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Technical Information

Electrochemical Nitrogen Dioxide Gas Sensor

NE4-NO2

For Industrial Application

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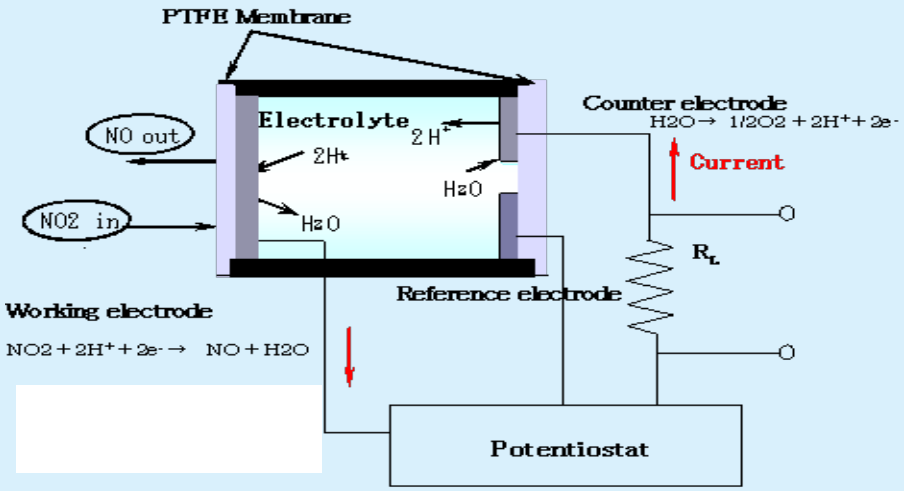
1. General

Nemoto NE4 series sensors were developed for industrial applications, and NE4-NO2 is a electrochemical nitrogen dioxide gas sensor. Shape and pin positions are compatible with others, but the stability, repeatability, durability and reliability are superior to others, however the price is competitive with others. Features and applications are as follows.

2. Detection principle

Electrochemical sensor consists of working electrode on which oxidization or reduction takes place, counter electrode on which reduction or oxidization takes place, and reference electrode which can monitor and keep the voltage at constant. Structure of electrochemical sensor is shown in the following figure, nitrogen dioxide gas diffuses through membrane into working electrode, and is reduced to nitrogen monoxide at working electrode. Consequently generated oxygen ion at working electrode reacts with proton, and then, water is generated at this oxidization reaction. Water molecule proceeds to counter electrode, and is reduced at counter electrode by generated current of this serial reaction. Total reaction is in the below described. NO2 gas concentration is proportional to the current that is generated by this serial reaction.



3. Features

- Quick response
- Excellent selectivity
- Good linearity and stability
- High reliability
- Excellent durability against high temperature and humidity

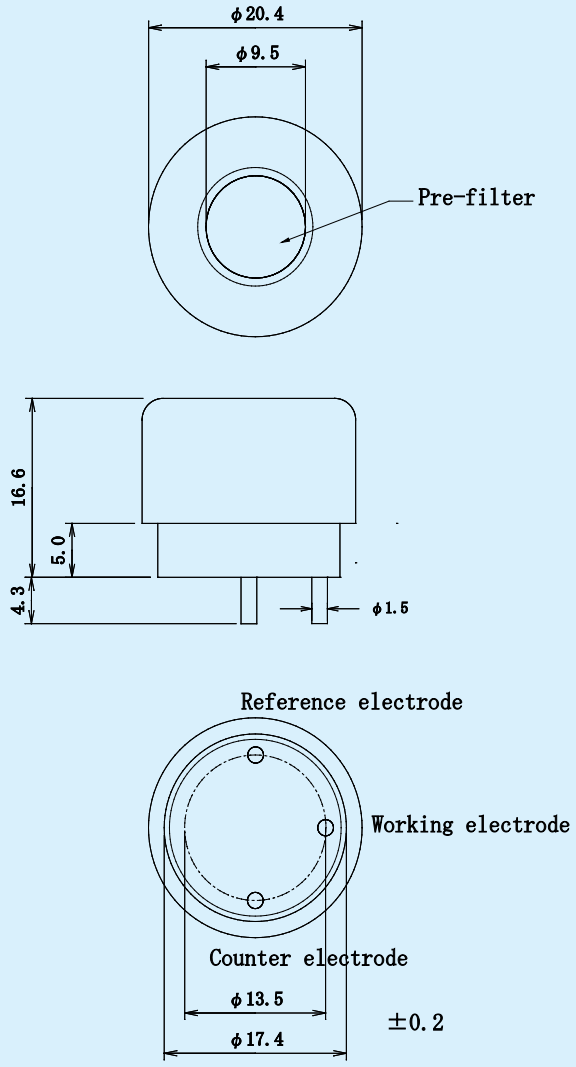
4. Detected gas

Nitrogen dioxide

5. Application

- NO2 gas densitometer for industrial application
- NO2 gas alarm for industrial equipment like for car parking area
- Environmental monitoring equipment

6. Dimensions and appearance



Case Material	PPO
Cap Color	Orchid
Weight	5 g (approx.)

Fig.1 : Appearance and dimensions of NE4-NO2

7. Ratings

1) Ambient temperature and humidity in operation — Temperature : -20 - +50 degree C; Humidity : 15 – 90%RH
2) Recommended ambient temperature and humidity in storage — Temperature : 0 – 20 degree C; Humidity : 15 – 90%RH
3) Operating pressure range — 0.9 – 1.1 atm
4) Detection range — 0 – 30ppm

5) Maximum overload 150ppm

6) Recommended load resistor 10 ohm

8. Specifications

1) Output signal	600 +/-150nA/ppm of NO2 (Contrary signal to other models)
2) Zero offset at 20 degree C	< +/-0.2ppm of NO2 equivalent
3) Response time (T90)	< 25sec.
4) Repeatability in the same day	< 2% of signal
5) Annual zero offset drift at 20 degree C	< +/-0.2ppm of NO2 equivalent
6) Zero offset temperature dependence (-20 ~ +50 degree C)	< +/-1ppm of NO2 equivalent
7) Minimum detection range	0.1ppm
8) Sensitivity reduction in long term	< 2% signal loss/month
9) Lifetime warranty	24 months
10) Recommended storage time	< 6 months

9. Electrical properties

9-1. Typical Gas Sensitivity

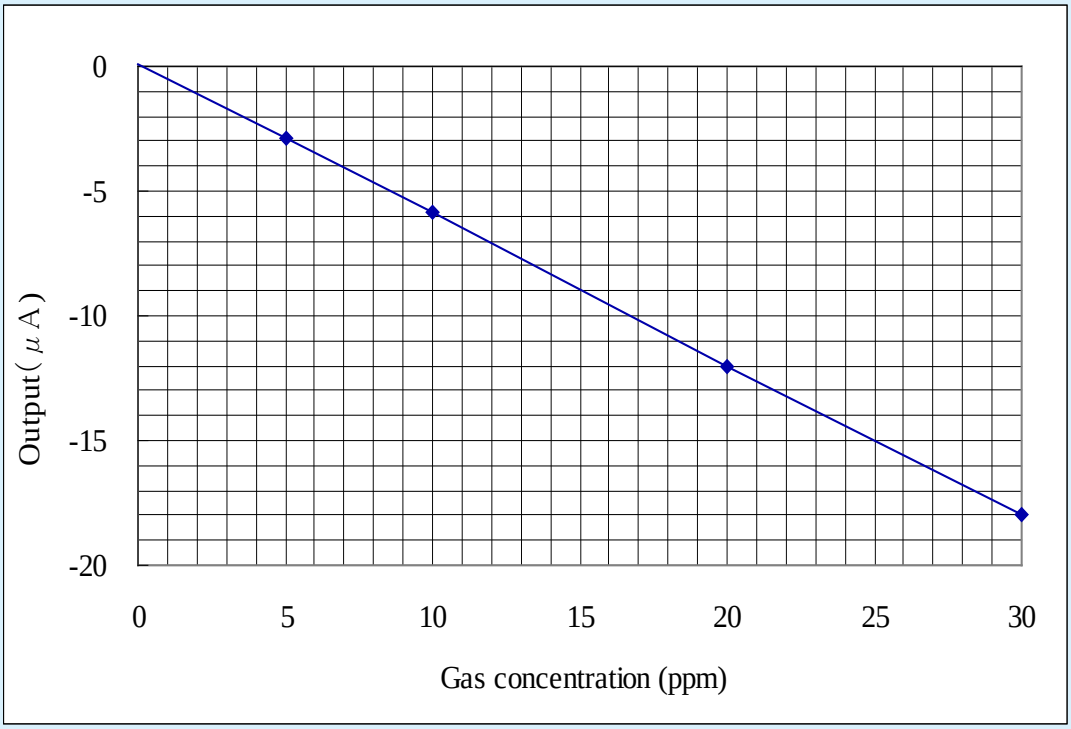


Fig.2 : Gas Sensitivity of NE4-NO2

9-2. Cross Sensitivity

Table 1 : Cross Sensitivity of NE4-NO2

Detected gases	Relative sensitivity (Sensitivity to NO2 is 100.)
Nitrogen dioxide	100
Carbon monoxide	0
Carbon dioxide	0
Hydrogen	0
Chlorine	0
Sulfur-dioxide	-2
Nitrogen monoxide	0
Hydrogen sulfide	-120
Ammonia	0
Ethyl acetate	Less than 0.5
Chlorine	Less than 100
Ethanol	0
Toluene	Less than 3
Ethylene	0

9-3. Temperature dependence

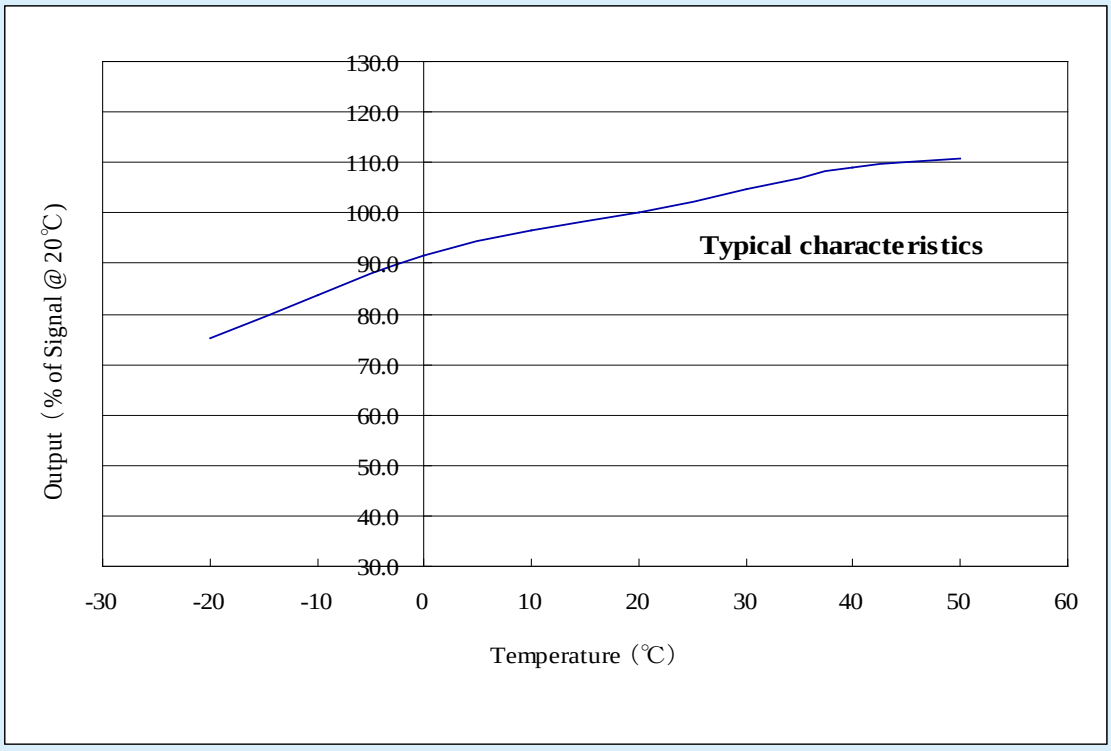


Fig. 3 : Typical temperature coefficient of NE4-NO2
(100 at 20 degree C)

9-4. Response and recovery characteristics

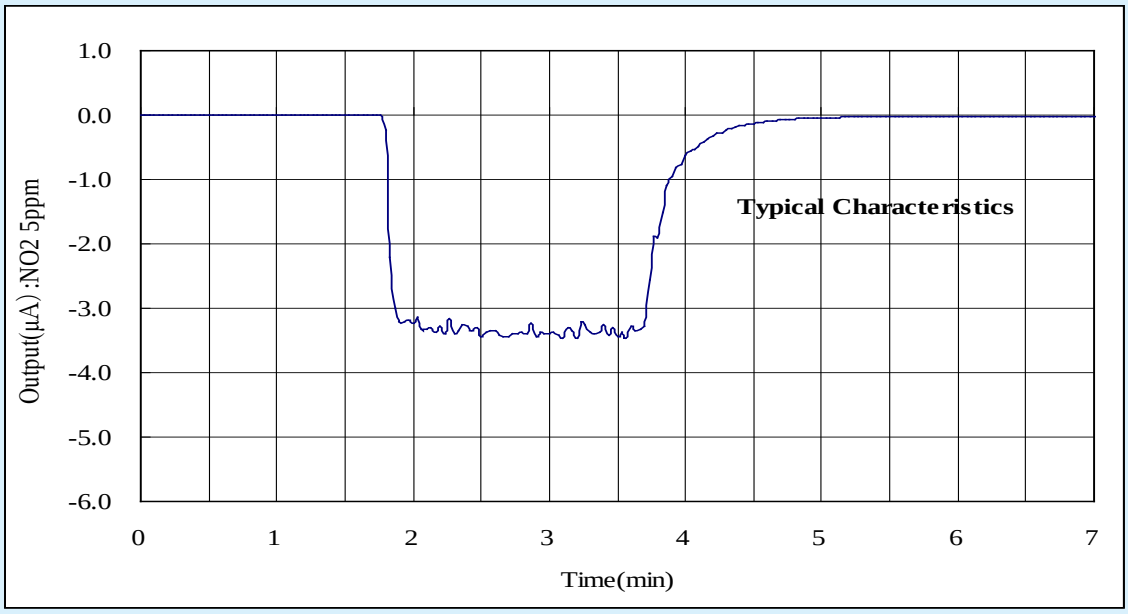


Fig.4 : Response and recovery characteristics of NE4-NO2
(at 20 degree C)

9-6. Long term stability

It is quite stable in normal circumstance.

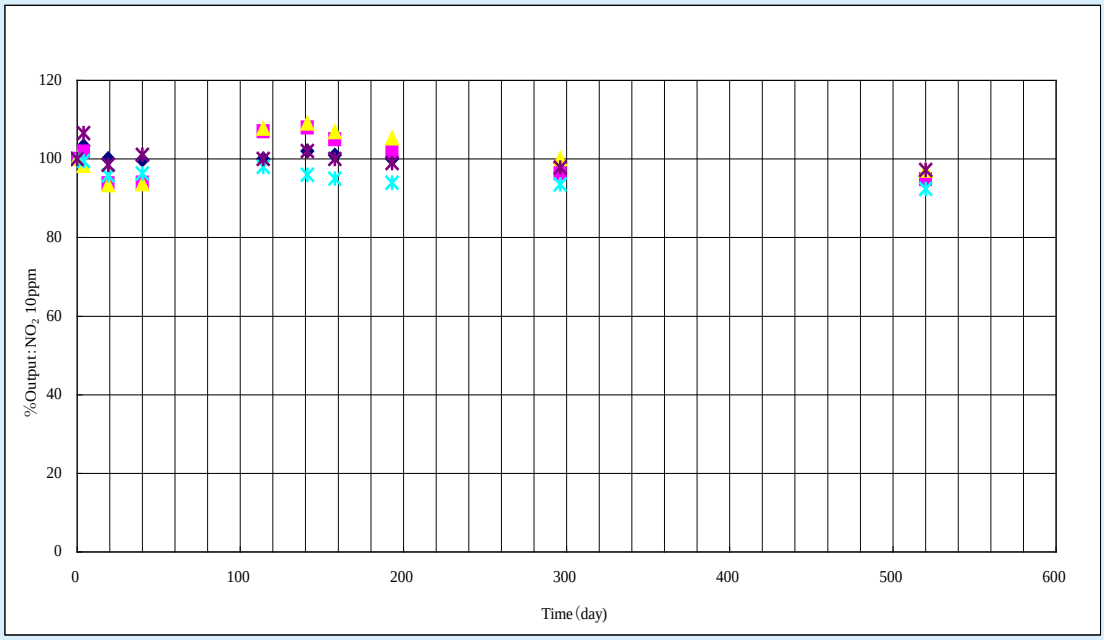


Fig.5 : Long term stability of NE4-NO2 in normal circumstance

10. Durability

NE4-NO2 is much durable in strict environment such as high temperature and high humidity, or in high temperature with dry. Features are as follows.

10-1. Durability in high temperature and high humidity

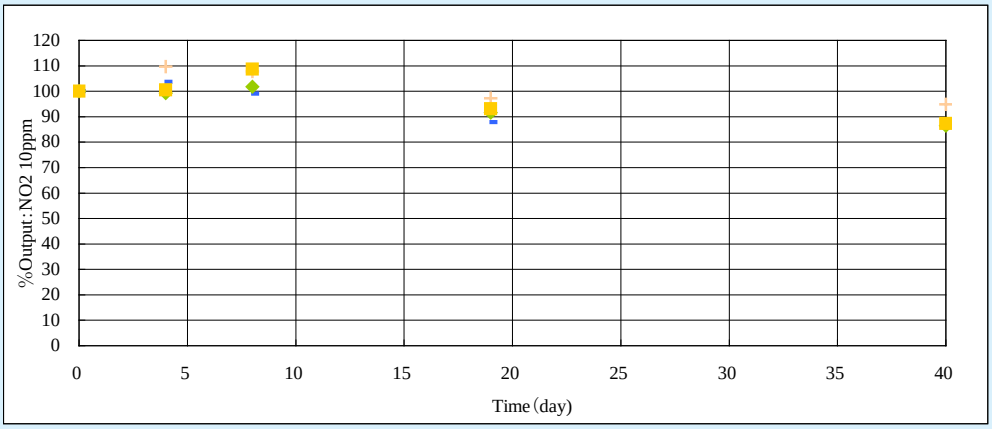


Fig. 6 : Durability in high temperature (50 degree C) and high humidity (90%RH).

10-2. Durability in high temperature

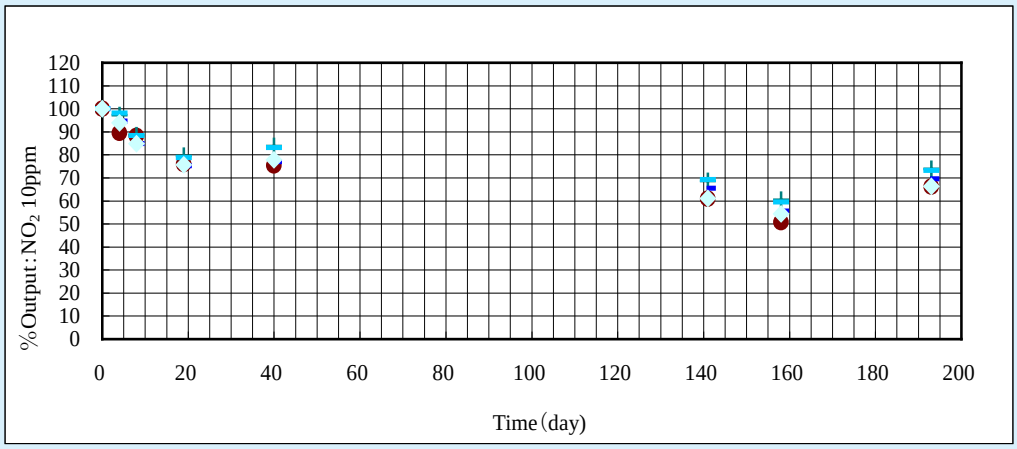


Fig. 7 : Durability in high temperature (50 degree C) with dry circumstance.

10-3. Low temperature durability

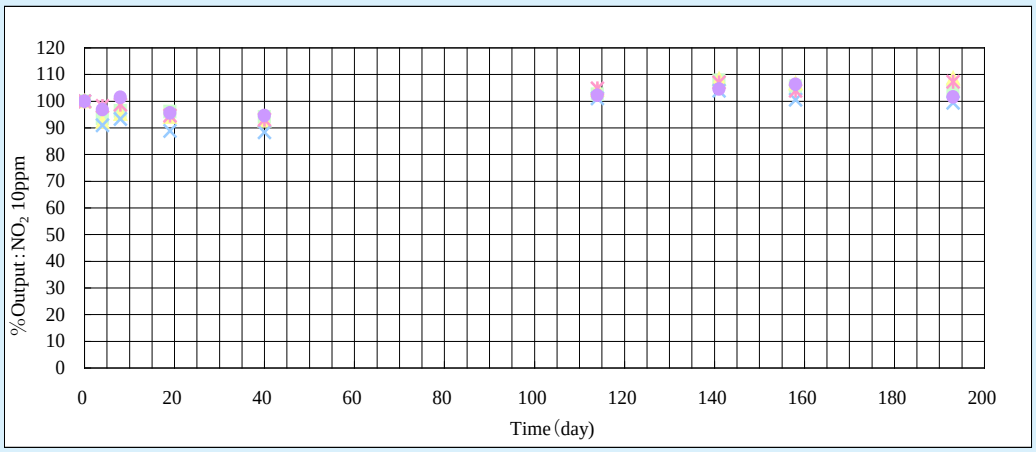


Fig.8 : Durability in low temperature (-20 degree C)

10-4. Exposure test in high concentration of nitrogen dioxide.

Test conditions NO2 gas concentration : 150ppm
Exposure time : 12hrs. continuous
Temperature and humidity : 25+/-1 degree C, 50+/-10%RH

Table 2. Exposure test in high concentration of nitrogen dioxide gas

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	
1	-0.07	-6.10	-0.19	-6.32	104.0
2	-0.07	-6.48	-0.17	-6.60	101.9
3	-0.08	-6.48	-0.21	-6.18	95.4
4	-0.05	-6.26	-0.15	-6.34	101.3
5	-0.05	-6.47	-0.28	-6.55	101.2

10-5. Thermal shock test

Test conditions

Sensor is stored in -20 degree C for 30min. and in +50 degree C for 30 min. respectively, and this cycle were repeated for 10 times.

Table 3. Thermal shock test

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	
1	0.00	-6.07	0.11	-5.94	97.9
2	-0.02	-5.97	0.16	-5.73	96.0
3	-0.05	-5.64	0.10	-5.57	98.8
4	-0.02	-5.98	0.08	-5.80	97.0
5	-0.03	-5.65	0.07	-5.54	98.1

10-6. Drop test

Test conditions

Sensor is dropped to concrete floor from the height of 1m with free fall for 5 times.

Table 4. Drop test

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	
1	-0.01	-6.24	-0.05	-6.31	101.2
2	-0.03	-6.09	-0.06	-5.96	97.9
3	0.00	-5.89	-0.02	-5.71	96.9
4	-0.01	-5.92	-0.06	-5.95	100.5
5	-0.02	-5.98	-0.05	-6.00	100.3

10-7. Exposure in noise gas

A. Exposure in SO2 gas

Test conditions

Sensor is exposed in 50ppm of sulfur dioxide for 2hrs. at normal temperature and humidity.

Table 5. Exposure in SO2

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	
1	-0.15	-6.40	-0.11	-6.14	95.9
2	-0.15	-6.54	-0.10	-6.80	104.0
3	-0.16	-6.75	-0.12	-6.86	101.6
4	-0.14	-6.80	-0.12	-6.68	98.2
5	-0.12	-6.83	-0.13	-6.83	100.0

B. Exposure in ammonia gas

Test conditions

Sensor is exposed in 200ppm of ammonia for 2hrs. at normal temperature and humidity.

Table 6. Exposure in ammonia

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	
1	-0.03	-6.55	-0.03	-6.39	97.6
2	-0.03	-6.43	-0.03	-6.24	97.0
3	-0.02	-6.08	-0.02	-5.98	98.4
4	-0.03	-6.36	-0.03	-6.26	98.4
5	-0.02	-6.39	-0.01	-6.11	95.6

C. Exposure in ethanol gas

Test conditions

Sensor is exposed in 200ppm of ethanol for 2hrs. in normal temperature and humidity.

Table 7. Exposure in ethanol

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	
1	-0.01	-6.36	-0.02	-6.17	97.0
2	-0.02	-6.19	-0.03	-6.16	99.5
3	-0.01	-5.99	-0.01	-5.87	98.0
4	-0.02	-6.26	-0.01	-6.05	96.6
5	-0.01	-6.14	-0.21	-5.84	95.1

D. Exposure in toluene gas

Test conditions

Sensor is exposed in 100ppm of toluene for 2hrs. at normal temperature and humidity.

Table 8. Exposure in toluene

No.	Before test (micro A)		After test (micro A)		Sensitivity variation ratio (%)
	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	Zero offset in air at 20 degree C	Sensitivity to 10ppm of NO2	
1	-0.15	-6.00	-0.15	-5.90	98.3
2	-0.12	-6.12	-0.13	-5.95	97.2
3	-0.17	-6.36	-0.16	-6.22	97.8
4	-0.13	-6.37	-0.13	-6.09	95.6
5	-0.18	-6.59	-0.16	-6.49	98.4

11. Recommended circuit diagram

Recommended circuit diagram for evaluation of NE4-NO2 is shown in figure 11. In this circuit diagram, OP97 as operational amplifier is employed, however the other low price one is to be applicable for actual use. And, thermistor is also employed, resistance value of 10Kohm at 25 degree C and around 3500 as B constant is recommended. Ishizuka thermistor is not pointed, and another one is also available.

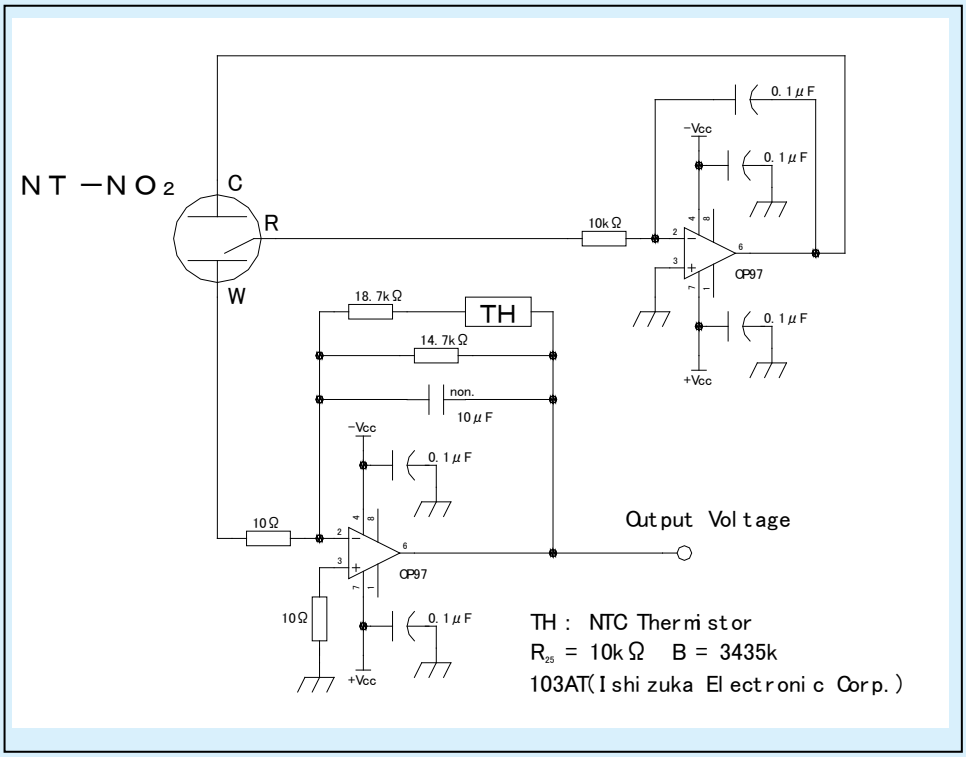


Fig. 9 : Measuring circuit diagram for evaluation

12. Notice on handling

12-1. Seasonal variation of sensitivity

Highly hygroscopic electrolyte is normally employed for electrochemical sensor, and then the sensitivity varies according to change of temperature and humidity, i.e. sensitivity is little lower in low humidity than in high humidity. Since it is because of amount of electrolyte, this seasonal variation of sensitivity should be taken into account in case that precise measurement is necessary. However, this variation is reversible phenomenon.

12-2. Design of gas alarm or gas densitometer

a. Calibration of gas alarm or gas densitometer is to be carried out in clean air after the output was stabilized.
b. Gas sensitivity reduction ratio of 2% per month is to be taken into account at designing of gas alarm as recommendation. In case that precise detection is required, periodical calibration.
c. In case that water drop or oil is on the pre-filter, accurate measurement may not be available because of low diffusion of detected gas to sensor. If such accident may be conceived, design of prevention from such one is to be considered.
d. Warranty time is 2 years in case of being used in normal circumstance.

12-3. Storage of sensor

It is recommended that electrochemical sensor should be stored in normal temperature and humidity, possibly 0-20 degree C, of clean air.

Recommended storage time after delivery is less than 6 months. If the storage time is extended, the warranty term is to be shortened. It is because the lifetime of electrochemical sensor is not dependent on being electrified or not like semi-conductive type or catalytic type, and then this matter is to be correctly comprehensive in order to keep quality.

12-4. General notice

- Use only within specified conditions.
- Sensor characteristics must be measured in clean air.
- Electrode pins must be correctly connected. Wrong connection does not allow correct functions.
- Do not apply voltage directly to electrode pins.
- Do not bend pins.
- Do not put excess vibration or shocks.
- If sensor housing is damaged or scratched, do not use.
- Do not blow organic solvents, paints, chemical agents, oils, or high concentration gases directly onto sensors.
- Do not solder pins of sensor directly. Use exclusive sockets.
- Do not disassemble or change any parts.
- In case that sensor is stored by detachment from circuit board, it is recommended that working electrode pin should be short-circuited with reference electrode pin in order to shorten the initial stabilization time.
- If sensor is used under irregular atmosphere, contact us.

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