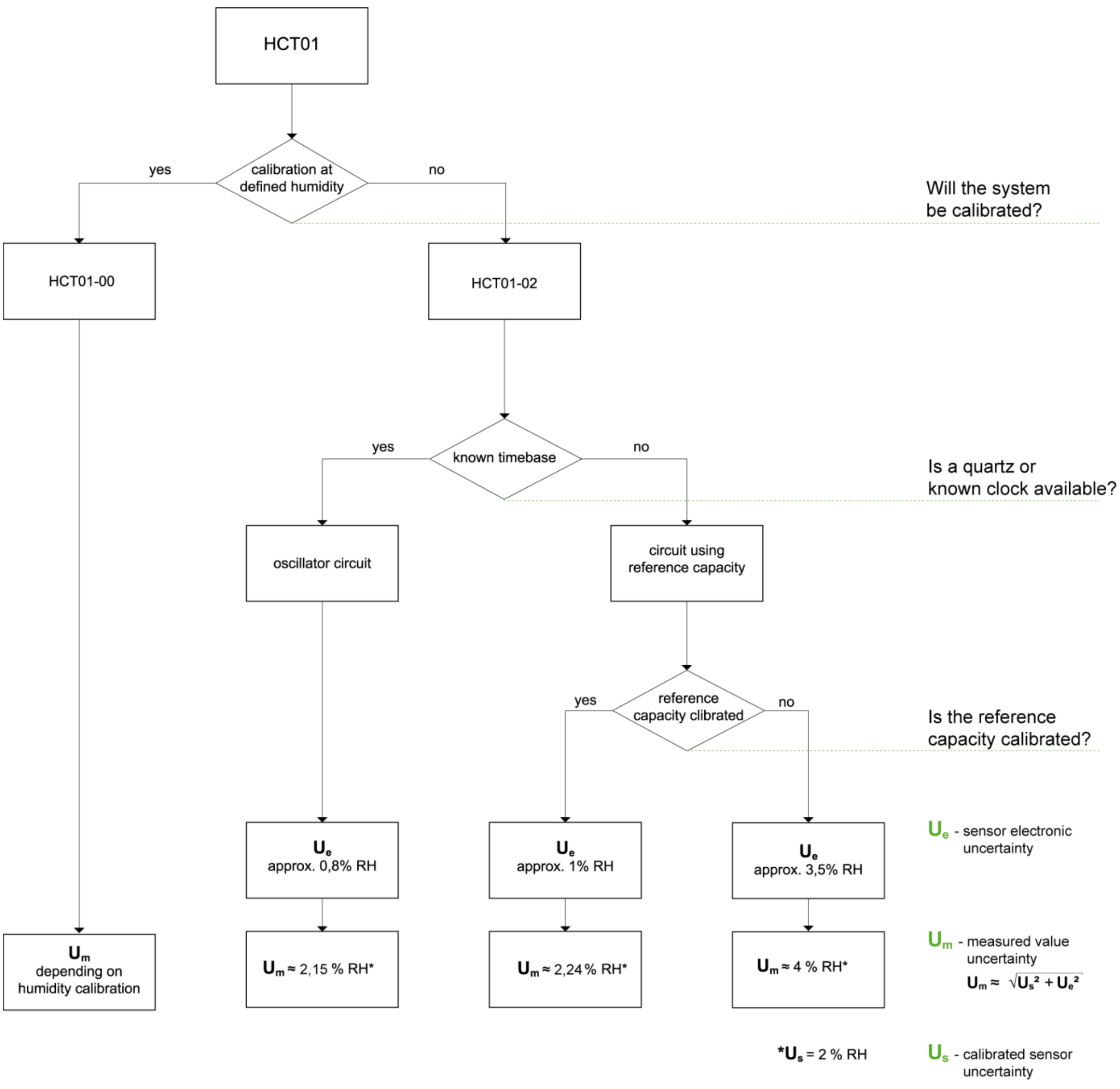


Figure 17: Possible HCT01 circuits

Schematic circuit configurations can be downloaded from www.epluse.com/hct01

8 Sample boards

On request there are two different sample boards available:

- Board with frequency output signal
- Board with microcontroller circuit

9 Contact information

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Revision history

Date	Revision number	Changes
21.11.2011	V_0.4	Major revision