DATE April 9, 2021

No. V-8475A-E

Messrs.

# SPECIFICATION

| | Oxygen Sensor Module | | |
|---|---|---|---|
| | FCX-MV-F | 0.1 to 25% $O_2$ | |
| | FCX-MV-F-AC | 0.1 to 25% $O_2$ | with sensor housing |
| | FCX-MW-F | 0.1 to 95% $O_2$ | |
| Model: | FCX-MW-F-AC | 0.1 to 95% $O_2$ | with sensor housing |

Project:

Distributor:

Distributed by:
Servoflo Corporation
75 Allen Street
Lexington, MA 02421
+1 781 862 9572
info@servoflo.com

Reference:

Yoshiyuki Uchiumi, Application Engineer
Sensor Department, Electronic Component Division
Fujikura Ltd.

Fujikura Ltd.

# Table of Contents



**Table shown below is revision records of this specification**

| | | | | |
|---|---|---|---|---|
| 3 | | | | |
| 2 | | | | |
| 1 | April 9, 2021 | Y. Uchiumi | Typo Correction: 7. Wiring Connection and Interface, Part number in diagrams | △A |
| Est. | Nov. 1, 2019 | Y. Uchiumi | Refresh | |
| | Date | Name | Comment | Mark |

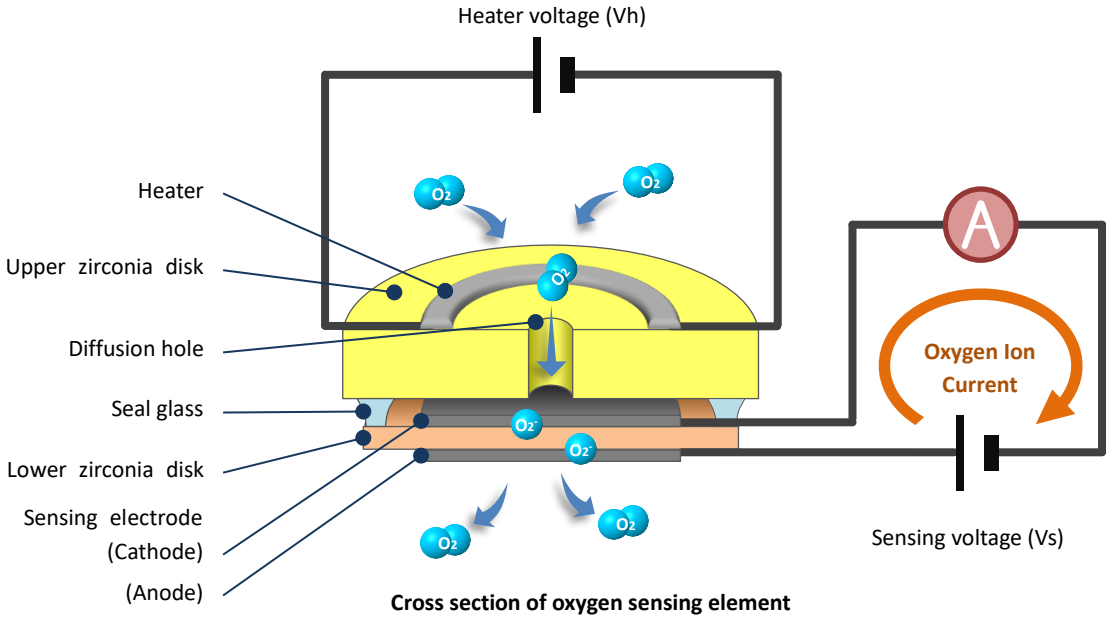
# 1 General

This document describes about the specification of Fujikura Ceramic Oxygen Sensor modules FCX-MV-F(-AC) and FCX-MW-F(-AC).

# 2 Principle of Fujikura Oxygen Sensor Element

Fujikura oxygen sensor is based on **limiting current method using zirconia solid-electrolyte** that has oxygen ion conductivity at high temperature. The upper side zirconia disk has a heater and a diffusion hole. A pair of electrodes is printed on the both side of the lower side zirconia disk. Two zirconia disks are bonded together by sealing glass and there is a cavity between the upper side zirconia disk and the lower side zirconia disk.

Sensing voltage is applied to the electrodes on the lower side disk and heater voltage is applied to the heater on the upper side zirconia disk. Oxygen ion conductivity is generated at the lower side disk when the oxygen sensing element is heated up to about 450°C. Oxygen in the cavity is converted to oxygen ions on the cathode electrode, moved to the anode electrode by the sensing voltage. Oxygen ions are converted to oxygen once again. There is no oxygen in the cavity when oxygen is pumped out. Oxygen at the outside flows into the cavity through the diffusion hole. However, oxygen flow is limited by the diffusion hole, oxygen ion current appears constant. Oxygen density can read from this behavior.




**Cross section of oxygen sensing element**

# 3 RoHS

This product is compliant with the Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS).

# 4 Device Name Code

**FCX - MV - F - AC**

| | | |
|---|---|---|
| **Sensor housing:** | **Blank:** | NOT equipped |
| | **AC:** | Equipped |
| **RoHS:** | **F:** | RoHS compliant |
| **Model:** | **MV:** | 0.1 to 25% $O_2$ |
| | **MW:** | 0.1 to 95% $O_2$ |
| **Series:** | **FCX:** | Fujikura Ceramic Oxygen Sensor |

## 5 General Specifications

| Item | Condition | | Rating Min. | Rating Typ. | Rating Max. | Unit | |
|---|---|---|---|---|---|---|---|
| Measuring Gas | | | Oxygen | | | | *1 |
| Gas Sampling | without -AC option | | Gas diffusion | | | | |
| | with -AC option | | Input to sensor housing | | | | |
| Measurement Range | FCX-MV-F(-AC) | | 0.1 | - | 25 | % $O_2$ | *2 |
| | FCX-MW-F(-AC) | | 0.1 | - | 95 | % $O_2$ | |
| Accuracy | FCX-MV-F(-AC) | | -0.25 | - | +0.25 | % $O_2$ | |
| | FCX-MW-F(-AC) | | -0.475 | - | +0.475 | % $O_2$ | |
| Output | FCX-MV-F(-AC) Output = -891 x ln(1 - [%$O_2$]/100) | at 0.1% $O_2$ | -1 | 1 | 3 | mV | *3 |
| | | at 25% $O_2$ | 253 | 256 | 259 | | |
| | FCX-MW-F(-AC) Output = -891 x ln(1 - [%$O_2$]/100) | at 0.1% $O_2$ | -3 | 1 | 5 | mV | |
| | | at 95% $O_2$ | 2588 | 2669 | 2758 | | |
| Power Supply | | | 4.8 | 5.0 | 5.2 | V | |
| Power Consumption | at 5 V | | - | 3.5 | - | W | |
| Response Time | 90% | | - | - | 30 | sec. | *4 |
| Warm up Time | | | - | 5 | - | min. | *5 |
| Gas Flow Rate | with -AC option | | 200 | - | 1000 | cc/min. | *6 |
| Gas Pressure | with -AC option | | - | - | 500 | kPa | |
| Operating Temperature | | | -10 | - | 50 | ℃ | |
| Operating Humidity | Non condensing | | 0 | - | 85 | %RH | |

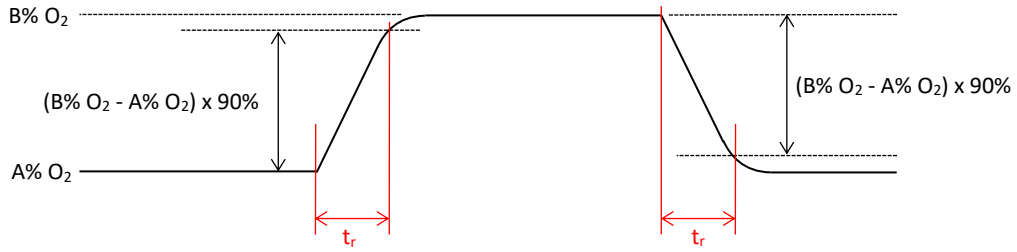
Notes:

*1) Balance gas of oxygen should be nitrogen. This module is calibrated with $N_2/O_2$ mixture gas.

*2) If the oxygen sensor module worked in out of the measurement range, the lifetime must be shortened.

*3) Please refer to Chapter 6 Output.

*4) Response Time ($t_r$)is defined as the time reaching 90% of the difference between A% $O_2$ and B% $O_2$ from the gas change started.




*5) During warm-up, the output is not correct. Please read the output once warm-up has been finished.

*6) If the pressure to the oxygen sensor changed, the output is subject to change upward/downward momentary.

# 6 Output

The output voltage is given by the following equation :

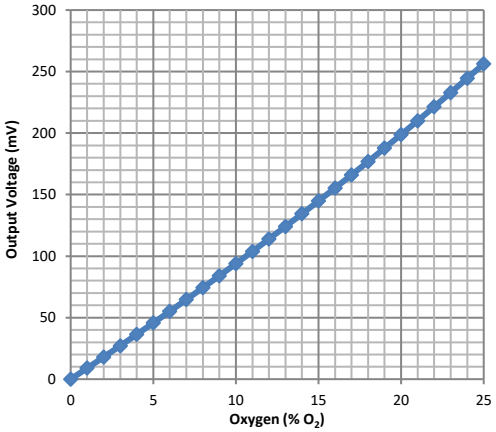
FCX-MV-F-AC **Output (mV) = -891 x Ln** $\left(1 - \frac{\%\ O_2}{100}\right)$ $\longleftrightarrow$ **% $O_2$ = (1 - exp** $\left(\frac{\text{Output (mV)}}{-891}\right)$ **) x 100**

Example: 14.6 % $O_2$ = 141 mV

Simplified Chart for Output:

Unit: mV

| Integer places \ Decimal places | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| % $O_2$ | | | | | | | | | | |
| 0 | (0) | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 | 8 |
| 1 | 9 | 10 | 11 | 12 | 13 | 13 | 14 | 15 | 16 | 17 |
| 2 | 18 | 19 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 26 |
| 3 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 35 |
| 4 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| 5 | 46 | 47 | 48 | 49 | 49 | 50 | 51 | 52 | 53 | 54 |
| 6 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| 7 | 65 | 66 | 67 | 68 | 69 | 69 | 70 | 71 | 72 | 73 |
| 8 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 |
| 9 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 |
| 10 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 |
| 11 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 |
| 12 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 |
| 13 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 |
| 14 | 134 | 135 | 136 | 137 | 139 | 140 | 141 | 142 | 143 | 144 |
| 15 | 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 |
| 16 | 155 | 156 | 157 | 159 | 160 | 161 | 162 | 163 | 164 | 165 |
| 17 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 174 | 175 | 176 |
| 18 | 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 186 | 187 |
| 19 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 197 | 198 |
| 20 | 199 | 200 | 201 | 202 | 203 | 204 | 206 | 207 | 208 | 209 |
| 21 | 210 | 211 | 212 | 213 | 215 | 216 | 217 | 218 | 219 | 220 |
| 22 | 221 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 231 | 232 |
| 23 | 233 | 234 | 235 | 236 | 238 | 239 | 240 | 241 | 242 | 243 |
| 24 | 245 | 246 | 247 | 248 | 249 | 250 | 252 | 253 | 254 | 255 |
| 25 | 256 | – | – | – | – | – | – | – | – | – |



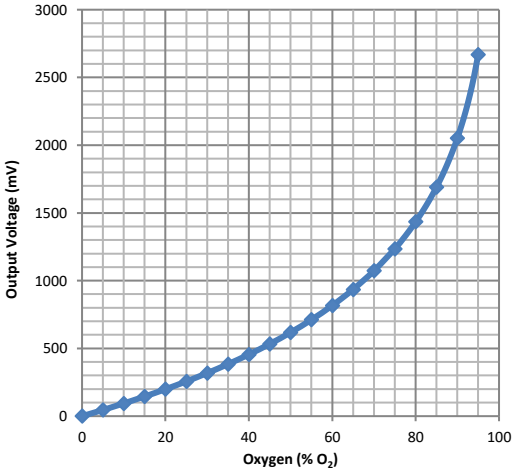

FCX-MW-F-AC **Output (mV) = -891 x Ln** $\left(1 - \frac{\%\ O_2}{100}\right)$ $\longleftrightarrow$ **% O2 = (1 - exp** $\left(\frac{\text{Output (mV)}}{-891}\right)$ **) x 100**

Example: 85.6 % $O_2$ = 1727 mV

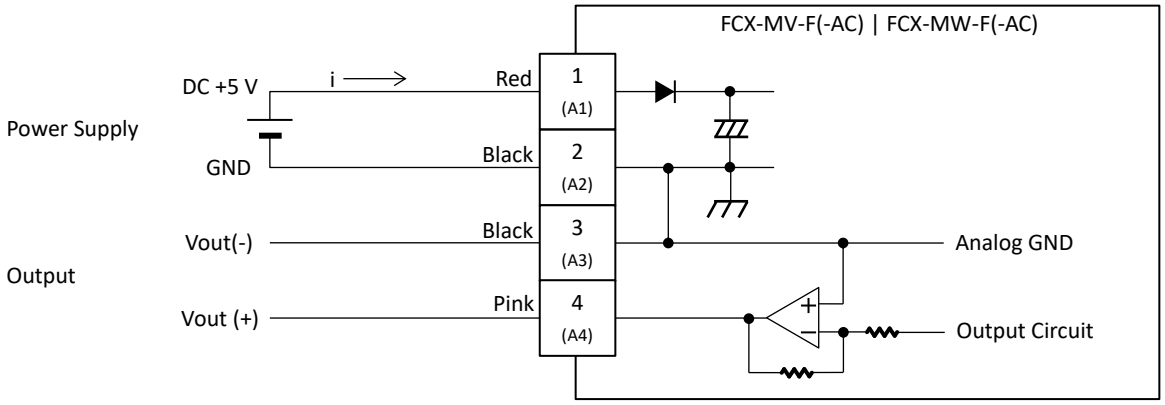
Simplified Chart for Output:

Unit: mV

| Integer places \ Decimal places | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| % $O_2$ | | | | | | | | | | |
| 0 | 0 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 | 8 |
| 1 | 9 | 10 | 11 | 12 | 13 | 13 | 14 | 15 | 16 | 17 |
| 2 | 18 | 19 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 26 |
| 3 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 35 |
| 4 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| 5 | 46 | 47 | 48 | 49 | 49 | 50 | 51 | 52 | 53 | 54 |
| 6 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| 7 | 65 | 66 | 67 | 68 | 69 | 69 | 70 | 71 | 72 | 73 |
| 8 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 |
| 9 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 |
| 10 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 |
| 15 | 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 |
| 20 | 199 | 200 | 201 | 202 | 203 | 204 | 206 | 207 | 208 | 209 |
| 25 | 256 | 258 | 259 | 260 | 261 | 262 | 263 | 265 | 266 | 267 |
| 30 | 318 | 319 | 320 | 322 | 323 | 324 | 325 | 327 | 328 | 329 |
| 35 | 384 | 385 | 387 | 388 | 389 | 391 | 392 | 393 | 395 | 396 |
| 40 | 455 | 457 | 458 | 460 | 461 | 463 | 464 | 466 | 467 | 469 |
| 45 | 533 | 534 | 536 | 538 | 539 | 541 | 542 | 544 | 546 | 547 |
| 50 | 618 | 619 | 621 | 623 | 625 | 627 | 628 | 630 | 632 | 634 |
| 55 | 711 | 713 | 715 | 717 | 719 | 721 | 723 | 725 | 727 | 729 |
| 60 | 816 | 819 | 821 | 823 | 825 | 828 | 830 | 832 | 834 | 837 |
| 65 | 935 | 938 | 940 | 943 | 946 | 948 | 951 | 953 | 956 | 959 |
| 70 | 1073 | 1076 | 1079 | 1082 | 1085 | 1088 | 1091 | 1094 | 1097 | 1100 |
| 75 | 1235 | 1239 | 1242 | 1246 | 1250 | 1253 | 1257 | 1260 | 1264 | 1268 |
| 77 | 1309 | 1313 | 1317 | 1321 | 1325 | 1329 | 1333 | 1337 | 1341 | 1345 |
| 78 | 1349 | 1353 | 1357 | 1361 | 1365 | 1370 | 1374 | 1378 | 1382 | 1386 |
| 79 | 1391 | 1395 | 1399 | 1403 | 1408 | 1412 | 1416 | 1421 | 1425 | 1430 |
| 80 | 1434 | 1438 | 1443 | 1447 | 1452 | 1457 | 1461 | 1466 | 1470 | 1475 |
| 81 | 1480 | 1484 | 1489 | 1494 | 1499 | 1503 | 1508 | 1513 | 1518 | 1523 |
| 82 | 1528 | 1533 | 1538 | 1543 | 1548 | 1553 | 1558 | 1563 | 1568 | 1574 |
| 83 | 1579 | 1584 | 1589 | 1595 | 1600 | 1605 | 1611 | 1616 | 1622 | 1627 |
| 84 | 1633 | 1638 | 1644 | 1650 | 1655 | 1661 | 1667 | 1673 | 1679 | 1684 |
| 85 | 1690 | 1696 | 1702 | 1708 | 1714 | 1721 | 1727 | 1733 | 1739 | 1745 |
| 86 | 1752 | 1758 | 1765 | 1771 | 1778 | 1784 | 1791 | 1798 | 1804 | 1811 |
| 87 | 1818 | 1825 | 1832 | 1839 | 1846 | 1853 | 1860 | 1867 | 1874 | 1882 |
| 88 | 1889 | 1897 | 1904 | 1912 | 1919 | 1927 | 1935 | 1943 | 1951 | 1959 |
| 89 | 1967 | 1975 | 1983 | 1991 | 2000 | 2008 | 2017 | 2025 | 2034 | 2043 |
| 90 | 2052 | 2061 | 2070 | 2079 | 2088 | 2097 | 2107 | 2116 | 2126 | 2136 |
| 91 | 2145 | 2155 | 2166 | 2176 | 2186 | 2196 | 2207 | 2218 | 2228 | 2239 |
| 92 | 2250 | 2262 | 2273 | 2284 | 2296 | 2308 | 2320 | 2332 | 2344 | 2357 |
| 93 | 2369 | 2382 | 2395 | 2408 | 2422 | 2435 | 2449 | 2463 | 2478 | 2492 |
| 94 | 2507 | 2522 | 2537 | 2552 | 2568 | 2584 | 2601 | 2617 | 2634 | 2652 |
| 95 | 2669 | - | - | - | - | - | - | - | - | - |



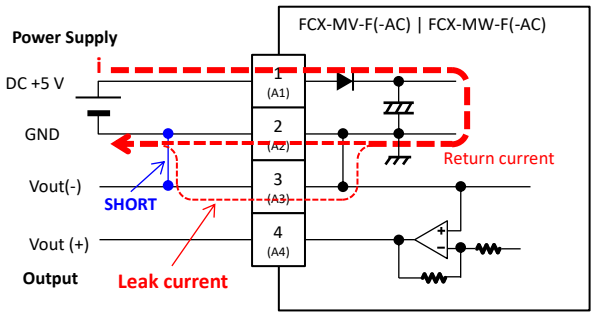
## 7 Wiring Connection and Interface ⚠




Notes:

*1) Do NOT short between GND of Power Supply and Vout(-) of Output with external wirings. It makes zero-shift of Output because the leak current flowed through the line of Vout(-).

*2) Please take care "unintentional short" between GND of Power Supply and Vout(-) with external wirings, when connecting a measurement device and a power source to the module. It would be recommended to check the electrical isolation between GND of Power Supply and Vout(-) of Output in the whole system.



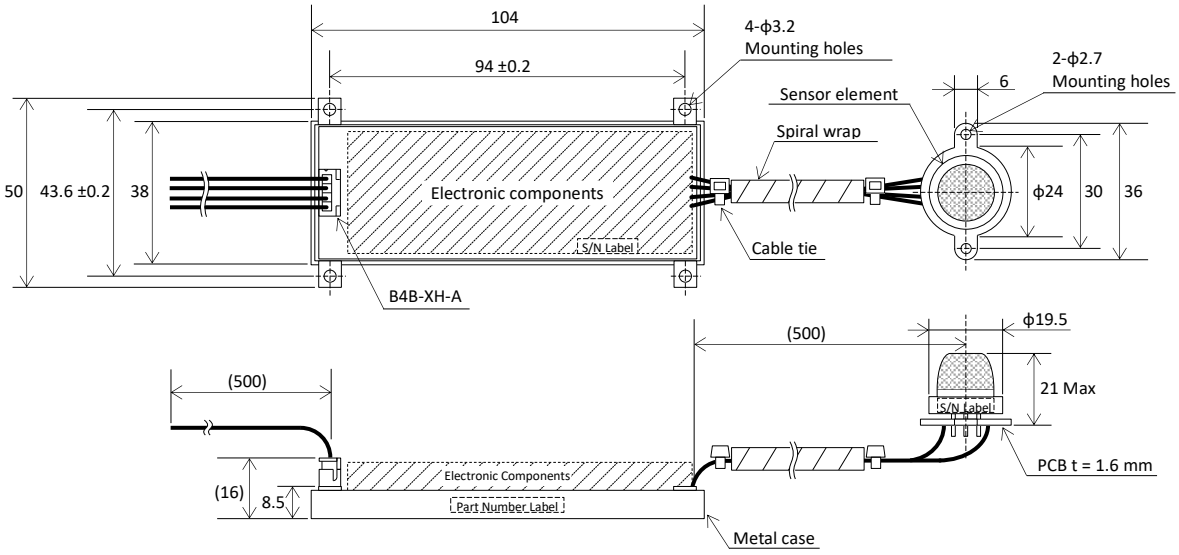

## 8 Calibration, Maintenance and Others

- The module including the oxygen sensor element is full-calibrated at the factory. User calibration is not required in the lifetime and user can NOT calibrate the module.
- Do NOT touch trimmers on the PC board. If setting of trimmers is changed, it is subject to damage the module.
- The module reaches the end of lifetime when the output does not meet the accuracy in the specifications.
- The module at the end of lifetime should replace a new module including an oxygen sensor. Fujikura does not provide services to replace and supply an oxygen sensor element only.
- For regular maintenance of the module, it would be recommended to check the output applying standard gases ($N_2$/$O_2$ mixture gases) to the oxygen sensor.
- Test report is attached to the module.
- Calibration certificate is available for a fee upon request.

# 9 Dimensions and Weights

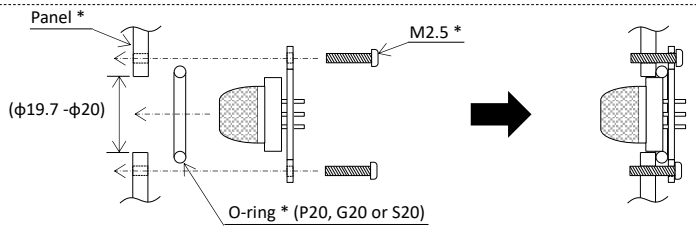
**FCX-MV-F, FCX-MW-F** Weight: Approx. 71 grams

Unit: mm



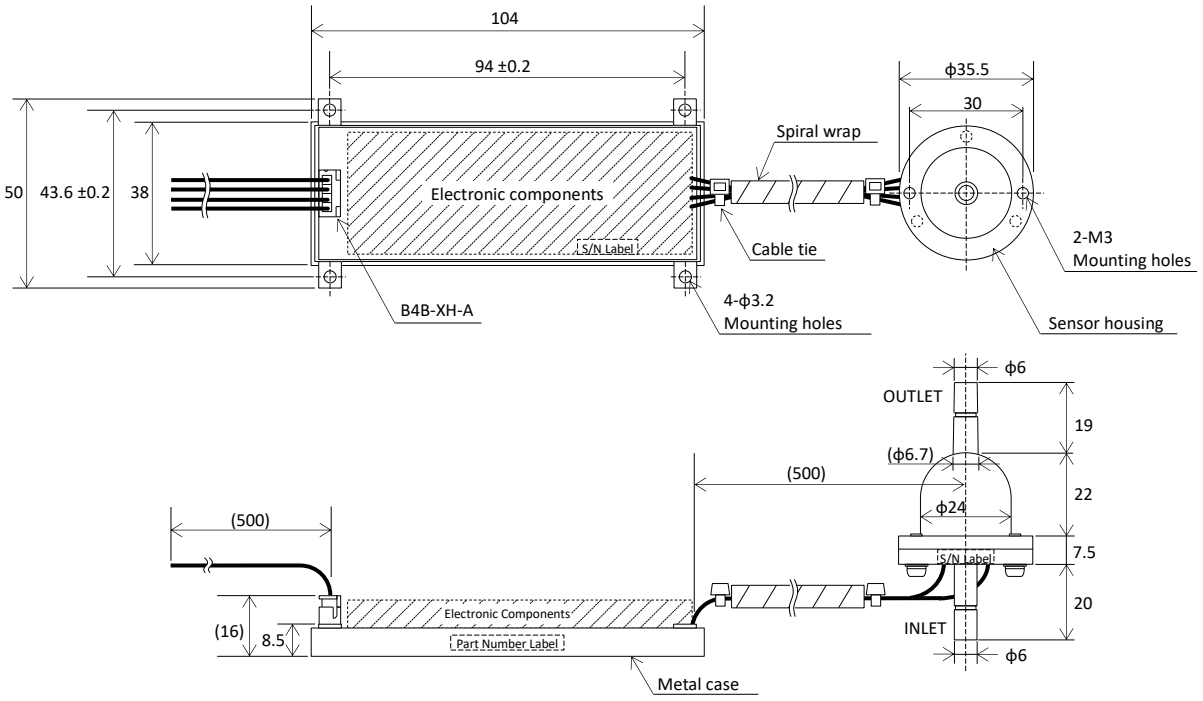

**Sensor Element Mounting (Reference)**

*: These are not accessories of the module.




**FCX-MV-F-AC, FCX-MW-F-AC** Weight: Approx. 95 grams

Unit: mm




Note:

*1) Please make a distance above the electronic components on the PCB for natural air cooling.

*2) Do NOT touch the sensor element during power on. The surface of the sensor element is hot.

*3) Do NOT touch the trimmers on the PC board.

## 10 Caution

Please carefully read the followings before using the oxygen sensor products.

**Applications for medical appliances, life-support equipment and low oxygen detectors**

*1) Fujikura products are not designed, intended or approved for use as components of surgical or life support systems, or other applications that may cause injury or death as a result of failure. In unapproved applications or uses where the customer implies, directly or indirectly, resultant injuries or deaths are due to Fujikura, Fujikura affiliates and agencies (citing for example, a design or manufacture fault), Fujikura, Fujikura affiliates and agencies shall be free from responsibility relating to any claims, costs, losses, and compensation.

*2) When a Fujikura product is to be used in medical appliances and oxygen detectors other than those mentioned above, it is strongly advised that fail-safe designs are established. Fujikura should be consulted for the necessary information.

**Service life and guarantee period**

*1) The end of service life shall be defined as the time when the output no longer meets the specified precision.

*2) The guarantee period is for one year from the date of shipment. During the guarantee period, should defects occur under normal conditions of use as specified in the manual and within the service life, the product will be repaired or replaced without charge. However, a repair or replacement fee will be charged in the following cases.

- Defect or damage due to inappropriate transportation or handling after delivery.
- Defect or damage caused by misuse, abuse or careless handling.
- Defect or damage due to unauthorized repairs or changes in configuration
- Damage to the cosmetic appearance caused during use
- Damage from fire, earthquake, flood or other natural disasters and abnormal voltage.

**Operational precautions**

Measurement of atmospheric gases:

| | |
|---|---|
| Calibration gas | The sensor should be adjusted with a calibration gas that is a mixture of nitrogen, $N_2$ (or argon, Ar) and oxygen, $O_2$. Other balance gases may result in incorrect measurements. |
| Combustible gases | An atmosphere continuing combustible gases such as methane, alcohol, hydrogen and carbon monoxide may cause errors in measurement. Since the sensor element functions at 450°C, gases that ignite below that temperature must not be used. |
| Silicon gases | Never use silicon gases containing siloxane, as these gases react with the sensor and produce oxides, destroying the performance of the sensor over a very short period. |
| Fluorocarbons | Do not use freons and others that contain halogens (F, Cl and Br), as these gasses react with materials inside the sensor and damage the performance. |
| Sulfur oxides and hydrogen | Never use sulfur oxides (SOx) and hydrogen ($H_2$), as they react with the sensor and destroy the performance of the sensor over a very short period. |

Operating conditions:

| | |
|---|---|
| Dust and oil mist | Employ a filter system to eliminate dust and oil mists that clog the sensor and analyzer filter, resulting in problems, measurement errors and incorrect responses. |
| Water and condensation moisture | Contact of the sensor with water may destroy the sensor. Exclude water from the system. |
| Others | ・ Do not touch the sensor mesh while in operation, since the sensor mesh is heated to 50 to 80°C.<br>・ Do not subject the sensor to a shock of 10G or greater which may cause breaks in the wiring and cracks in the sensor chip.<br>・ The sensor element is made of a ceramic material. Never expose it to heat suddenly as this could destroy the element. |

**Others**

Any product described in the catalogues may be altered without prior notice to improve reliability, function or design. Fujikura is not responsible for any incidents due to application of products and circuits described in the catalogues. No Fujikura patents or rights are licensed to a third party.