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Users Manual

Humidity sensor NHS-12

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Contents:

1) What is humidity sensor?

Humidity is one of the most common factors, as well as temperature, that exist in the atmosphere. There have been various ways to measure the humidity. For instance, a hygrometer using a hair has been used for a long time by making use of its properties that expends and shrinks by absorbing and releasing moisture. As a dew indicator that optically detects a dew point can accurately detect humidity, it is used for measuring equipment. The former method is simple and convenient, but cannot accurately measure humidity; in addition, the response speed is very slow. The latter method is accurate but expensive and large-sized.

Electronic type of humidity sensors are recently getting popular because of the low cost and the relatively accurate & reliable performances. These electronic types of humidity sensors are classified into several kinds.

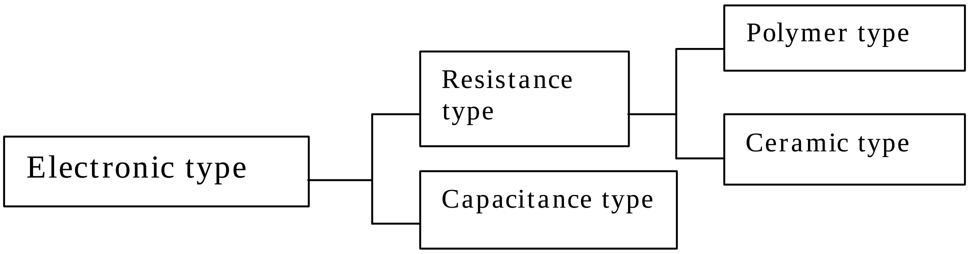


Fig. 1-1 Classification of electronic type humidity sensors

Electronic type humidity sensors are roughly classified into two groups according to the humidity detection methods, resistance value alteration type and inductive capacitance alteration type. The resistance type sensors are classified into further two groups by the materials used for detection, polymer type and ceramic type.

Resistance type sensors have a simple structure and the best cost merit. Especially polymer type sensors, because of the superiority in the performances and reliability, are widely used for portable hygrometers, residential air conditioners, humidifiers, dehumidifiers, and humidity control units for commercial air conditioners. Ceramic type sensors detect humidity, as same as polymer type sensors, by measuring the alteration of impedance caused by the absorption of moisture, but are out of market now because of the hysteresis of moisture absorption/adsorption on the ceramic surface and the deterioration tendency as time passes.

Capacitance type sensors consist of a material which dielectric constant varies by humidity absorption, and the material is sandwiched by the two electrodes in order to detect humidity by variations of inductive capacity between the two electrodes. This detection method can accurately measure the humidity levels in wide ranges from low to high because the humidity levels are proportional to the inductive capacity. The capacitance type sensors are used mainly for measuring equipment, but have a complicated structure compared with the resistance type sensors, and need difficult production technologies. This type of sensors is rarely used for domestic appliances because of the high cost and the complicated application circuit.

Nemoto's NHS-12 is a resistance type sensor, but can measure a wide range of humidity. This innovative sensor is widely used also for applications that require accurate measuring results.

2) Features of NHS-12

Up to now, users have been using polymer type humidity sensors with concerns about their durability and reliability. It is because current polymer-type humidity sensors are made of a hydrophilic polymer film, and users are uncertain of its durability under high temperature/humidity or dew-condensation conditions as well as the resistivity to organic solvents and harmful noise gases.

Nemoto's **NHS-12** has repelled such concerns of users. NHS-12 shows excellent stability under high temperature/humidity conditions compare to other polymer type humidity sensors. NHS-12 shows also excellent resistivity to organic solvents like acetone and alcohol, and to acidic gases like NOx and SOx, as well as to alkali gases like ammonia. Users will enjoy its reliability for a long time of period.

In addition, NHS-12 has lower impedance and is less affected by temperature. These features enable to measure a lower humidity range than 20% RH that could not be accurately measured before by conventional resistance type humidity sensors.

3) Applications of NHS-12

The accurate and reliable sensor, **NHS-12**, can be used for a wide range of products that require humidity control functions. The following are application examples.

1) Humidity controlling unit for residential appliances such as **air conditioners, humidifiers, dehumidifiers, ventilation fans** that require durability and reliability.
2) Humidity controlling unit for **greenhouses** at high temperature/humidity.
3) Portable **hygrometer** that must be of best cost performances.
4) **Copy machine** that must work in a wide range of temperature/humidity.

The following products are also available.

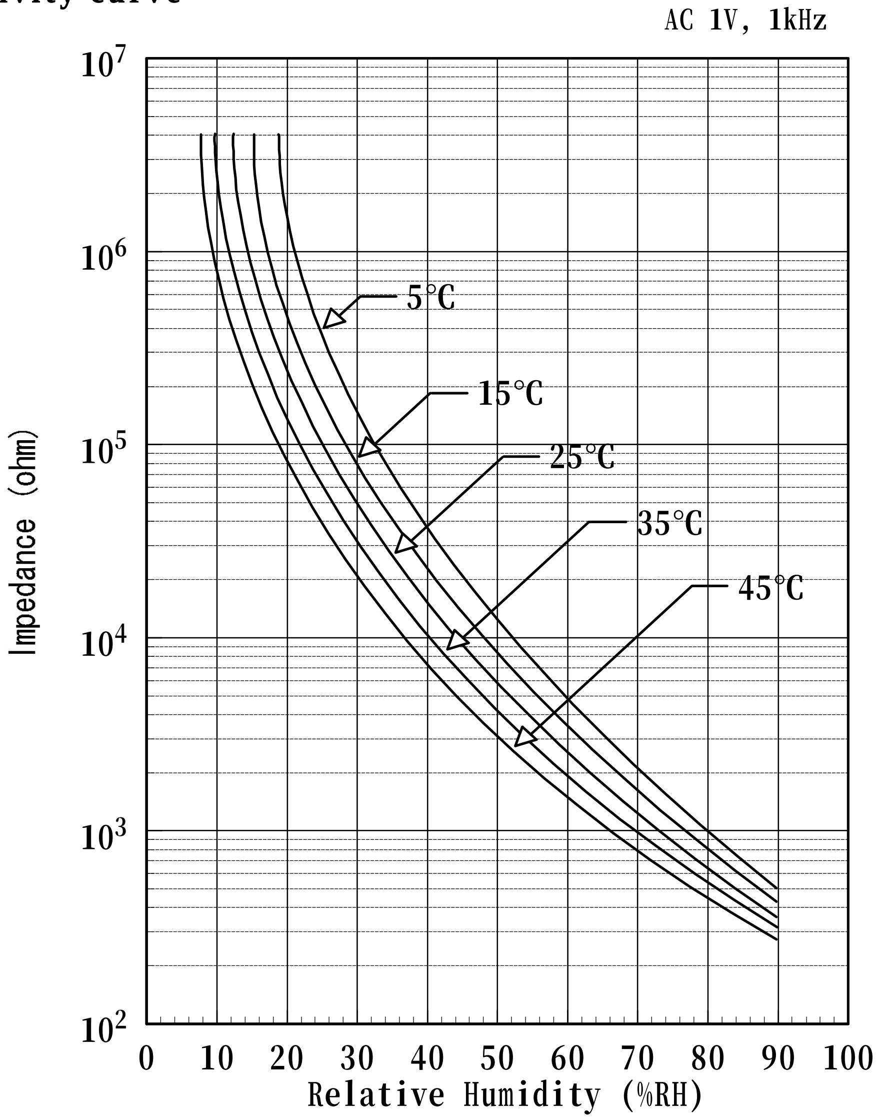
- * **NHS-12F**: Flexible lead wires are provided to enable to measure humidity in the area far from the PCB.
- * **NHU series**: Small sized humidity detection units with NHS-12 mounted on a basic control circuit that enables DC input - DC output.

4) Specifications of NHS-12

(4-1) Specifications

Supply voltage	AC 1V (Sine or square wave)
Rated power consumption	**2** mW
Operational humidity range	10 ~ 90% RH
Operational Temperature range	0 ~ 60°C
Humidity range for storage	-20 ~ 60°C
Frequency	500Hz ~ 2kHz（1kHz recommended）
Guaranteed impedance	6 KΩ（25°C, 50 ± 5% RH）

(4-2) Sensitivity curve



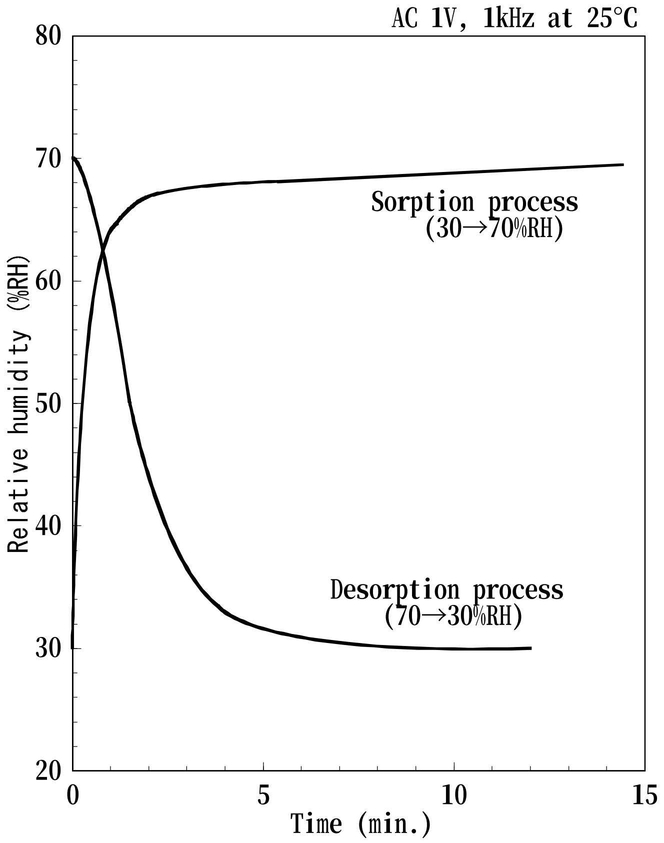
(4-3) Data table

Typical data of NHS-12

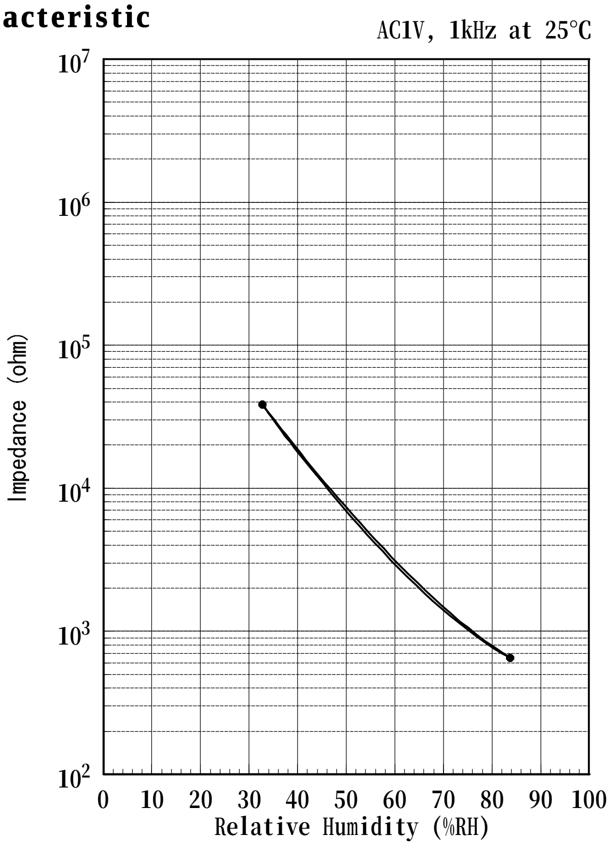
AC1V, 1kHz Unit: KΩ

	5 °C	10 °C	15 °C	20 °C	25 °C	30 °C	35 °C	40 °C	45 °C
10%RH	—	—	—	—	—	—	3900	1500	840
15%RH	—	—	4800	1800	900	590	410	280	200
20%RH	1700	930	520	350	250	180	140	105	81
25%RH	390	270	185	140	105	82	64	51	41
30%RH	155	115	84	65	51	41	33	26.5	22
35%RH	74	56	43	34	27.5	22	18	15	12.5
40%RH	40	31	23.5	19.5	16	13	11	9.1	7.7
45%RH	21.5	17	14	11.5	9.5	8.0	6.6	5.7	5.0
50%RH	13	10.5	8.6	7.2	6.1	5.1	4.4	3.7	3.2
55%RH	7.9	6.6	5.5	4.7	4.0	3.4	2.9	2.5	2.2
60%RH	5.1	4.3	3.7	3.1	2.7	2.3	2.0	1.75	1.55
65%RH	3.3	2.8	2.45	2.15	1.85	1.6	1.4	1.25	1.1
70%RH	2.2	1.85	1.6	1.4	1.25	1.1	0.99	0.89	0.81
75%RH	1.5	1.3	1.15	1.0	0.90	0.81	0.73	0.67	0.61
80%RH	1.05	0.92	0.81	0.73	0.66	0.60	0.55	0.51	0.47
85%RH	0.71	0.64	0.58	0.53	0.48	0.44	0.41	0.38	0.35
90%RH	0.50	0.46	0.42	0.38	0.35	0.33	0.31	0.29	0.27
95%RH	0.35	0.32	0.30	0.28	0.26	0.25	0.24	0.22	0.21

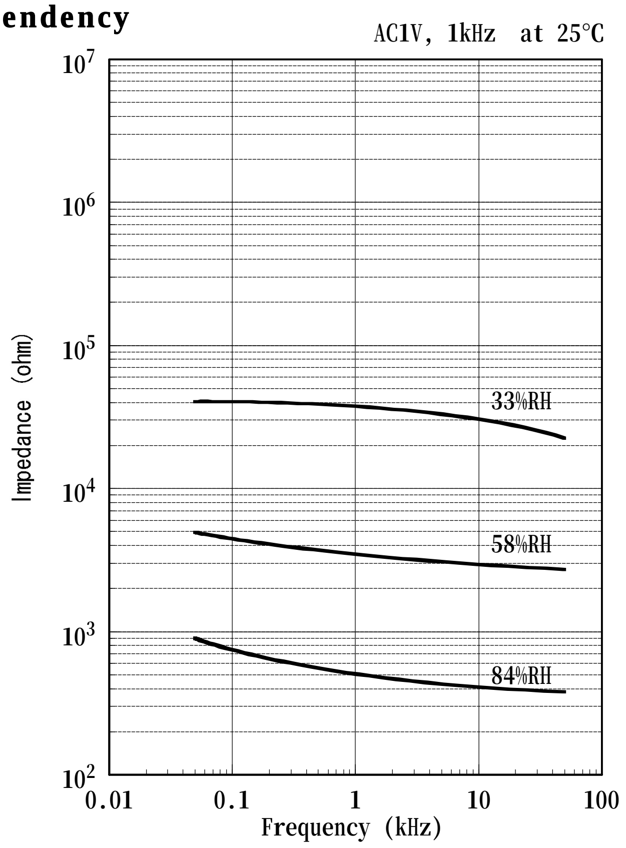
(4-4) Response/Restoring characteristics



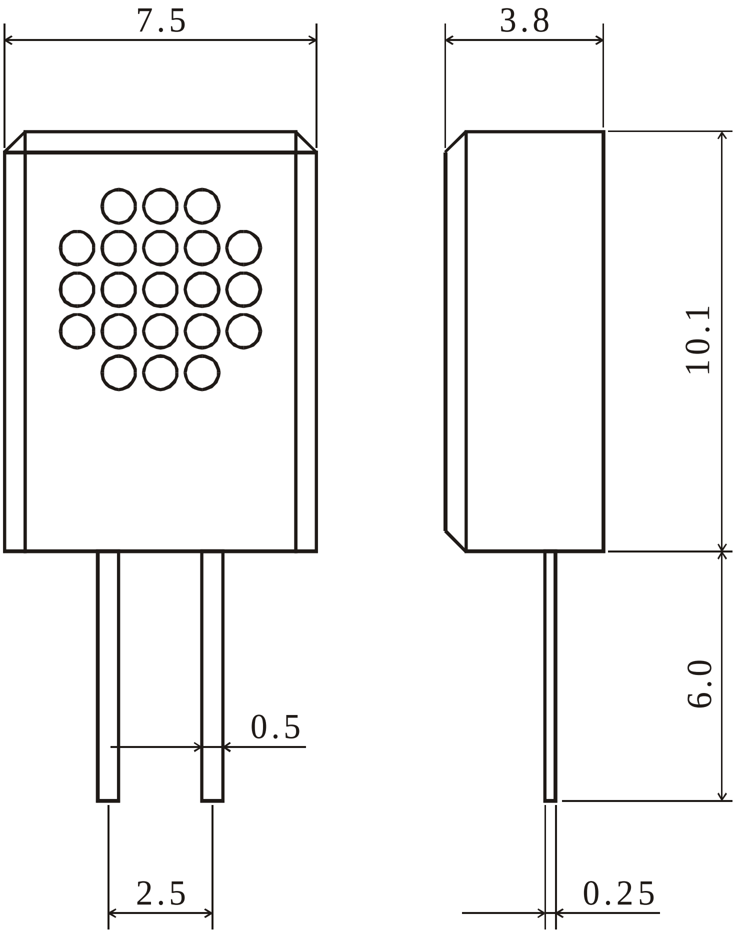
(4-5) Hysteresis characteristic



(4-6) Frequency dependency



(4-7) Dimensions



Unit: mm

Material of case	ABS
Pins	Phosphoric bronze, soldered

5）Reliability tests

Test conditions: After exposed to the following atmospheres, NHS-12 was taken out and left in room conditions for 60 minutes. Then the resistance value was measured under 25°C and 50% RH. The following tables show the variations before and after tests.

(5-1) Weatherability

High temperature test (80°C, 1,000 hrs.)	< ± 1% RH
Low temperature test (-20°C, 1,000 hrs.)	< ± 2% RH
High Temp./humidity test (60°C, 90%RH 1,000 hrs.)	< ± 3% RH
Low humidity test (25°C, <15%RH 1,000 hrs.)	< ± 2% RH
Energized in high temp. (80°C, AC 1V, 1 KHz, 500 hrs.)	< ± 1% RH
Energized in high temp./humidity (60°C, 90%RH, AC 1V, 1 KHz, 1,000 hrs.)	< ± 1% RH

(5-2) Atmosphere tests

Methanol (Conc. 1%, 100 hrs.)	< ± 1% RH
Ethanol (Conc. 1%, 100 hrs.)	< ± 3% RH
Ammonia (Conc. 1%, 100 hrs.)	< ± 2% RH
Acetic acid (Conc. 1%, 100 hrs.)	< ± 1% RH
Mixed solvents (Benzene 3 : Toluene 3 : Xylene 4, saturated 100 hrs.)	< ± 1% RH
H_2S (Conc. 200 ppm, 20 hrs.)	< ± 1% RH
Acetone (Conc. 1%, 100 hrs.)	< ± 1% RH
SO_2 (Conc. 200 ppm, 20 hrs.)	< ± 2% RH
Cigarettes (2 pcs./18 litter2, 25 hrs x 2 times)	< ± 2% RH

(5-3) Physical properties

Drop test (Dropped onto wooden plate from a height of 1m 3 times)	Passed
Vibration test (Amplitude of 5mm, X, Y, Z directions 10Hz for 20 min.)	Passed
Tensile strength of lead wire (Pulled with 1 Kg. load for 10 seconds.)	Passed
Lead wire vending test (Lead wire was vented to 90 degrees with 250g load, and vented again to opposite direction.)	Passed

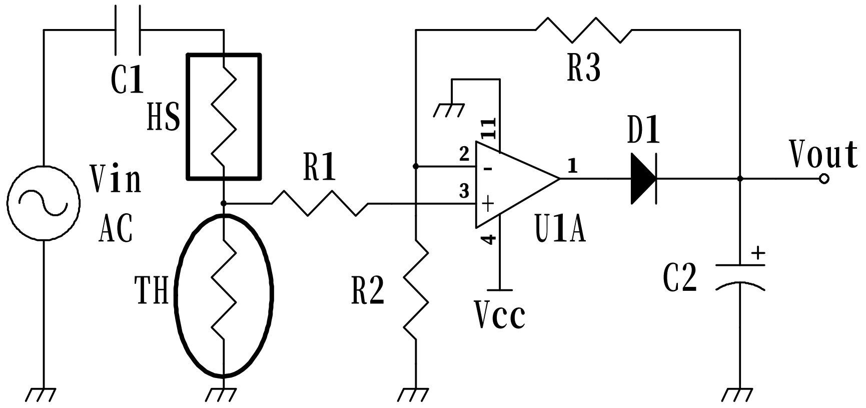
6) Circuit designing

(6-1) Basic circuit and output characteristic

NHS-12 is operated by AC with a frequency around 1 KHz. The impedance of humidity sensors exponentially varies as humidity varies, and the sensor is dependent to temperature. Therefore, for the most accurate measurement results, some additional circuits would be required such as temperature compensation circuit, linearizing circuit, etc. By using such additional circuits, linearized outputs can be obtained from low (10%RH) to high (90%RH) humidity ranges. Please refer to **(6-2) Designing of measuring circuit** for detailed information.

For applications that do not require very accurate measurement in a wide humidity range, NHS-12 practically works with the following simple circuit having just a temperature compensation circuit.

In order to compensate the temperature dependency of a humidity sensor, there are two methods; Either **making use of the fact that the current of a diode has temperature dependency** or **making use of the temperature characteristic of NTC thermistor.** In case that a humidity sensor has too large temperature dependency, the former method can not be used. However, it is extremely difficult for users to select a diode that is matched with the humidity sensor, and even if a matched diode has been selected, the diode may often become discontinued. Whereas, selecting a matched thermistor for NHS-12 is very easy. Users can pick up one that has a B constant matched with the temperature dependency of NHS-12. **NHS-12 has smallest temperature dependency that allows users to take a universal type thermistor having 3,500 - 4,000 of the B constant in order to compensate the temperature dependency.**



U1	2902	C2	22μF／16V
R1	10 kΩ	D1	1SS133
R2	6.8kΩ	HS	NHS－12
R3	10 kΩ	TH	R_{25} = 10kΩ, B = 3435k
C1	0.1μF	Vin = 1V_{RMS} 1kHz	

Fig. 6-1 Basic operational circuit

The most basic circuit using a thermistor is shown in Fig 6-1, and output characteristic when the basic circuit is used is shown in Fig 6-2. As this circuit does not have a logarithmic conversion circuit, the lower output is obtained in the lower humidity range and the output is saturated in the higher humidity range. This circuit may not be good to cover from low to high humidity ranges, but can be practically used for a simple control unit that requires to measure humidity only in the range of 40%RH - 80%RH. But as the outputs are in an S-shaped curve that is hard to be linearized, this circuit may not be not good for measuring equipment like hygrometers. Temperature compensation circuit for hygrometers is shown in **(6-2)**. The output level of the circuit can be adjusted by replacing R1, R2, and R3.

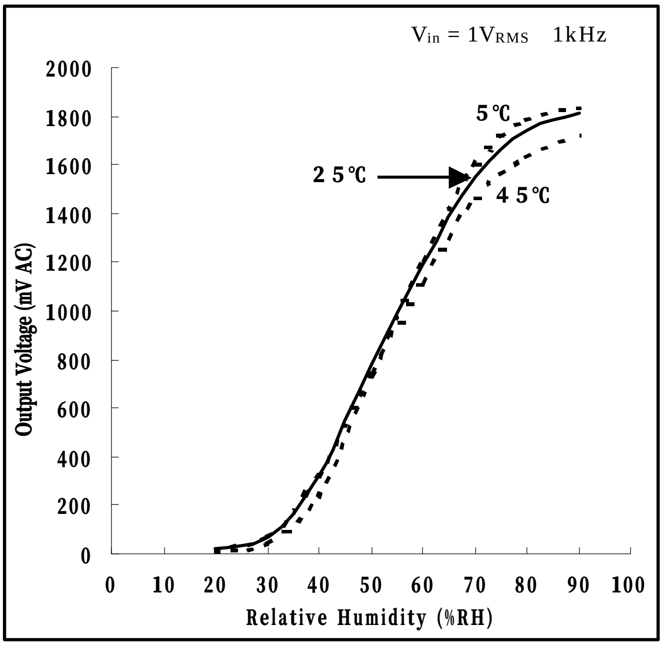


Fig. 6-2 Output characteristic

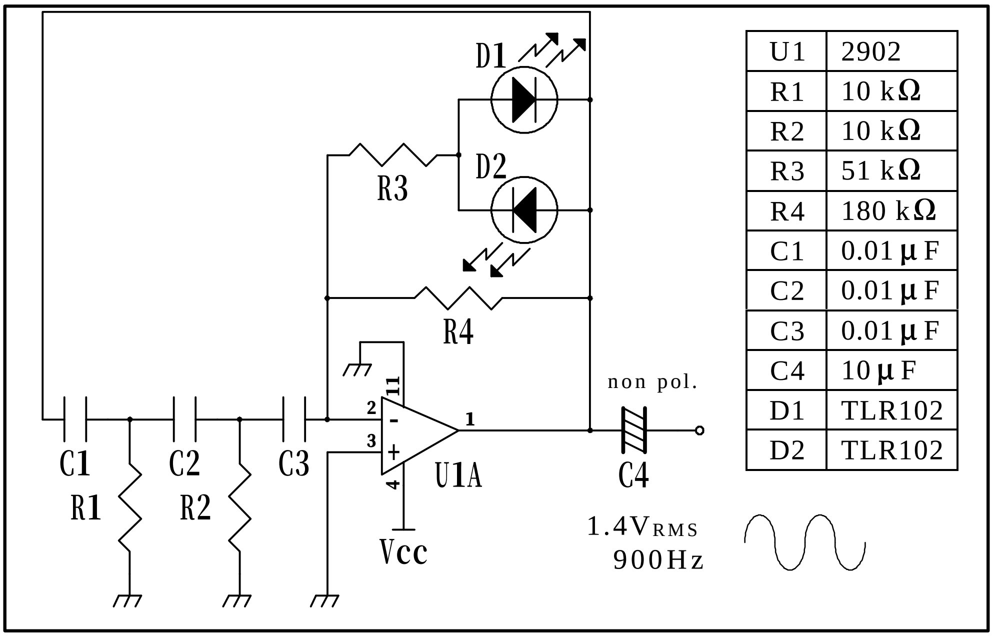
(6-2) Humidity measuring circuit

(6-2-1) Oscillation circuit

Incorrect supply voltage may affect to the life and stability of a humidity sensor. Therefore attention must be paid to correct supply voltage upon designing a circuit. The ideal AC current to be supplied to the sensor is the one with sine wave. Too high supply voltage would affect to the stability and too low voltage would cause problems on the circuit designing. In case of NHS-12, 1 V_{RMS} should be the best. The circuit diagram which creates sine wave by using LEDs is shown in Fig. 6-3.

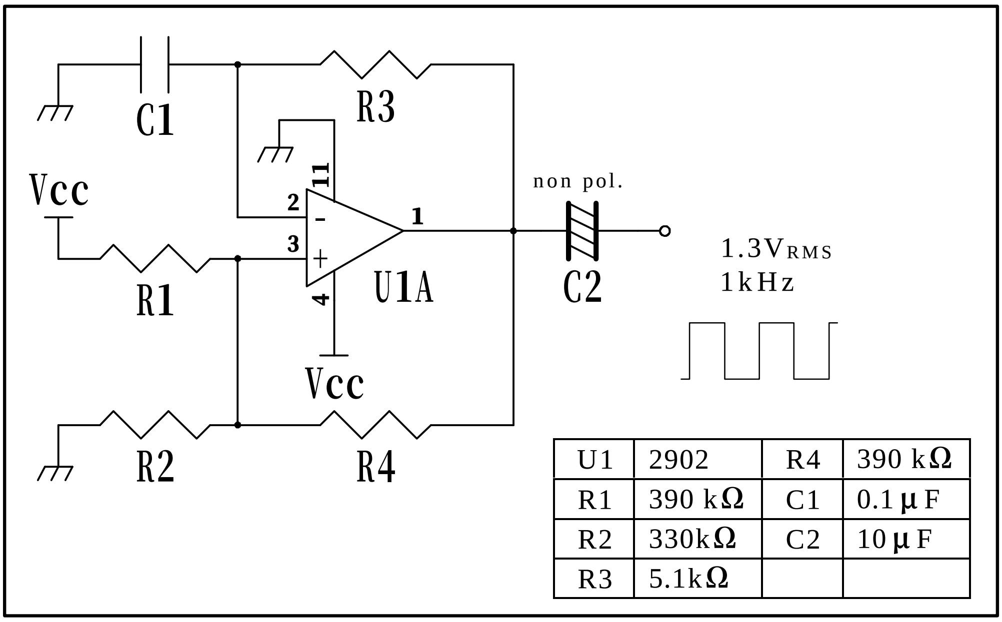
In case that a square wave is supplied, the duty ratio must be symmetric when 0 V is put in the center. Fig 6-4 shows a circuit to generate such a square wave.

When AC containing a tiny DC (even 10 mV) is supplied to the sensor, it may cause a shorter life of sensor. It is recommended to remove a DC part contained in AC.



U1	2902
R1	10 kΩ
R2	10 kΩ
R3	51 kΩ
R4	180 kΩ
C1	0.01 μF
C2	0.01 μF
C3	0.01 μF
C4	10 μF
D1	TLR102
D2	TLR102

Fig. 6-3 Oscillation circuit (Sinusoidal oscillation)



U1	2902	R4	390 kΩ
R1	390 kΩ	C1	0.1 μF
R2	330kΩ	C2	10 μF
R3	5.1kΩ		

Fig. 6-4 Oscillation circuit (Square oscillation)

In the above circuit, output voltage can be adjusted by changing the resistance value of R1. However, when the difference between R2 and R3 gets bigger, the performances get instable and it becomes difficult to obtain symmetric square wave. The following formula represents the oscillation frequency "f" of this circuit.

$$f = \frac{1}{2C1 \cdot (R3) \cdot \ln \cdot (1 + (2 \cdot (R2)/(R1)))}$$

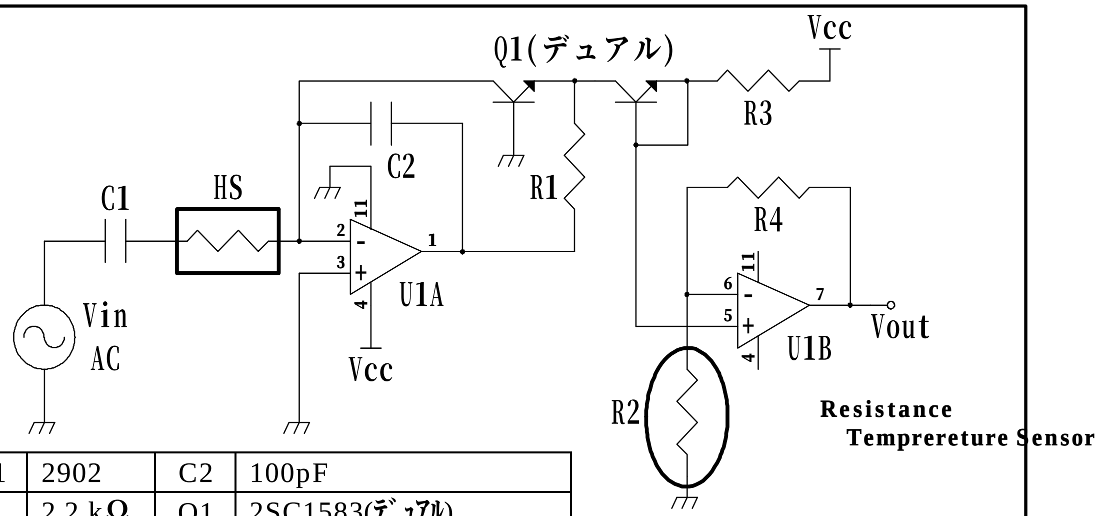
As shown in **(4-6)**, relatively flat impedance characteristic is obtained in the range from 500 Hz to 2 KHz. In the area lower than 500Hz, the frequency dependency of impedance is getting bigger in a higher temperature range, and in the area greater than 2 KHz, on the contrary the frequency dependency is getting bigger in a lower humidity range. Therefore an oscillation circuit should be designed to have NHS-12 work in the range of its operational frequency.

NHS-12 shows the best performances in a circuit designed with the recommended frequency, 1 KHz.

(6-2-2) Circuit for logarithmic conversion

The impedance of humidity sensor logarithmically varies as humidity varies. It therefore is required to logarithmically convert the output voltages, otherwise smaller outputs are obtained in a lower humidity range and saturated outputs in a higher humidity range. (S-shaped output curve)

Fig. 6-5 shows a circuit for logarithmic compensation to linearize the S-shaped output curve. This circuit is to convert the outputs to the ones that can be easily read. In this circuit, R2 works to stabilize the circuit by canceling a drift by temperature.



U1	2902	C2	100pF
R1	2.2 kΩ	Q1	2SC1583(ﾃﾞｭｱﾙ)
R3	50kΩ	HS	NHS−12
R4	15 kΩ	R2	R_{25} = 1kΩ, ±0.3% / ℃
C1	1 μF	Vin = 1V_{RMS} 1kHz	

Fig. 6-5 Logarithmic conversion circuit using transistor

There is another **conversion circuit using diodes**. This method is simpler than the above method using a transistor, and is commonly used because a fewer number of components is required to get relatively better performances. Fig. 6-6 shows a circuit for logarithmic conversion using diodes. Fig. 6-7 shows the output results from this circuit. In comparison with the Fig. 6-2, the output curve in the low and high humidity ranges is compensated to a more linear curve. But, please pay attention that the temperature dependence of diode affects output signal.

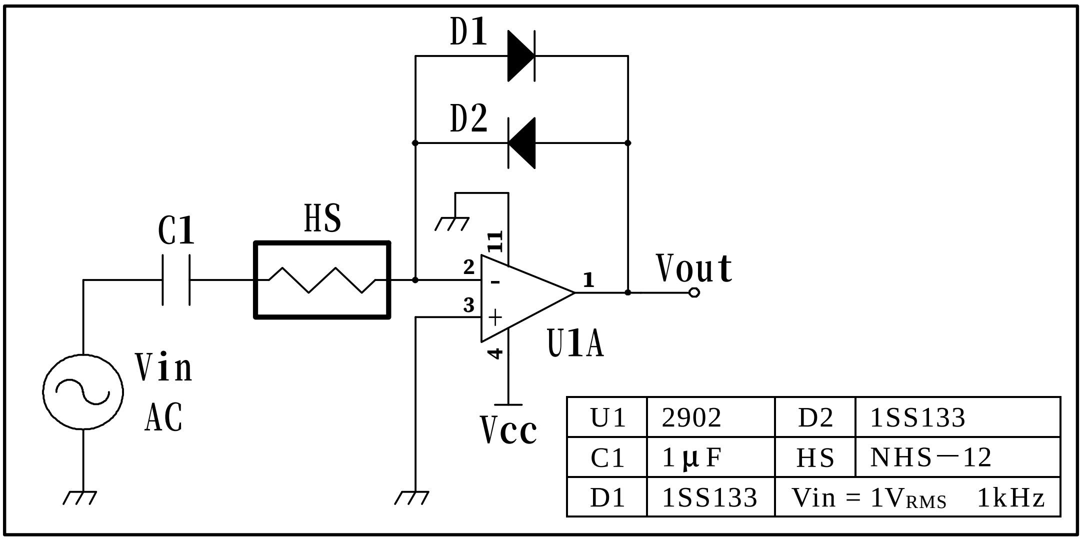


Fig. 6-6 Logarithmic conversion circuit using diodes

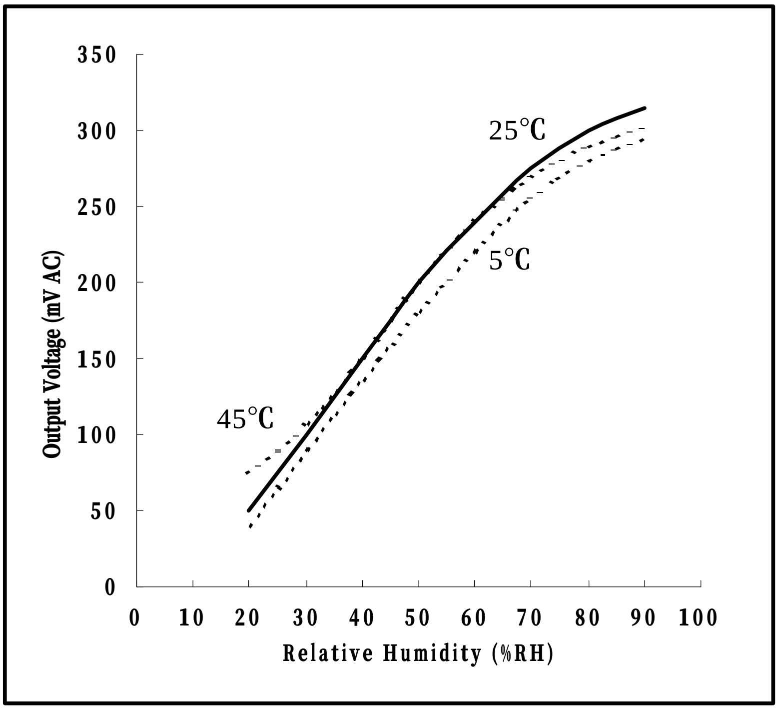
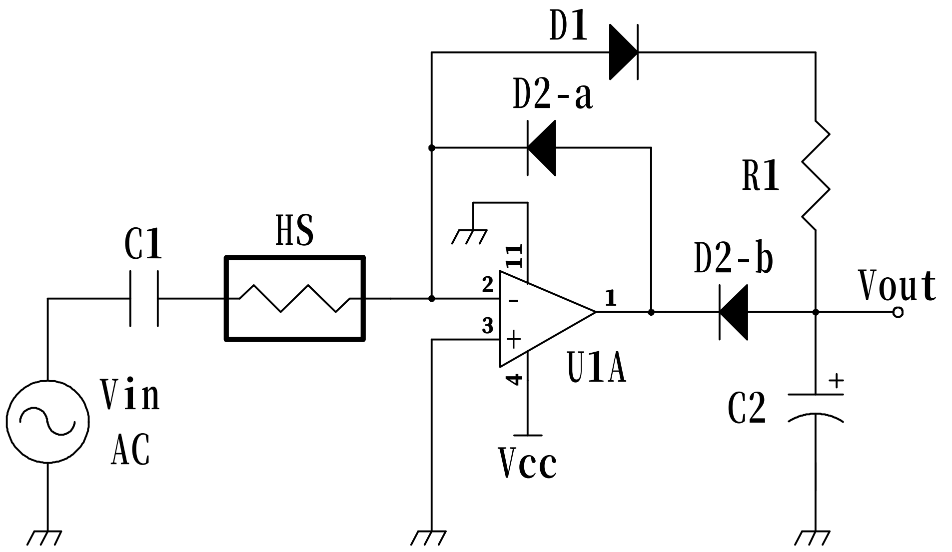


Fig. 6-7 Compensated output curve

(6-2-3) Temperature compensation circuit

Humidity sensors (regardless of manufactures) have own temperature dependency, and need an appropriate temperature compensation circuit. Fig. 6-1 shows the most basic compensation circuit, but for more accurate measurements, it is very useful method that the order direction current of diode normally has temperature dependence as described in item (6-1). For example, the circuit diagram specified in Fig.6-8 shows the temperature compensation by using D1 in logarithmic conversion circuit which is described in item (6-2-2).

In this circuit, the current is adjusted by the value of R1 in order to obtain more accurate temperature compensation and revise the linearity. And, for restraining ripple voltage which generates when the alternating current is changed to the direct current by rectification circuit, C2 requires to some extent large capacitance.



U1	2902	C1	1μF
R1	300Ω	C2	10μF／10V
D1	HSM123	HS	NHS−12
D2	HMS123	Vin = 1V_{RMS} 1kHz	

Fig. 6-8 Temperature compensation circuit

(6-2-4) Calibration and evaluation of outputs

It would be a time-taking job to calibrate or evaluate a circuit using a standard humidity generated in your labs. Usually calibration or evaluation of a circuit is done using dummy signals obtained by putting a resistor instead of a humidity sensor.

Firstly, from the data table 4-3 (Basic characteristics of NHS-12), impedance values are selected that are equivalent to humidity ranges you want to calibrate or confirm. In case you want to confirm outputs in the range from 30%RH to 70%RH under 25°C, you take the impedance values of NHS-12, i.e. 51 KΩ at 30%, 6.1 KΩ at 50%, and 1.25 KΩ at 70% from the date table. Secondly a resistor equivalent to the impedance value (≤ ± 1%) is put in the circuit instead of the sensor, then output voltage is measured.

When the circuit shown in Fig. 6-5 is used, the following outputs are obtained; 100mV at 30%RH, 200mV at 50%RH, and 275mV at 70%RH under 25°C. By using the dummy resistors, you can confirm whether your circuit works correctly or not.

In case you want to change the output characteristics, you can adjust the circuit constant during a dummy resistor is put in your circuit, then obtain desirable output curve.

(6-3) Model circuit using NHS-12

Fig. 6-9 shows a **Model circuit using NHS-12** adapting the above techniques, and the output characteristic from this circuit is shown in Fig. 6-10.

This circuit compensates the output curve shown in the Fig. 6-7 (Linearity is lost in the higher range than 70%RH.) by additional current adjustment of R1 specified in Fig. 6-8 and suitable balance of circuit constant in an amplification circuit. Thus accurate measurement can be done in the wide range from low (20%RH) to high (90%RH) humidity.

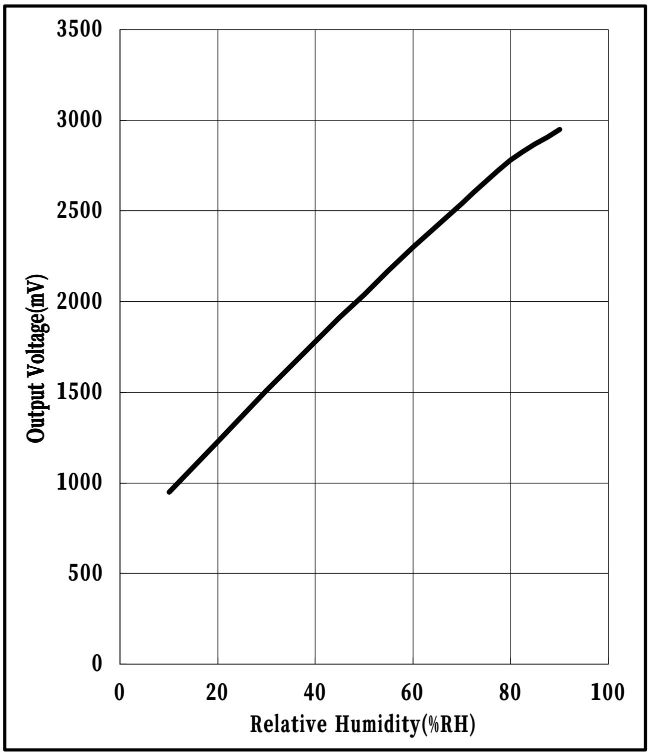


Fig. 6-10 Output characteristics of Model circuit

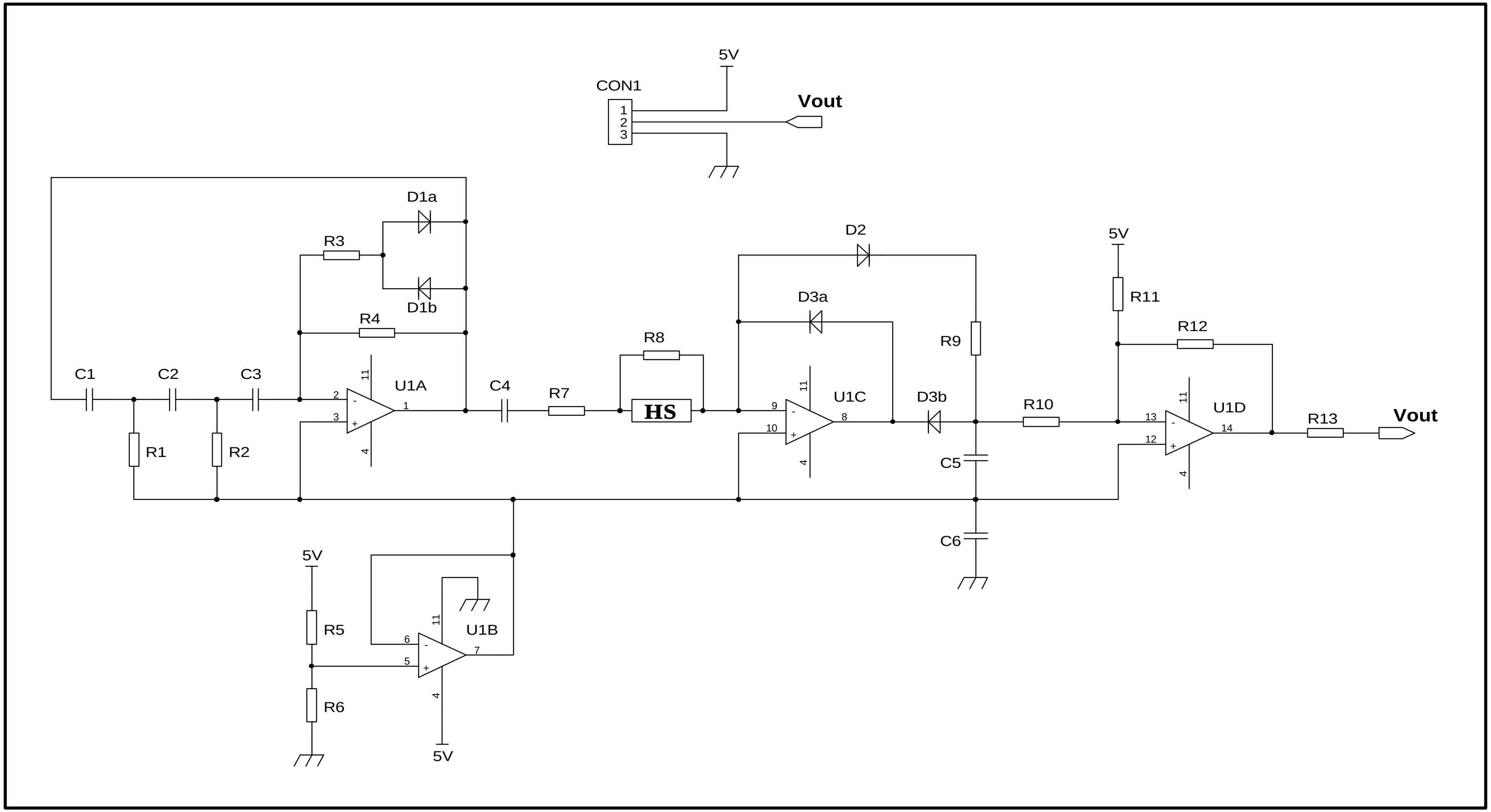


Fig. 6-9 Model circuit using NHS-12

(6-4) For higher accuracy

The model circuit shown in **(6-3)** should be accurate enough (≤ ± 5%) for residential hygrometers or humidity controllers. However when more accurate measurement is required, multiple approximation methods should be required for linearizing the output. For this purpose, more complicated circuits would be required. This users' manual does not include information on such circuit.
You may find a suitable circuit in reference books for circuit designing. Or technical advices will be given by us upon request.

7) Mounting NHS-12 onto devices

Mounting or assembling a sensor onto a device may affect not only to the basic features of the device but also to the sensor life. Mounting or assembling method is a very important point in manufacturing reliable quality devices.

(7-1) Mounting onto various devices & appliances

(7-1-1) Onto air conditioner

There are two ways to assemble a sensor in air conditioners; To locate a sensor in the air stream, or to locate independently outside of the air stream. And each method has merits and demerits.

In case of location in the stream of sucked air

The merit is faster response because the sensor is in the stream, and more accurate humidity detection is possible by direct measurement.
Demerit is contamination on the sensor surface because the sensor is always exposed in the air flow. In the worst case, a sensor in the air flow may have a shorter life compared with the one located outside of the air flow. In addition, the sensor detects only the humidity of the sucked air itself but may not detect the humidity of the overall air in the room where the air conditioner is installed.

Fig. 7-1 shows the recommended positioning of sensor when it is put in an air stream. By **putting the back face of sensor against air flow**, contamination on the front face of a sensor by cigarette smoke etc. can be minimized.
Even if the sensor is positioned like this, it would not affect to the sensitivity and response characteristics of **NHS-12**.

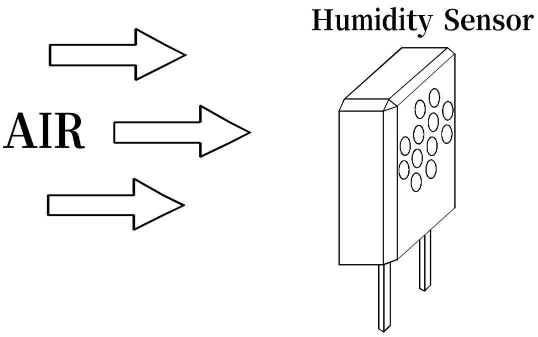


Fig. 7-1 Positioning of sensor

In case of location out of the stream of sucked air

This method lessens much the possibility of contamination on the sensor surface. Therefore relatively longer life is expected, but it may take a longer response time.

Fig. 7-2 shows a location of sensor that improves the response speed.
A sensor is to be located near the air-sucking openings.
It is also possible to mount a sensor outside of an air conditioner, for instance in the remote controller, to prevent contamination and for faster response speed.

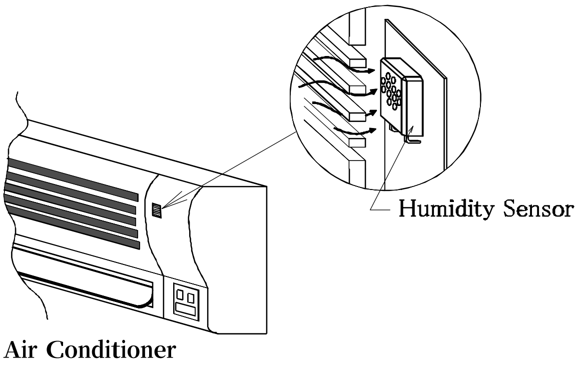


Fig. 7-2 Mounting onto to air conditioner

(7-1-2) Mounting to dehumidifiers

As same as air conditioners, there are two ways to assemble a sensor in dehumidifiers. The merit and demerit are the same as the case of air conditioners. The most appropriate location is to be determined depending on applications and required performances of your final products.

(7-1-3) Mounting onto humidifiers

In case of regular humidifiers, air sucked from outside is blown out of a steam outlet through the main body of the apparatus where controlling PCB is assembled in. For humidifiers of this system, a sensor is to be directly mounted on the PCB. The back surface of the sensor is to be positioned against the air flow for the longest possible life.

Humidifiers and dehumidifiers have a water tank that is taken out and put in when necessary. Attention must be paid to the sensor location so that a sensor does not get wet by water. Even if a sensor is not mounted on the PCB, it is to be located in a place where does not get wet by water or steam.

(7-1-4) Mounting onto Automatic ventilator

Ventilators to be installed in kitchens and rooms can also be automatically controlled using NHS-12. In this case, the air inlet is much larger than the one of air conditioners, humidifiers, or dehumidifiers. Therefore the possibilities of the contamination by sucked air would become much larger when a sensor is exposed directly to the air flow. You are recommended not to place a sensor in the air flow, but to put it on the PCB or in the location shown in the Fig. 7-3. The best location would be near an opening at a corner where is not near to the fan. The front surface of a sensor is to be faced to the opening.

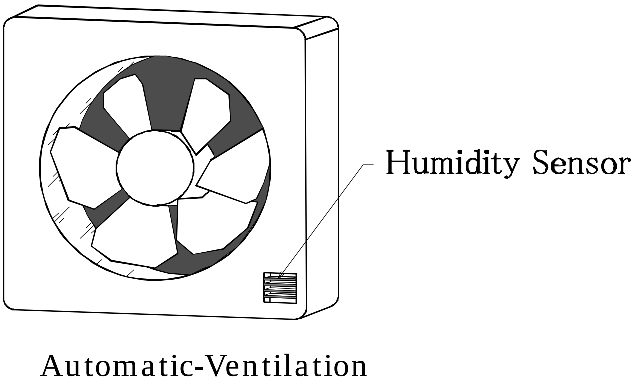


Fig. 7-3 Location of NHS-12 on automatic ventilator

(7-2) Extension of sensor wiring

It is recommended to mount NHS-12 directly onto a PCB. But in some cases it may be required to locate the sensor with a distance from the PCB. In such a case the sensor and the PCB must be connected with signal wires.

As NHS-12 puts out low impedance even in the lower humidity range, such extended wiring does less affect to the performances.

However please note the following.

a) When highly accurate measurement results are required, please use shielded wires.

b) It is not necessary to use shield wires if the signal wires are shorter than 150 cm and the target detection range is more than 40% RH.

c) Even if the target detection range is less than 40% RH, it is unnecessary to use shield wires if the wires are shorter than 50 cm. However shielded wires should be used if the length is more than 50 cm. In this case, the maximum wire length must be less than 100 cm.

d) In the detection ranges which impedance is more than 1 KΩ, the impedance may be affected by noise signals and extended wiring. Therefore please confirm that the output characteristic is not affected even if the length is within the ranges mentioned in above b) and c).

8) How to generate standard humidity

Japan Industrial Standard **J7920 (Hygrometer - Test methods)** specifies two basic methods, "Separation Method" and "Saturated Salt Solution Method".

Constant humidity generators using the Separation Method are available on the market. The Saturated Salt Solution Method would be the simplest and least-expensive method to obtain Standard Humidity if the salt solutions are properly handled. Therefore this brochure illustrates only the basic principle of Separation Method, but detailed explanations of Saturation Salt Solution Method so that users can evaluate or inspect their products using the Saturation Salt Solution Method in their labs.

(8-1) Separation Method

As shown in Fig. 8-1, dry air is separated into two flows. One flow passes through a chamber that is saturated with water vapors, and is mixed with the other flow at a designated ratio in order to obtain a designated humidity.

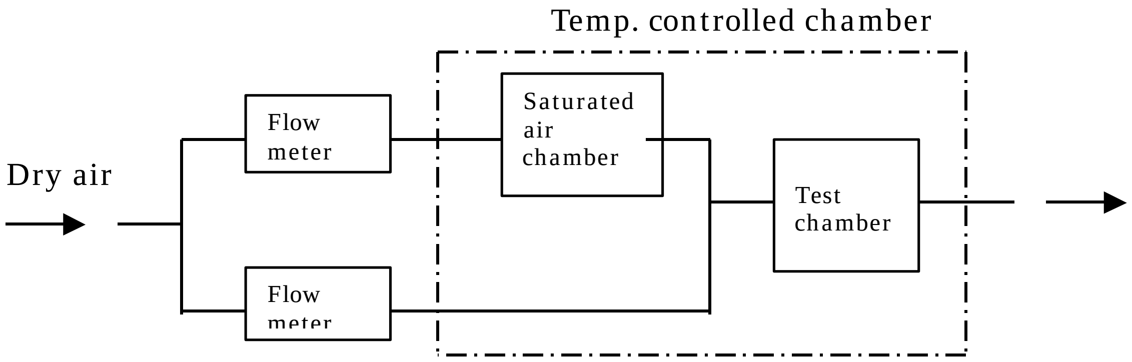


Fig. 8-1 Principle of Separation Method

In this method, it is required to severely control the temperature, saturation condition in the saturated air chamber, constant air flow, constant air pressures in both of the saturation and test chambers, and accurate mixing ratio of dry and wet airs. Accurate and constant temperature control is required also in the temperature controlled chamber. For this purpose, generally a water bath is used for controlling temperature in the range of 50°C or more, and an oil bath in the range less than 50°C. In order to maintain the temperature range of 0 ~ 20°C, the original air should be cooled down using a cooling apparatus.

The relative humidity generated by this method can be calculated using the following formula.

$$U = \frac{P_t \cdot \gamma}{P_5 - (1 - \gamma) \cdot e_5} \times 100\ (\%)$$

U : Relative humidity (%)
P_t : Pressure in test chamber
P_5 : Pressure in saturated air chamber (Pa)
γ : Ratio of dry air and total air quantity (Separation ratio)
e_5 : Saturation vapor pressure in saturated air chamber

Constant humidity generators using separation method would cost about US$16,000 ~ 63,000 depending on functions and specifications.

(8-2) Saturated Salt Solution Method

Relative humidity of the air that is balanced with the saturated salt solution can be determined by the kind of salt and the atmospheric temperature. Therefore a designated humidity can be obtained by constantly keeping the temperature of the whole chamber containing a saturated solution of a salt. General users **can easily generate a very accurate (within ± 1%RH) humidity** with simple apparatus as they properly handle a saturated salt and accurately control the temperature.

(8-2-1) Kinds of saturated salt and saturated vapor pressure

Table 8-1 shows relative humidity (%) of air that is balanced with typical saturated salt solutions.

Table 8-1 Relative humidity (%) and kinds of saturated salt

Salts		Temperature (^oC)								
		0	5	10	15	20	25	30	35	40
Potassium sulfate	K_2SO_4	99	98	98	98	98	97	97	97	96
Potassium nitrate*	KNO_3	96	96	96	95	95	94	92	91	89
Potassium chloride	KCl	89	88	87	86	85	84	84	83	82
Sodium chloride	NaCl	76	76	76	76	75	75	75	75	75
Sodium bromide	NaBr	65	64	62	61	59	58	56	55	53
Magnesium nitrate**	$Mg(NO_3)_2 \cdot 6H_2O$	60	59	57	56	54	53	51	50	48
Potassium carbonate	$K_2CO_3 \cdot 2H_2O$	43	43	43	43	43	43	—	—	—
Magnesium chloride	$MgCl_2 \cdot 6H_2O$	34	34	33	33	33	33	32	32	32
Lithium chloride	LiCl	11	11	11	11	11	11	11	11	11

* : May corrode metals
**: May be instable at less than 20^oC

(8-2-2) How to make saturated air chamber

Necessary equipment and materials

Desiccator: Plastic vessels would be the best. 20 ~ 30 liter containers would be good for less than several ten pieces of sensors. It may need several hours to stabilize the temperature in the chamber after exchanging saturated salts. In case several humidity levels are required one after another, multiple numbers of desiccators are to be provided.

Fan for agitation: Small-sized fan for general use.

Slide rheostat: For controlling the fan speed.

Thermometer: Regular mercury thermometer or thermo-couples to be put in a desiccator.

Saturated salt: 500g of saturated salt is provided for designated humidity.

Deionized water: For dissolving a salt for saturation.
Commercially available distilled water can be used instead.

Vessel for saturated salt:
Chemical-resistant plastic (PP or PE) containers with a wide opening and a lid would be fine. Volume of a container should be 1/10 ~ 1/15 of a desiccator.

Outline of testing system

Fig. 8-2 shows the outline of a basic test chamber with saturated salts. Your own test chamber is to be made referring to this basic system for evaluation of sensors and sensor units.

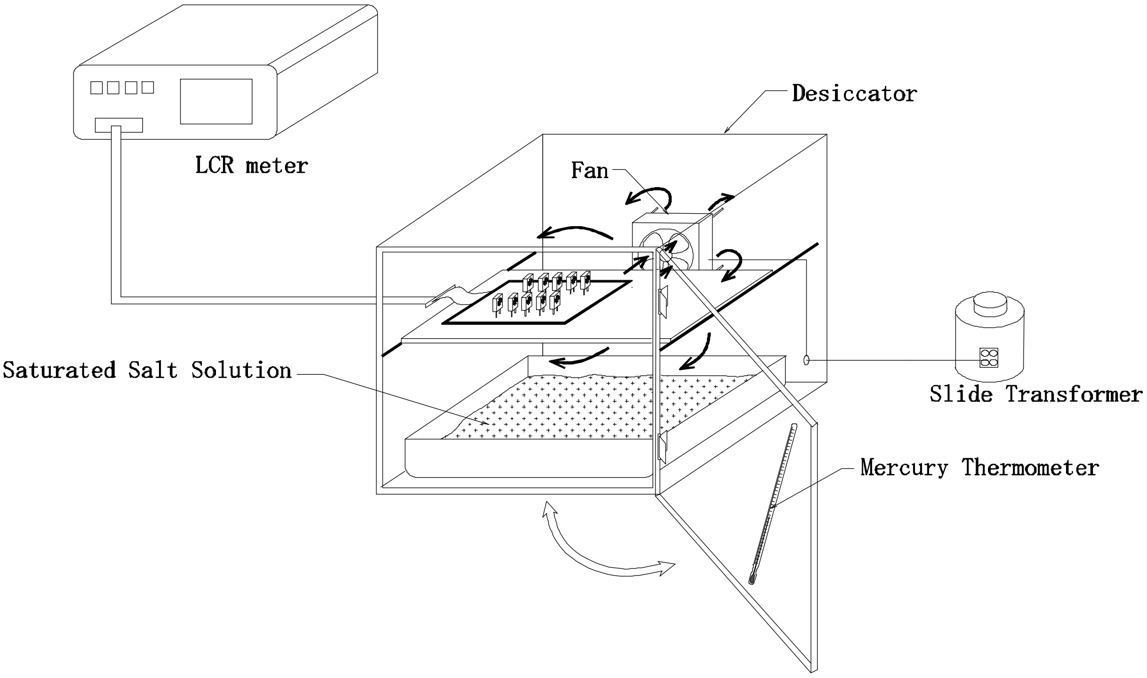


Fig. 8-2 Basic testing chamber

It is necessary to put a fan at a location that the wind does not directly hit test samples and the air inside the chamber is gently agitated and circulated. It may not be definitely needed to use a slide rheostat for controlling air velocity, but too strong air flow may blow off the salt that has been dried up and stuck to inside walls of the chamber. Blown-off salt particles may cause contamination on test samples.

The signal wires between test samples and LCR Meter should be the shortest possible. Shielded signal wires must be used for measuring the low impedance range (less than 1 MΩ) under low temperature and low humidity atmosphere. In case of measurement at room temperature and humidity, shielded wires would not be required and practically accurate results can be obtained with 1 meter of non-shielded wire.

How to make saturated salts

1) Deionized water of 40 ~ 50°C is prepared. 1 liter would be enough for a kind of salt.

2) Salt is put in a container and water is gradually added. Water should NOT be added till the salt is completely dissolved. "Half-melted sorbet condition" would be ideal. Too much added water should prohibit generating an accurate humidity level.

3) The container is lidded and stored. Upon using the solution, attention is to be paid that both of the container and solution are well adapted and stable to the ambient temperature.

(8-2-3) Remarks for humidity measurement using saturated salt

1) It would take 20 ~ 40 minutes after the door is opened and closed that the humidity in the test chamber gets stabilized. The time for stabilization can be shortened by quick door actions.

2) In case of measurement using a single desiccator with multiple saturated salts (salts are exchanged time to time), it would take a longer time to get the humidity stabilized. In order to get the most reliable test data, measurement is to start after the humidity has got stabilized. For the judgment of humidity stabilization, it is recommended to put a humidity monitor in the test chamber, or to monitor the impedance of the humidity sensor. In both of the cases, measurement is to start after confirming that the readings of the monitors are stabilized. A time for stabilization is dependant to the ambient humidity and a kind of salt, but it may take one to several hours in the worst case.

3) For temperature dependency tests, the test box is to be put in a thermo-hygrostat chamber, and the impedance is measured after temperature in the thermo-hygrostat chamber is stabilized. As it also would take a longer time to get the temperature stabilized, the afore-mentioned monitoring measures are to be taken.

4) The state of a saturated salt gets changed as time passes by repeating hydration and dehydration. As shown in the "**How to make saturated salts - (2)**", the saturated salt is to keep the "**Half-melted sorbet state**" by adding deionized water or gentle-drying. This is very important for accurate measurement results.

(8-3) Test using a thermo-hygrostat chamber

It is possible to simply evaluate the characteristics of humidity sensors and units using a thermo-hygrostat chamber. However very accurate results would not be expected. We therefore do NOT recommend this method, but this may be convenient to get rough evaluation results.
The following are remarks for this method.

1) Generally, in a thermo-hygrostat chamber, deionized water placed on a evaporator is heated up to generate water vapors and the humidified air is compulsorily circulated in the chamber. As the humidity is controlled by on-off of the heater, the humidity of the circulated air always varies by ± 5 ~ 10%RH even if the indicator shows a stable reading. Therefore the sensor output may widely vary when the circulated air is blown directly onto the sensor. In order to avoid this phenomenon, the sensor is to be covered with a large hood, or a separate container having an opening is put in the thermo-hygrostat chamber. Test samples are placed inside of this separate container for measurement. <u>Even though such measures are taken, very accurate tests results would not be expected.</u>

2) Just only for evaluation of sensors and units whether they are within the specifications or not, you may use standard humidity sensors that have been accurately measured beforehand. These sensors are used as upper and lower limit samples and are measured together with test samples in a thermo-hygrostat chamber. It may happen that inaccurate results are obtained if there is a difference in the response speed of the standard sensors and the test samples.

9) Measurement of impedance

(9-1) Using LCR meter

Impedance of a humidity sensor can be easily measured using LCR meter. As shown on the Fig. 9-1, the both lead wires of NHS-12 are connected to the input terminals of LCR meter. This is the most recommendable method for measuring the impedance characteristic of the sensor. Test conditions should be 1V and 1 KHz. The measured values are the definite impedance values.

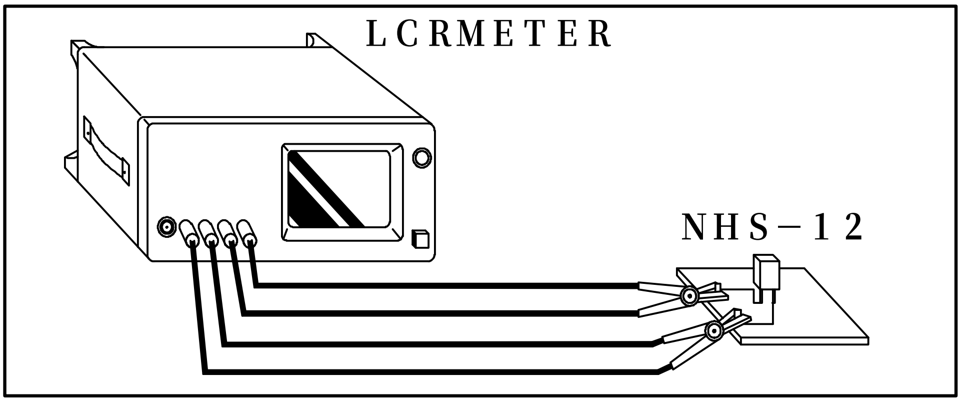
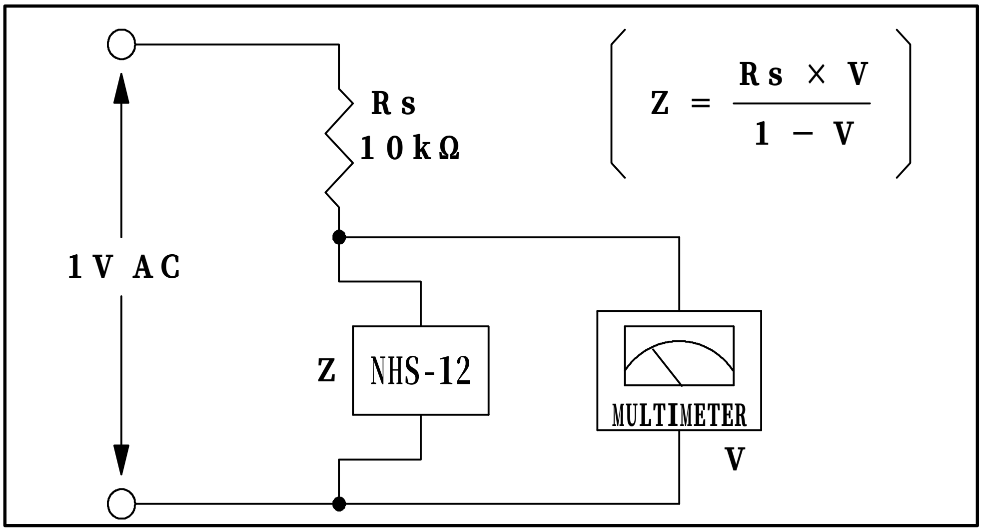


Fig. 9-1 Measurement using LCR meter

(9-2) Using sine wave oscillator and AC voltmeter

Characteristics of a humidity sensor can be evaluated using sine wave oscillator and AC voltmeter. The basic circuit is shown in Fig. 9-2.



$$\left(Z = \frac{Rs \times V}{1 - V} \right)$$

Fig. 9-2 Measuring circuit using sine wave oscillator

In case that voltage is directly supplied to a humidity sensor, protective resistors (10 KΩ) are to be connected in series. The impedance (Z) of the sensor is illustrated in the following formula

$$Z = (Rs \times V) / (1 - V) \qquad (Rs = 10\ \mathrm{K\Omega})$$

(9-3) Using commercial power supply

In case of using commercial power supply, 100 ~ 200V, the voltage should be reduced to 1V using a transformer. Fig. 9-3 shows a circuit for this purpose. Impedance of the humidity sensor (Z) can be calculated by the formula in **(9-2)**. However, generally speaking, the impedance may differ from the standard characteristics (1 KHz) in the frequency ranges lower than 100 Hz. This circuit is helpful for rough evaluations but does not give accurate results.
We therefore do NOT recommend this method.

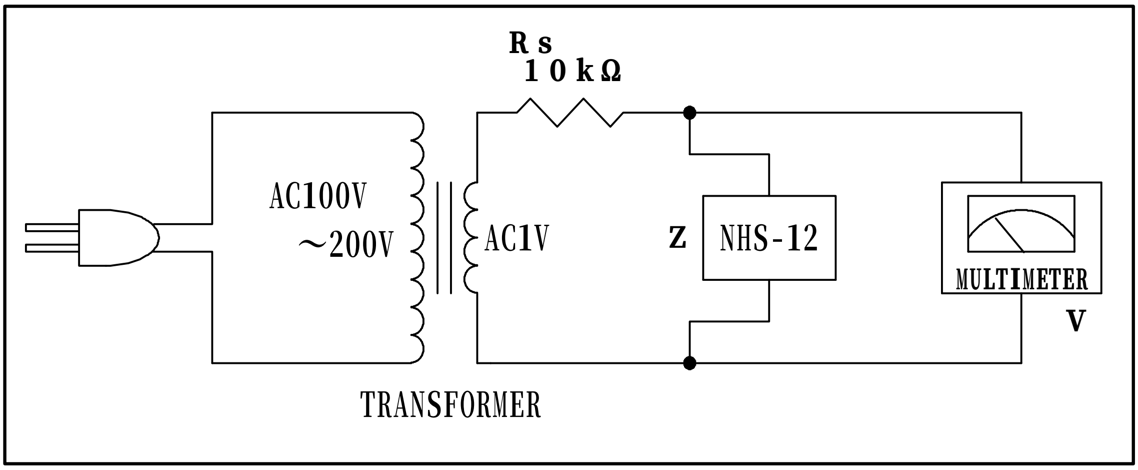


Fig. 9-3 Measuring circuit using commercial power supply

10) Remarks:

* Do not disassemble sensors. The polymeric humidity sensing layer that is formed on the electrode is very soft and fragile. Please do not touch the layer otherwise proper functions may not be expected.
* Do not blow water vapors, water, organic solvents, paints, or oils directly on to the sensor.
* Keep the sensor away from corrosive gases and high concentration of organic solvent. If your product may be used under severe conditions, please consult us for assistance.
* Do not insert a foreign object into the vent hole of the sensor. Damaged polymer layer would not work properly.
* NHS-12 is durable enough under high temperature/humidity or dew condensation conditions, but storage for a too long time under too severe conditions may cause improper functions.

Remarks for measurement

* NHS-12 is not operated with DC. Please use the rated AC.
* Refrain from using a regular tester for measurement on NHS-12. DC current may damage the sensor. Please measure properly as mentioned in the **9) Measurement of impedance.**

Remarks for mounting

* NHS-12 is to be mounted on a PCB in a location kept away from water or water vapors.
* The polymeric humidity sensing layer may be damaged at 100°C or more. Refrain from using re-flow soldering systems.
* NHS-12 works properly regardless of positioning (upright or upside down). However for the best reliability, NHS-12 is to be placed at the right location with the right positioning.
Please refer to the **7) Mounting NHS-12 onto devices**.

Should you need further information or have questions, please feel free to contact us. Our engineers should be happy to assist you.

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