Quantum Sensor MIJ-14PAR Type2/K2

A sensor for photosynthetic photon flux density

This is MIJ-14PAR type2/K2 without amplifier. The exterior is same as type2 with amplifier; thus 90% of parts are same, but installed passive type temperature compensation circuit instead of amplifier. Simultaneously, by review of optical system, transitional characteristic improved at cosine error (less than 80°) at range of practical use. As a result, MIJ-14PAR type2/K2 is the respond for the demand for high-end PAR sensor.

<Key Features>

○Passive Temperature Compensation Circuit (P.T.C.C). ±0.01%/℃
○By pursuing of incident angle characteristic, MIJ-14PAR provides only ±1.5% error of incident angle characteristic(0～79°) by using large sized diffuser(Made of PTFE R40 which have curved surface) with additional aperture.
○Optical System: Si photodiode+ UVIR filter+ HOYA LB40 (red attenuation)+φ4.0 aperture for light pass antirefelection
○All parts can be separated so that it is possible to do the partial repair.(Only for assembling of bulkhead connector used adhesion bond)
○MIJ-14PAR used watertight type bulkhead connector. The cable is detachable.
○Already installed level gauge on the base. Using three screws for leveling, and it can be fixed by two screws.
○Molecular sieve and silica gel are installed at Internal level gage base. It is easy to change them.

<Technical Specification>

Measuring range	0～5,000μE
Output	Representative value around 9mV at 2300μE, Calibration factor stated as ###.##μE/mV on the label
Thermal characteristic	Less than ±0.01%/℃
Unit of measurement	μE (μmol・S-1・m-2)
Response Speed	0.2μ Sec
Cosine error	< ±1.5% at 0～79° (<-50% peak at 80～89°)
Azimuth error	< ±0.5% over 360° at 60° elevation
Main materials	Main frame: A5052, Coating: Black anodised, diffuser: PTFE
Operating Conditions	-40～80℃
Dimension	Max external diameter:φ54mm、Hight:38.6mm
Weight	sensor part:127g, cable weight:120g
Pin assign	White/Output+、Black/Output-
Price	¥70,000 (without TAX)

<Standard and Option>

Sensor Body	MIJ-14PAR弐型/K2 (StandardTCP without amplifer + 5m cable, Screws for mounting M4-30×2)
Junction cable 5m	MIJ-14CCA

Internal chemichals

watertight type connector

disjointed appearance

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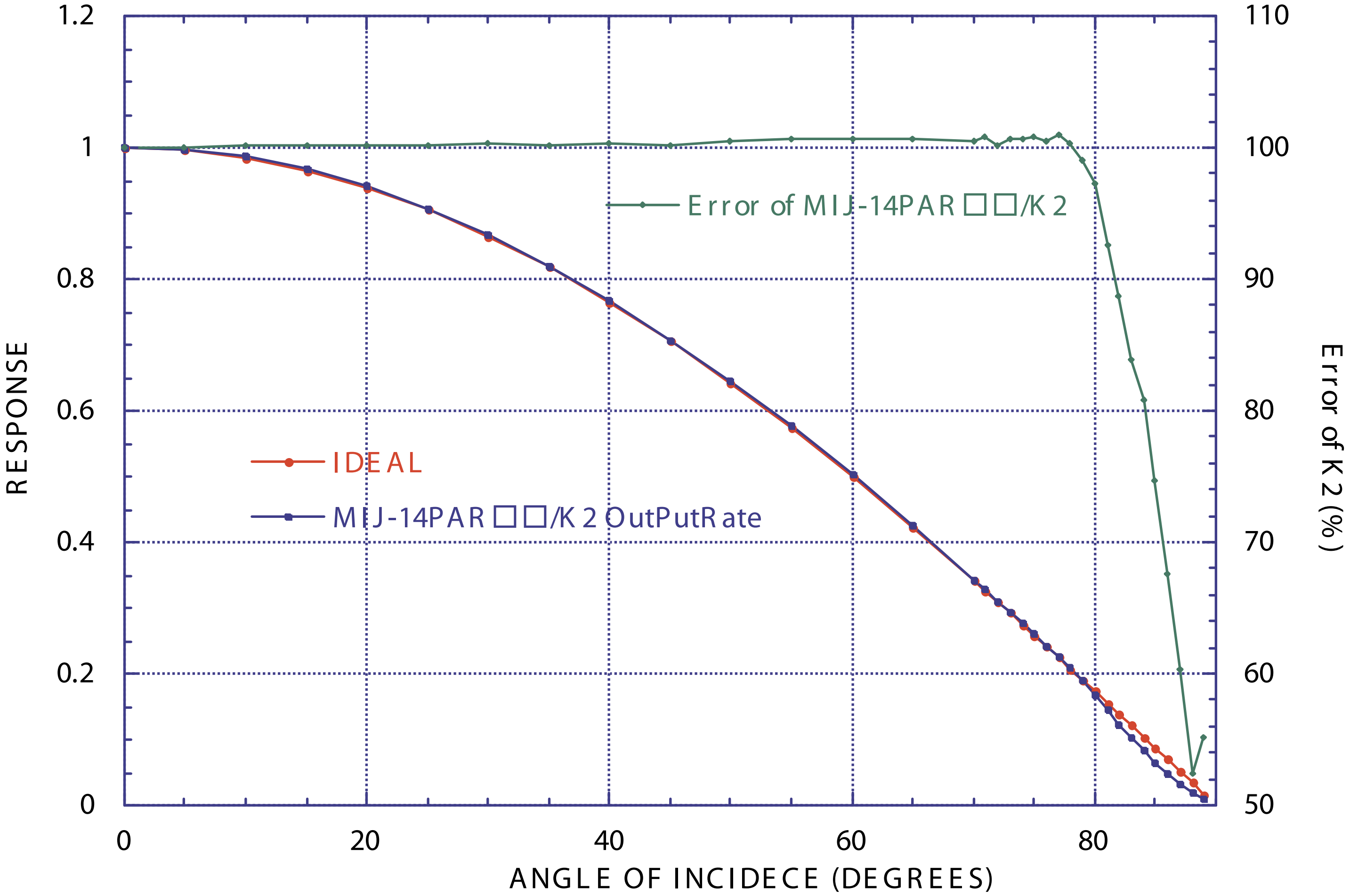
<Cosine error>

Irradiated incident angle from the sunlight to the sensor is changing. Reasons of that is seasonal variation during annual cycle, sunrise to sunset during diurnal rhythm; thus, the incident angle will be changing due to season and time. Therefore, the light sensor must response properly to the incident angle; this is because CAN type and plastic mold typed photodiode are not designed for considering the incident angle. This is the one of the reason that photodiode itself cannot be used for light sensor. To adjust this response depends on the diffuser and shading ring. The geometric design produce high flexibility, but diffuser of MIJ-14 series designed for considering the transmission spectrum, diffusion coefficient, water resistant, machining accuracy limit during mass-production, smooth removal raindrops, and dry deposition. As a result, we chose PTEF for material. Therefore, the shape became φ14mm, ejection hight 1.3mm, surface curvatureR40、minimum wall thickness 4.5mm. Compared to flat designed diffuser, it is true that the curvature causing disadvantage for the incident angle characteristic, but MIJ-14 purposely designed to suppress the overestimation for the lens effect from raindrop and to smooth removal of raindrop. To decide PTFE of minimum wall thickness, from material diffusion coefficient and the test result, verified enough diffusion was limit of 4.0mm; thus decided to 4.5mm. In this case, enough diffusion meaning is if there is no uneveness of light intensity in proportion to incident angle when observed the light that transmitted through diffused plate from the inside of diffused plate then it can be called enough diffusion. As long as filter and photodiode exist under the diffuser, if there is uneveness then it will affect the response of photodiode and cause cosine error. From the test, diffuser bears angle range from 0～80° in regard to incident angle characteristic. If set angle range more than 0～80°, as long as designed like diffusion plate ejected from the main frame then the ideal response will be over estimated(>+100%). On the other hand, if the physical relationship between diffuser and mainframe is flat then as long as not infinite plane then the range will be 15～90° which will consider as underestimated. MIJ-14 set the shield ring around the outside of the diffuser for suppressing these errors; thus, it will bring underestimation.

For the demand of high-end user, we installed φ4.0 aperture to make full flat responce at 0～79° .In fact, this adjustment brought small effect, but this setting is may or may not meaningful.



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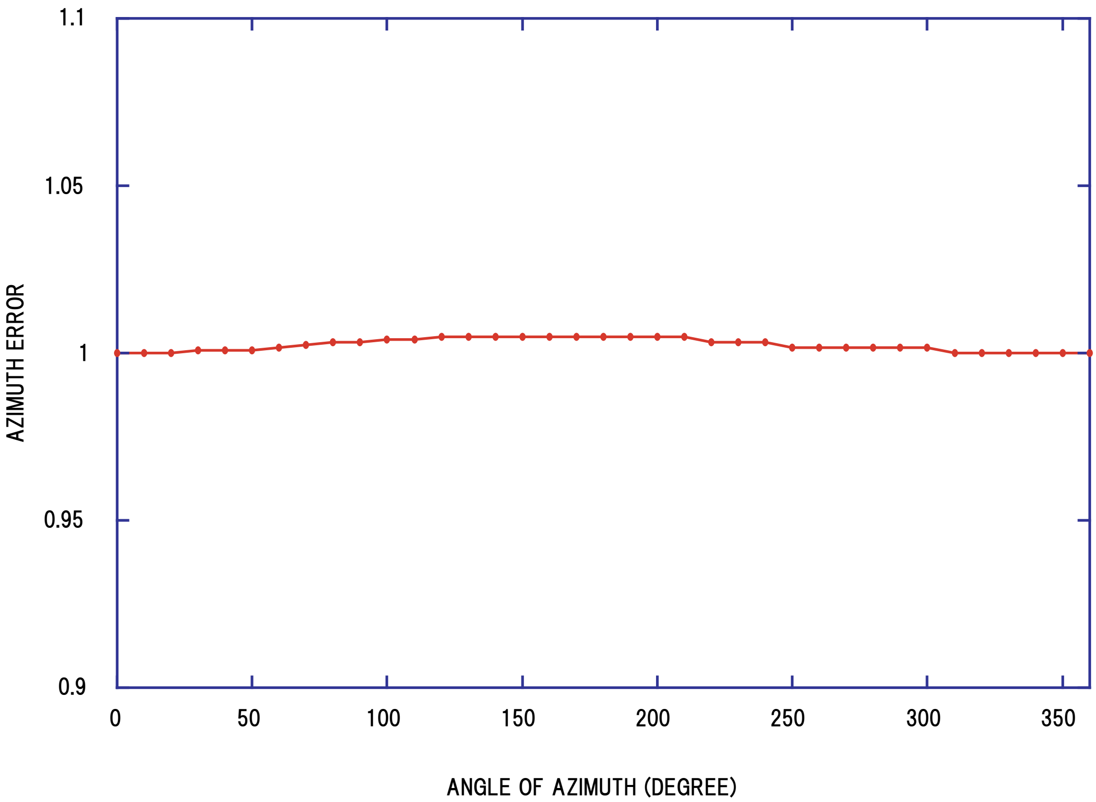
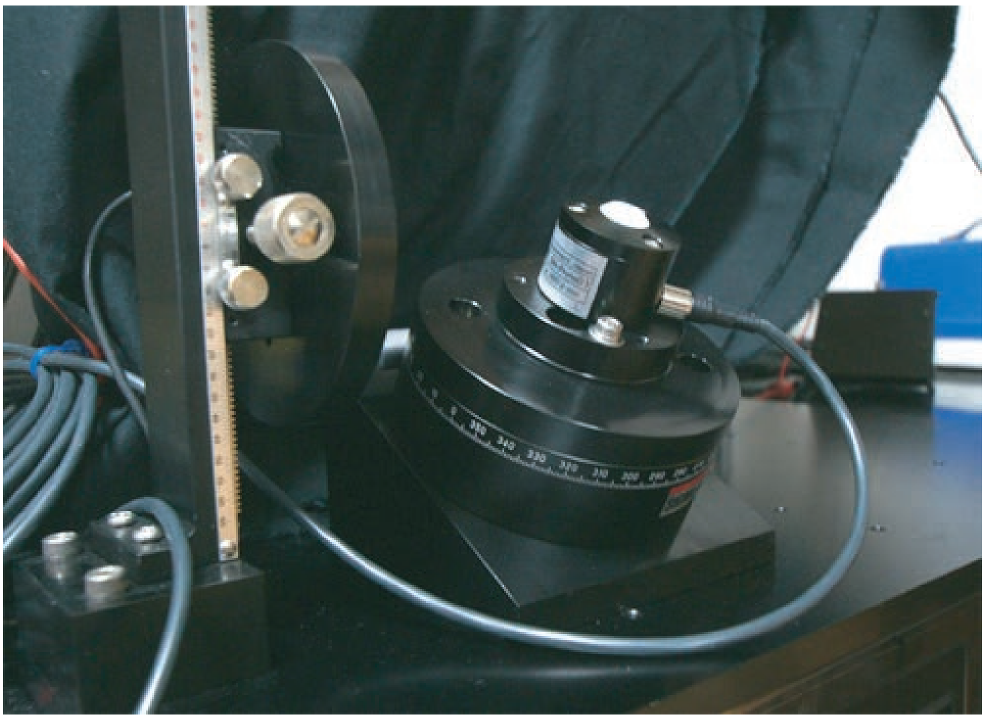
<Twirl angle characteristic・azimuth error>

Changing sensitivity in proportion to twirl angle is ideally completely flat. For the cause of turbulence, because of convenience of manufacturing, normally the light receiving surface of photodiode is square. Therefore, the light will penetrate through the diffuser to the light receiving surface. Thus, in the case of not enough diffusion, the angle to the certain extent, main frame or can wall of photodiode will create the shade so the effective light receiving area will change and also the light sensitivity will change due to twirl angle. Another reason is the machines of machining accuracy. The general tolerance is ±0.05mm; this mean, bigger diffuser make less error; for instance, when diffuser (ϕ8mm) make dimension error of maximu0.05mm then it will cause 0.6% of azimuth error. MIJ-14series consider this point then set to the ϕ14mm. As a result, the turbulence measured value is maximum 0.48%. Below shows MIJ-14 series of azimuth characteristic of slope at 60° and picture of azimuth test instrument.





60° azimuth characteristics test instrument

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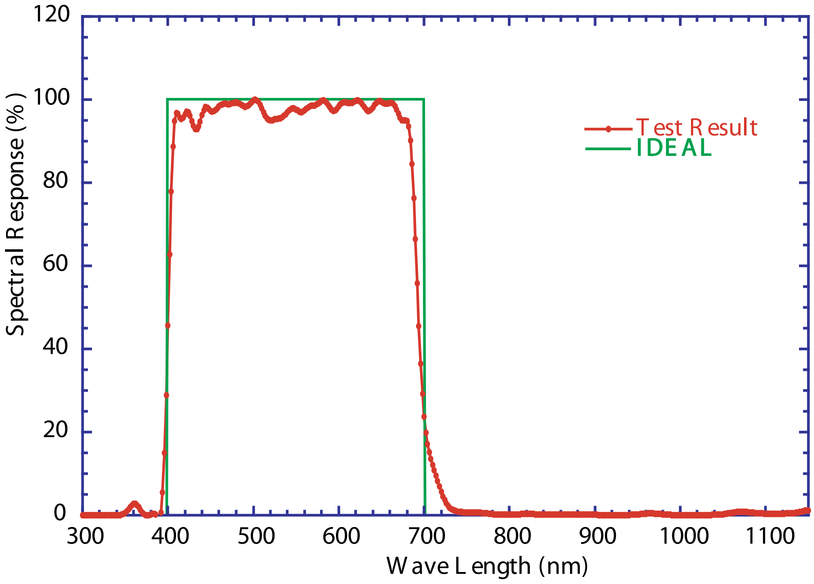
<Wavelength Sensitivity Characteristics・Spectra Error>

Estimation of photosynthetically active radiation (PAR) will be done by measuring 400～700nm of photosynthetic photon flux density (PPFD) . The other side, plant leave will transmit more than 700nm of infrared region of light quantum; therefore, NIR-PFD (Near Infrared Photon Flux Density) ratio will be increased inside of the leave because infrared region is no use for photosynthesis. During the day of clear sky, NIR-PFD /PPFD is about 0.9 but the inside of plant will rise around 6.0; thus, if the sensor which sense the NIR-PFD (even small amount) cannot measure precise PPFD. Type K2 using combination of UV/IR cut off filter + colored glass Hoya-LB40 + Si photo diode as used for Classic type of MIJ14. An actual sensitivity characteristic is shown as below; it shows the mostly ideal characteristic.



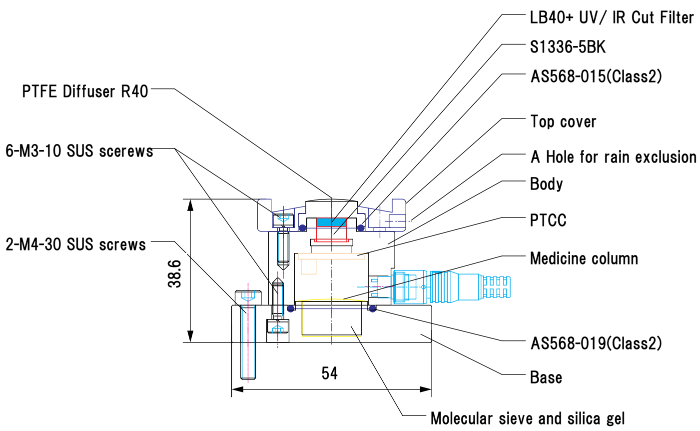
<Cause and Prevention of Sensor Degradation>

General PAR sensor is composed of main frame, acryl diffuser, interior Si photodiode, UV/IR cut filter, blue filter for adjustment the red color sensitivity, and shunt resistor(no shunt resistor in the case of current output). For the aged degradation parts wrote as red color. At the below, wrote the cause of degradation for each parts.

Parts ・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・	Causes ・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・	
1 Diffuser ・・・	・・・・・・・・ UV, Water Vapour,Temperature Change	・・・・・・・・・・・Underestimation for about 2 years, after 2 ye
2 UV/IRcut filter	Water Vapour,Oxidation ・・・・・・・・	・・・・・・・・・・・・・・・・・・・・・・・・・・Underestimation
3 Blue filter ・・	・Water Vapour,Temperature Change ・・・・	・・・・・・・・・・・・・Underestimation

For #1, it shows interesting degradation. The cause of degradation is because of opal (white) acryl which deteriorate from UV. It causes the decline in light transmission which also cause decline in sensor output. In contrast, material itself has hygroscopicity thus it repeats moisture absorption and dry so it results gradual breaking from the surface; therefore, the surface will lose its luster so it will cause decline in reflection coefficient. As a result it will increase the sensor output. Both causes of above fact will offset; thus, some individual will be able to balance but breaking of surface will disturb the shape. For #2 from somewhere, usually water vapor or water enter from tiny space or bonded part of diffusers and it will mix with oxygen inside of frame so it will cause rust of evaporated metal film. Therefore, light transmission of the rusted filter will decline sharply and the disturbance of transmission of spectrum will occur. For # 3, phenomenon in the case of using gelatin filter which used plastic filter and it will cause decline in coefficient of transmission.

MIJ-14 series solved above troubles. For issue #1, used diffuser made of PTFE. The demerit is that impossible to use adhesion bond so require fastening by using O ring, top caver, and screws for cerclage; thus it became high cost. For issue #2, improve quality of the metal deposition itself for the water resistance and also putting drying agent. For #3, it solved by using blue glass filter. For other solution, to fastening base used O ring, and for embedding connector embed with filler for water protection. In addition, set the low gas transmission typed NBR made O ring and put desiccant for the solution of transmitting of tiny amount of aerial water vapor after assembling or setting. Put around 100 of molecular sieve one each of the molecular sieve can dry up to DP-50℃ in the case of 30℃, when 60%RH of water vapor enter inside of dead volume. Moreover, for easy exchange identification put a few silica gel.



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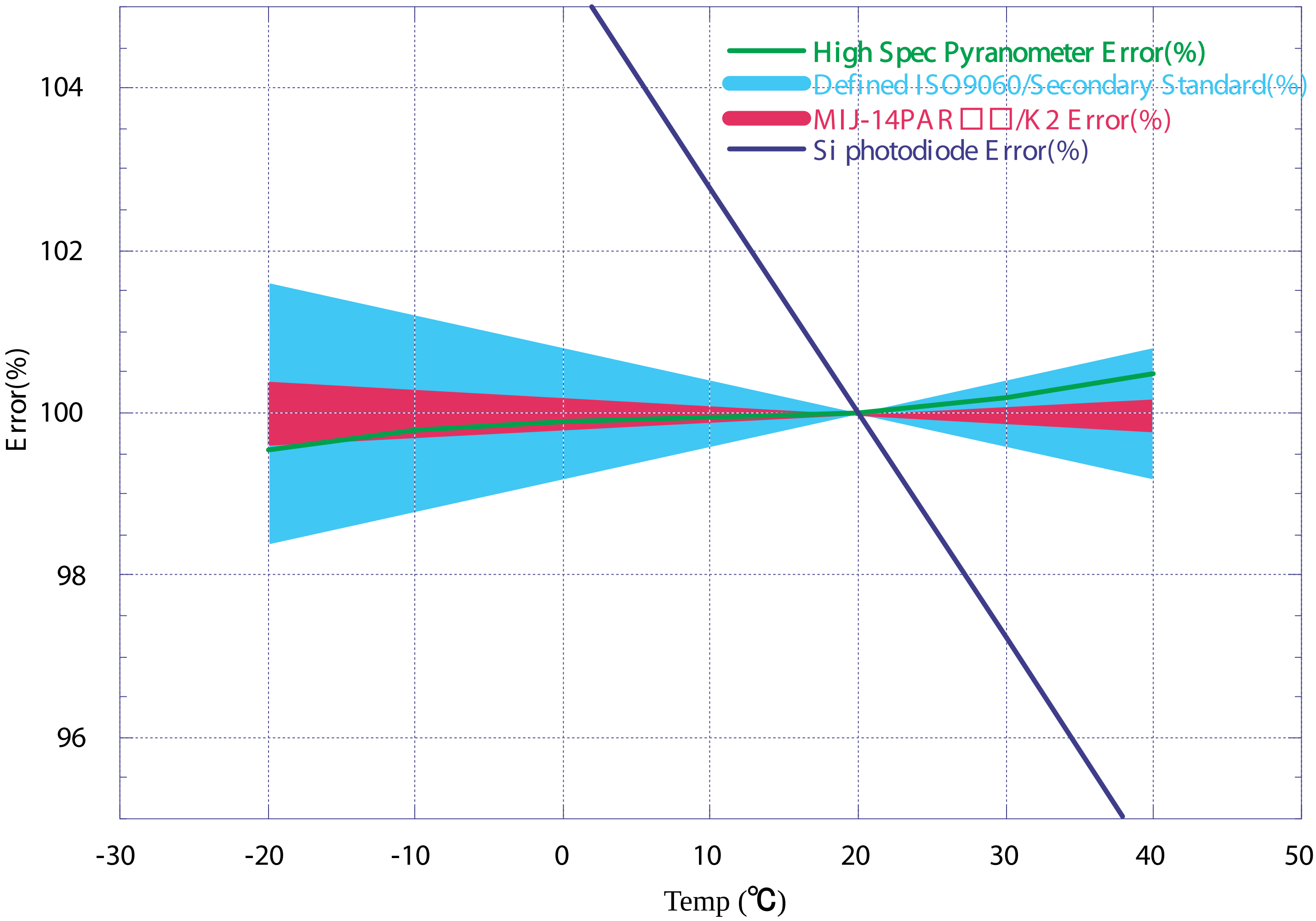
<P.T.C.C (Passive Temperature Compensation Circuit)>

Type K2 using the UV/IR cut filter which superimposed on Si photodiode. The range of light reception set as only 400～700nm among 280～1100nm of the si's light reception. Therefore, this setting leading the negative value for the thermal characteristics, and the actual value shown -0.276%/℃. Environmental temperature change result 30℃ is common range on the annual fluctuation, For instance, if there is the value of 2000μE then the calculation will be 2000μE ×-0.276%/℃÷100%×30℃=165.6μ as you can see the value which showed big error. Up to now, there is no solution for this temperature characteristics and even the thermopile typed Pyranometers, which has 150 years of history and also best ranked among ISO9060 shows 0.04%/℃. In addition, there is the famous Dutch Pyanometer which has best reliability but it shows 0.017%/℃ (Average of -20～40℃). These two results are good result because air temperature and sunlight brings temperature change, which affect the temperature characteristics of cold junction. However, at particular point their products shows good result because although temperature change wil show result as linearity, their products do temperature compenation with thermistors which behave as nonlinnearity. On the other hand, PTCC which installed in type K2 is simply multiply negative linearity of si's temperature characteristics by positive linearity; thus, this way is easier to achieve results. However, there is the characteristics for the PTCC, it cannot influence negative compensate; this is the reason to installed si to type K2. Temperature characteristic of GaAsP element is positive temperature characteristic. The figure below shows Secondary Standard which defined ISO9060, high spec pyranometer, the range of temperature characteristics of K2, and the current value of Si element, which generally used for PAR sensor in the world or shows the temperature characteristic at current value I that resistance jointed in parallel to si and then converted to V.

The spec of type K2 achieved less than 0.01%/℃ in times of mass production. For the temperature error with above mentioned condition, type K2 achieved 2000μE ×±0.01%/℃÷100%×30℃=±6μE. As a reference, it is possible to produce Everest typed of ± 0.001%/℃ by driving this circuit characteristic. However, it requires 5 to 8 times of environmental test and circuit adjustment and feed back with that result on the grounds that it is difficult to mass-produce. Thus we will not actively produce.

Notice: There is not debate is on going for compensation of the temperature characteristics among field of PAR sensor and High spec pyranometer there is big difference of price and also difference of the parameter of measurement so in reality it should not compared to them. Thus, reluctantly explained type K2 compared to pyranometer.



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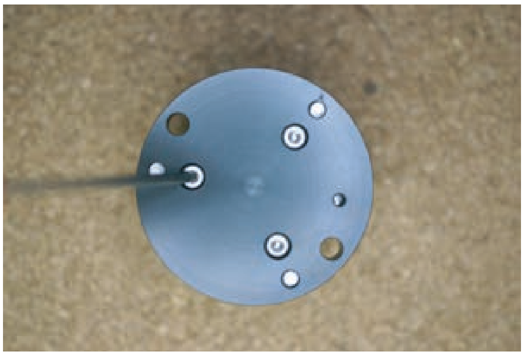
<Maintenance & How to Break Up>
when to change the chemical inside and diffused plate and procedure for both at below.

1. Screw off 3 screws from base parts by using side to side 2.5mm hexagon wrench.



2. Take off the base. Usually the O-ring will be left inside of main body so please do not lose it.

3. Procedure for descant is same as 1 and 2. In this case take off the plastic cap locating on the middle of the level. If you take off the cap directly, there would be the problem that chemical will be drop. To take off the plastic cap properly please see 4 and 5.

4. As showing picture, place the level upside down and then use nail to pull off vertically

5. Inside of the cap there is molecular sieve and silica gel. The molecular sieves will no change color even if they absorb water so only if the color of silica gel were changed then it is time to change the chemicals. Yellow color is indicating dry condition. Assemble reverse procedure above after change chemicals .

6. The diffuse plate can change easily. If you detect big damage then see the procedure below. After changing the diffuser, calibration value will be changed within ±5μE (at 2000 μE). Screw off the 3 screws on the top cover by using side to side 2.5mm hexagon wrench.

7. Please do not touch inner part of UV/IR filter and diffuser. There is O-ring under the diffuser so please do not lose it.

8. Please follow opposite direction for the assembling. Please take care for putting O ring properly. It is better to put Vacuum grease on the O ring this will help to improve water resistance.

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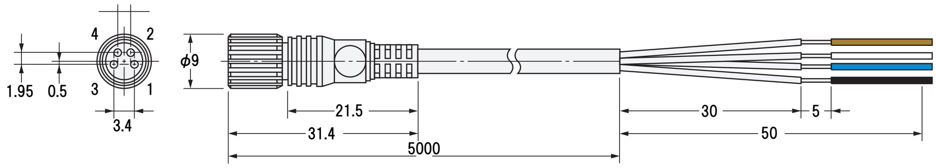
<Wiring to data logger and to others >
The standard version of MIJ-14 Type2 donot requires the power supply. Please follow Pin assign below for the Input of deta logger.

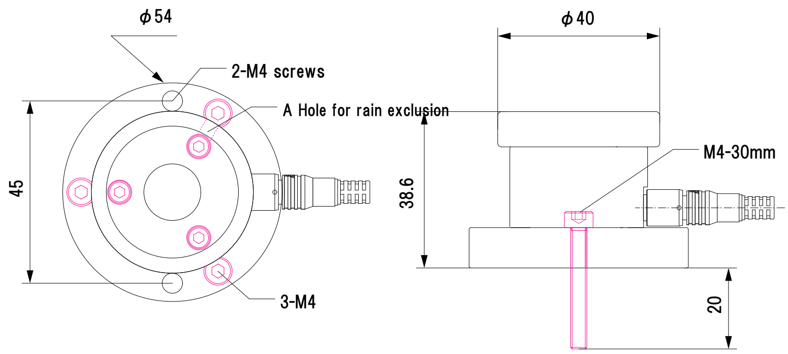
White/ signal +
Black/ signal -

<Converting signal output (mv) to μE (μmol・S-1・m-2)>
Third line of the Body Lable shown the number like 255.55μE/mV, this number is differ for each sensor. Thus, to know the μE, just multiply voltage value by the number on the label.



Wireing for K2
1.BROWN / NOT USE
2.WHITE / SIGNAL POSITIVE+
3.BLUE / NOT USE
4.BLACK / SIGNAL GRAND-

<Set Up>
Set up must be done certainly and need to be fixed horizontally. The base of MIJ-14 will work as the level controller. Set level with three M4 screws which positioned at 120° . For fixing, use 30mm long two M4 screws. As you can see the figure below, there are 2 holes for fixing which is 45mm P.C.D.



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