Quantum Sensor MIJ-14PAR Type2

A sensor for photosynthetic photon flux density

<Key Features>

○By pursuing of incident angle characteristic, MIJ-14PAR provides only ±1.5% error of incident angle characteristic(0～80 degree) by using large sized diffuser(Made of PTFE R=40 which have curved surface).

○Using GaAsP photodiode solved the degradation problem in the case of using Si photodiode + UV/IR cut off filters.

○Spectral error of GaAsP is repressed by using blue filter(red attenuation) HOYA LB40.

○All parts can be separated by easy technic so that it is possible to do the partial repair.(Only for assembling of bulkhead connector used adhesion bond.)

○To avoid the retting from the takeoff parts of the cable, MIJ-14PAR used watertight bulkhead connector. The cable is detachable.

○Output convirsion rate is easy to understand. Internal amplifier keep conditioning all the time to 1mVDC at 1μE; thus, it is possible to do the high precision measurements during dim environment. (e.g.: inside of the tree canopy, sunrise, and sunset hour)

○Zero point will be auto adjusted by Auto Zero circuit, and it will feed back to the measured value at all time.

○Already installed level gauge on the base. Using three screws for leveling, and it can be fixed by two screws. (Not require leveling fixture optional.)

○Molecular sieve and silica gel are installed at Internal of base. It is easy to change them.

<Technical Specification>

Measuring range	0～5,000μE
Output	1.0mVDC at 1.0μE、Max 5000.0mVDC at 5,000.0μE
Noise level	±0.05mV (=±0.05μE) at 0 or at F.S. (S/N ratio 0.001% at F.S.)
Unit of measurement	μE (μmol・S-1・m-2)
Power requirement	6～14VDC, 0.5mA or less
Start up time	0.05 sec from power on
Temperature characteristic	< 0.15%/℃
Incident angle characteristic	< ±1.5% at 0～80° < ±21% at 80～90°
Twirl angle characteristic	Azimuth error : < ±0.5% over 360° at 60° elevation
Main materials	Main frame: A5056, Coating: Black alumite, diffuser: PTFE
Operating Conditions	-20～60℃
Dimention Weight Pinassign	Max External diameter:φ54mm、Hight:38.6mm Sensor part:127g, cable weight:120g White/Output+, Black/Output-, Blue/Power+, Brown/Power-

<Reference Standard and Option>

Sensor Body　MIJ-14PAR type2 (include 5m cable, Screws for mounting M4-30)

Extension cable 5m　MIJ-14CCA

Internal chemichals

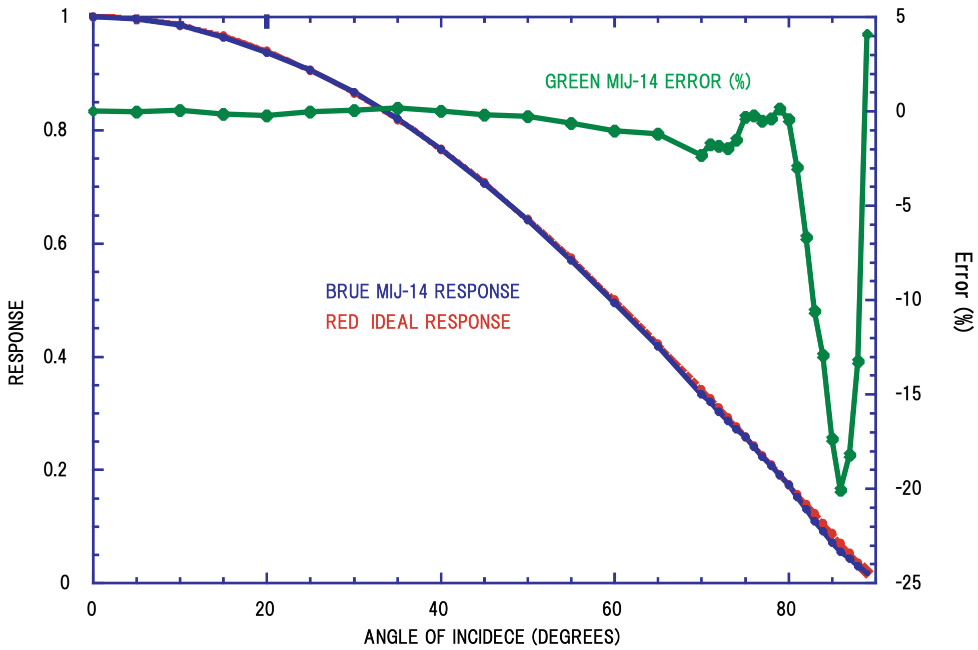
watertight connector

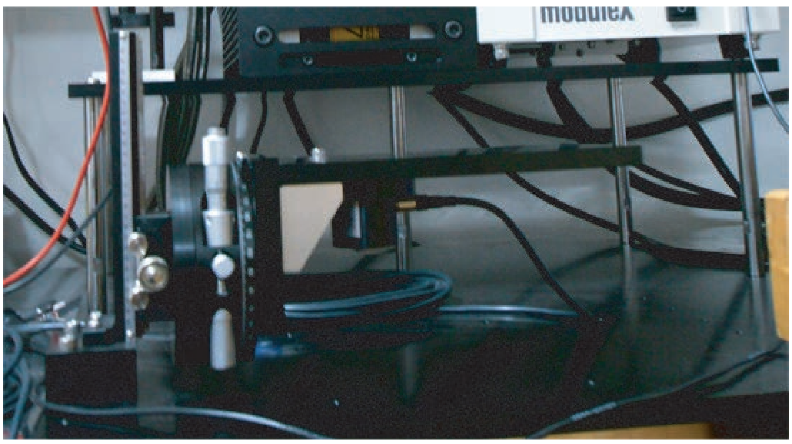
Internal substrate

disjointed appearance

<Incident angle characteristic・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 cosine response is 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, chose PTEF for diffuser. Therefore, the shape became ϕ14mm, ejection length 1.3mm, surface curvature R=40mm, 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-14PAR 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 unevenness 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 unevenness 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 80°, as long as designed like diffuser 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. That's error used as test value range of 80～89° and suppressed error to -20%. In fact, error of -20% is large amount, but there is the fact that when solar elevation lower then direct sun light will be decrease (i.e.direct sun light ratio in Summer time 50% in Winter 10%). When consider these facts, in realistic, the above error will be halved. As a by-product, working as suppressing the light entering that diffused reflected inside of the tree canopy. Below shows MIJ-14series of cosine characteristic at cosine range0～89° and picture of cosine characteristic test instrument.

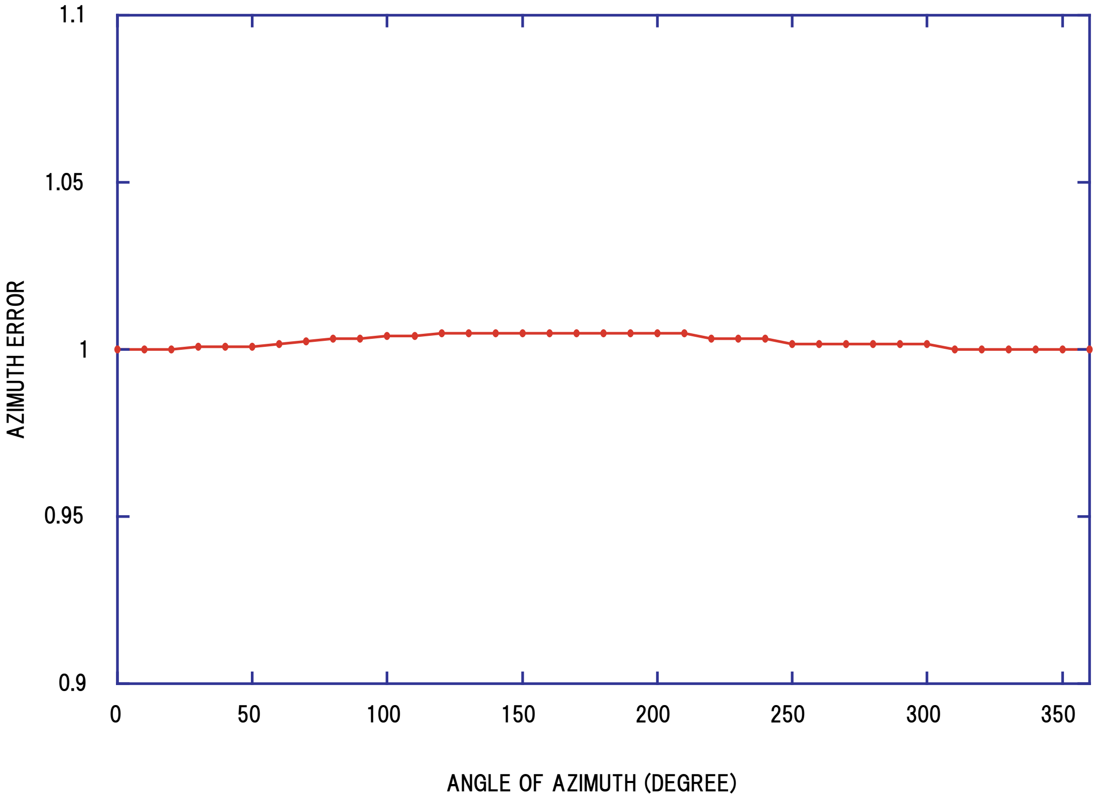


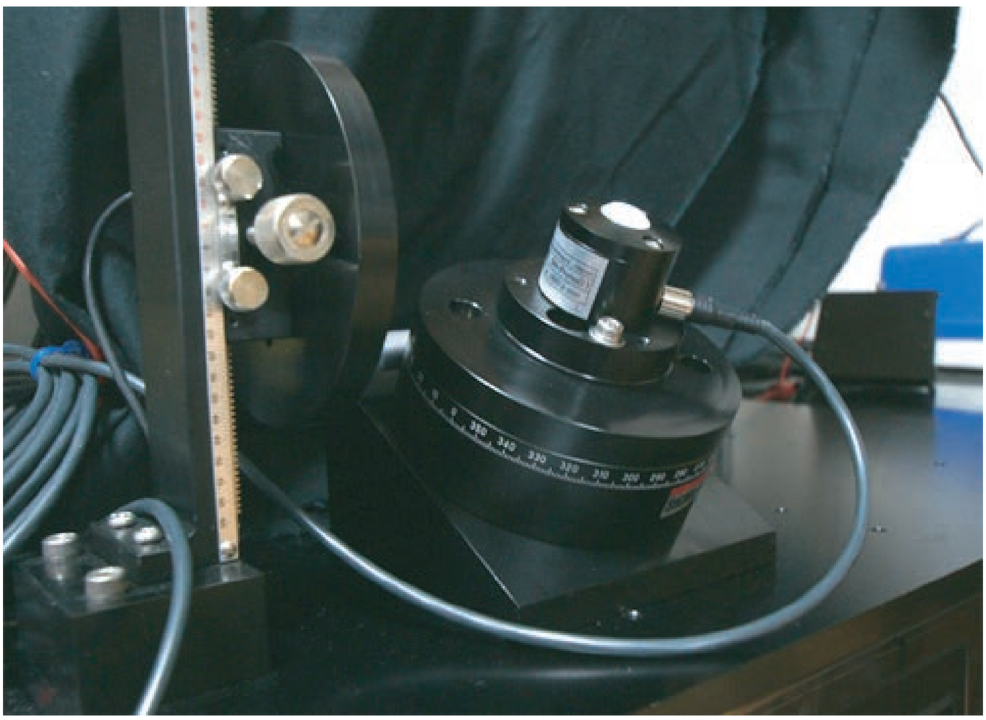


Cosine characteristic test instrument

<Twirl angle characteristic・azimuth error>

Changing sensitivity in proportion to twirl angle is ideally completely flat. Because of convenience of manufacturing, normally the light passive area of photodiode is square. Therefore, the sun light pass through the diffuser to the light passive area. 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 passive area on photodiode 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, measured value is maximum 0.48%. Below shows MIJ-14 series of azimuth characteristic of slope at 60° and picture of azimuth test instrument.

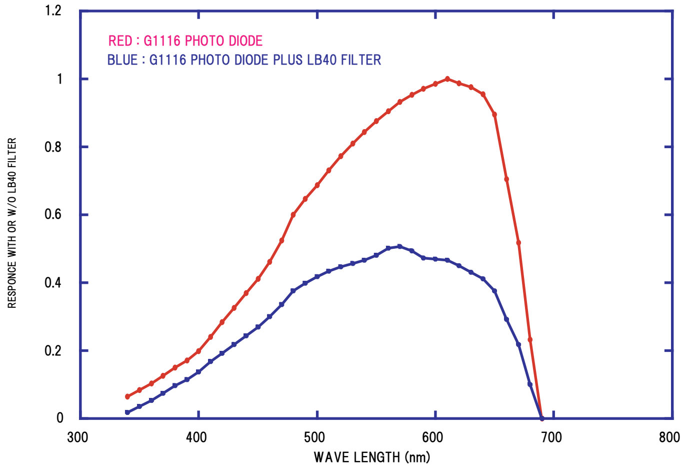




60° azimuth characteristics test instrument

<Wavelength Sensitivity Characteristics・Spectra Error>

Estimation of photosynthetically active radiation (PAR) will be done by measuring 400 to 700 nm of photosynthetic photon flux density (PPFD).The other side, plant leave will transmit more than 700 nm 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. For that reason, there is the particular design that using UV/IR cut off filter to strongly absorb the component of NIR-PFD. However, the Si photodiode of maximum sensitivity for the NIR-PFD range is 800 to 1000nm; thus, optical side effect tend to happen. In addition, UV/IR cut off filter is made by metal coat. It have the characteristic of aged deterioration. On the other hand, GaAsP will not sense the range above 680nm so it does not require using such filter. Usefulness of GaAsP type sensor is verified by many researchers and Pearcy(1989) who is the leader in this area also suggested. Moreover, MIJ-14 series added HOYA-LB40 so it balanced the spectrum sensitivity of 400〜700nm and it suppress the nice spectrum error of fine and rain day.



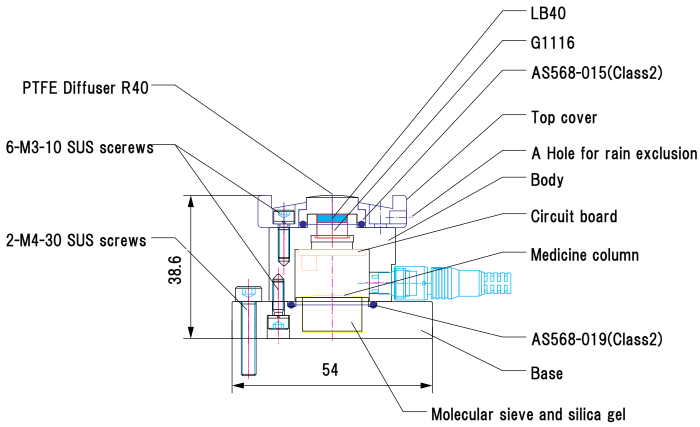
<Cause and Prevention of Sensor Degradation>

General PAR sensor is composed of main frame, acryl diffuser, 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 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 metal coated 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 cover, and screws for cerclage; thus it became high cost. For issue #2, deleted UV/IR filter by using GsAsP photodiode. 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-II O rings 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 which a grain of molecular sieve can dry up to DP-50℃ in the case of 30 degree, 60%RH of water vapor enter inside of dead volume. Moreover, for easy exchange identification put a few silica gel.

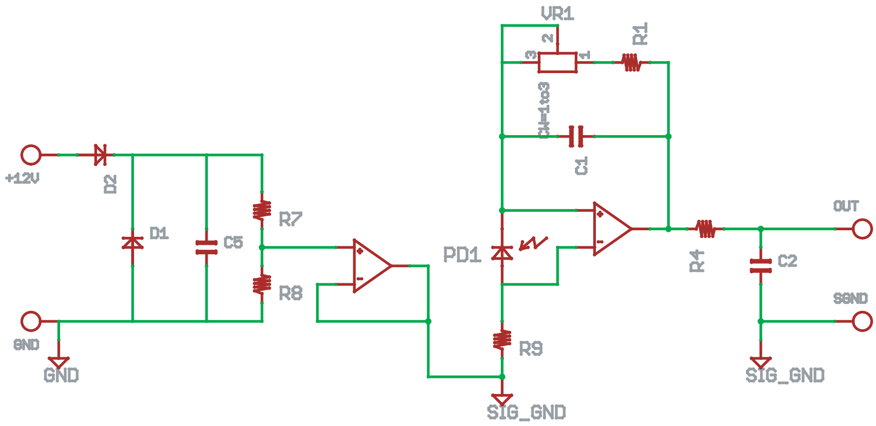


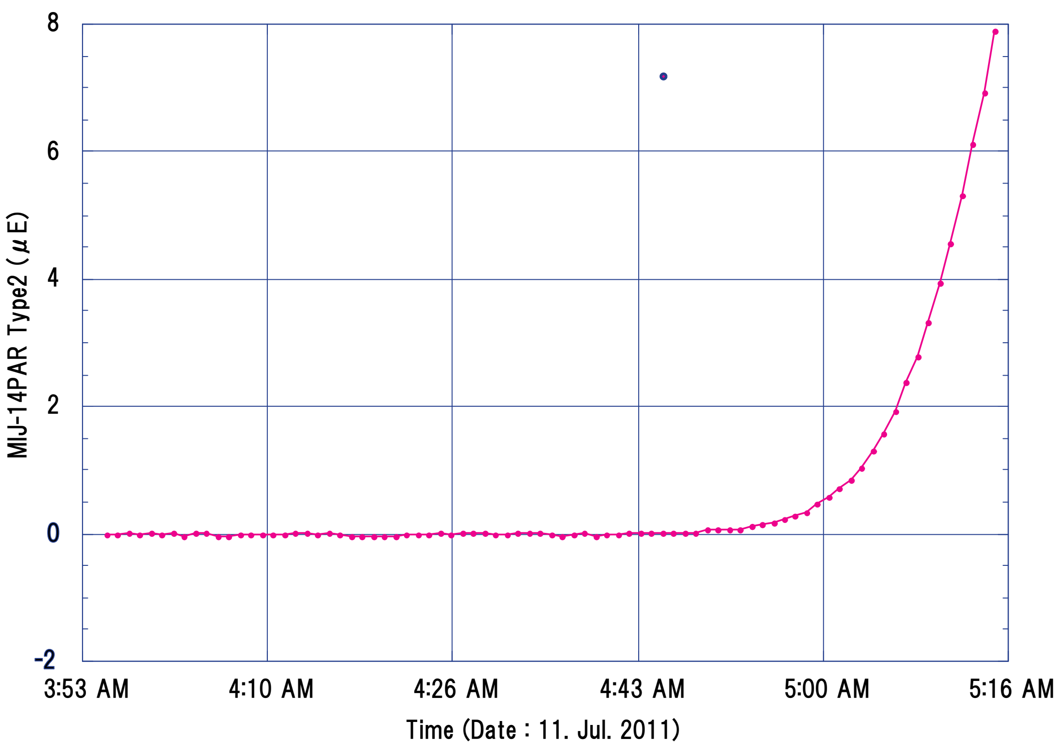
<Internal Amplifier>
Using auto zero amplifier for internal amplifier. It is hard to find general OP amplifier (even low offset product) which have below 0.1mV. If let amplify then offset voltage will doubled so even if using 0.1mV of offset voltage, it can be ten times then it can be used as 1mV offset voltage. In addition, it will affect by temperature drift; thus, there is the disadvantage for outdoor using because of extreme temperature change will occur. The auto zero amplifiers is made for solving these faults by using the dual amplifier which have main amplifier and offset amplifier so that it mutually operating offset adjustment and general signal amplification. It is measuring offset voltage at all time, and it will lower the offset voltage and it has low affectivity from temperature drift this is because it output the feed backed signal as measurements. This is effective for both zero and span points.

The span adjustment during calibration will be done by controlling multi-turn trimmer but trimmer's temperature characteristic is defective so using fixed shunt resistance which have well temperature characteristic and set ratio 60% + trimmer about 40%. As a result, minimize the temperature drift plus make possible to adjust with unit of 0.1mV (0.1 μ mol).

To improve resistance for exogenous noise, mounted the shortest distance (about 4mm) between photodiode and amplifier circuit.

Organized the differential amplification for electric potential difference of at both ends of photodiode; thus, the organization is little different from general amplifier for photodiode. As mentioned above because of the auto zero amplifier, affection of the offset voltage and temperature drift are minimized. In addition, the common mode rejection ratio is higher than general OP amplifier but depending on power environment it may affect by common noise so there may be 0.4 to 1mV offset will be detected. For prevention of the above problem, this device using active ground circuit; thus, reference voltage separated from GND power during differential-input so it successfully achieved the common noise to decrease and output during shield will be less than 0.5mV. General light sensor is often use only electric current/voltage conversion. In this case,F.S.10mV, noise 0.05mV, and S/N ratio is about 0.5%; however, this device's S/N is F.S.5,000mV, noise 0.05mV, and S/N ratio 0.0001%.





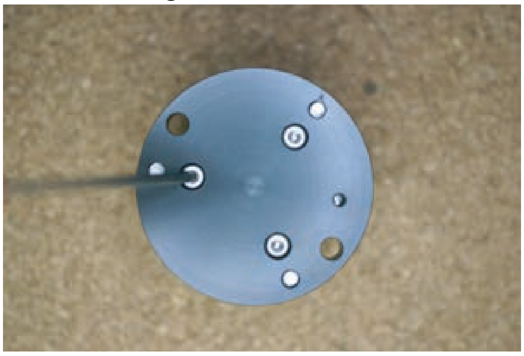
Time	μE	Time	μE
3:55 AM	-0.01	4:35 AM	-0.02
3:56 AM	-0.02	4:36 AM	-0.03
3:57 AM	0.01	4:37 AM	-0.02
3:58 AM	-0.02	4:38 AM	0.01
3:59 AM	0.02	4:39 AM	-0.03
4:00 AM	-0.02	4:40 AM	0.00
4:01 AM	0.01	4:41 AM	-0.02
4:02 AM	-0.03	4:42 AM	0.01
4:03 AM	0.01	4:43 AM	0.03
4:04 AM	0.01	4:44 AM	0.01
4:05 AM	-0.03	4:45 AM	0.03
4:06 AM	-0.04	4:46 AM	0.03
4:07 AM	-0.02	4:47 AM	0.01
4:08 AM	-0.01	4:48 AM	0.01
4:09 AM	-0.02	4:49 AM	0.06
4:10 AM	-0.01	4:50 AM	0.07
4:11 AM	0.00	4:51 AM	0.08
4:12 AM	0.01	4:52 AM	0.07
4:13 AM	0.02	4:53 AM	0.12
4:14 AM	-0.02	4:54 AM	0.16
4:15 AM	0.02	4:55 AM	0.18
4:16 AM	-0.02	4:56 AM	0.23
4:17 AM	-0.03	4:57 AM	0.29
4:18 AM	-0.03	4:58 AM	0.34
4:19 AM	-0.03	4:59 AM	0.47
4:20 AM	-0.03	5:00 AM	0.59
4:21 AM	-0.03	5:01 AM	0.72
4:22 AM	0.00	5:02 AM	0.85
4:23 AM	-0.02	5:03 AM	1.05
4:24 AM	-0.02	5:04 AM	1.30
4:25 AM	0.01	5:05 AM	1.57
4:26 AM	-0.02	5:06 AM	1.94
4:27 AM	0.01	5:07 AM	2.38
4:28 AM	0.01	5:08 AM	2.80
4:29 AM	0.01	5:09 AM	3.33
4:30 AM	-0.02	5:10 AM	3.94
4:31 AM	-0.02	5:11 AM	4.57
4:32 AM	0.01	5:12 AM	5.32
4:33 AM	0.01	5:13 AM	6.12
4:34 AM	0.02	5:14 AM	6.93
		5:15 AM	7.90

Actual measuring example: measured value of noise level & numerical value(μ E)

<Zero&Span adjustment>

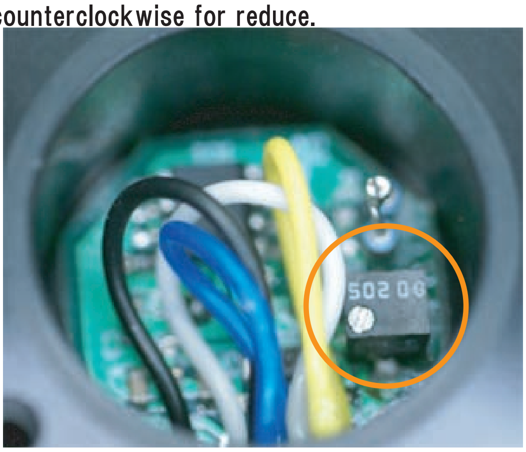
As mentioned above, zero adjustment is unnecessary and cannot do zero adjustment by manually. It is possible to adjust by turning trimmer for the span adjustment. Set MIJ-14upside down position and open the cover and then turn trimmer clockwise direction for raise gain and turn counterclockwise for decrease. However, for this adjustment it already adjusted before shipping from EMJ, so only user can adjust who can prepare standard light source. See below for procedure. It is also showing when to change the chemical inside and diffuser 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. From the top view the connecter should be down side and you will see the trimmer at lower right side. Then use 0.9 to 1.2 mm of flathead screwdriver. The position as picture you can screw clockwise for gain and counterclockwise for reduce.



4. procedure for descant is same as 1 and 2. In this case take off the plastic cap locating on the middle of the level. To take off the plastic cap properly please see 5 and 6.

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

6. Inside of the cap there is molecular sieve and silica gel. The molecular sieves will no change even if they absorb water so only if the color of silica gel were changed then it is time to change the chemicals (Recomend 1 year at usual field condition). Yellow color is indicating dry condition. Assemble reverse procedure above after change chemicals .

7. The diffuser can change easily. If detect big damage then see the procedure below. Screw off the 3 screws on the top cover by using side to side 2.5mm hexagon wrench.

8. Please do not touch blue filter and inner part of diffuser. There is O-ring under the diffuser so please do not lose it.

<Wiring to data logger and to others >
The standard version of MIJ-14 requires the power supply. Wire the DC12V and It's electric power consumption is 0.45mA or less. Correspond to both driving method of Continuous and pre-heat (excitation) so it can use both differential and single end. See below for precaution for wiring to each case.

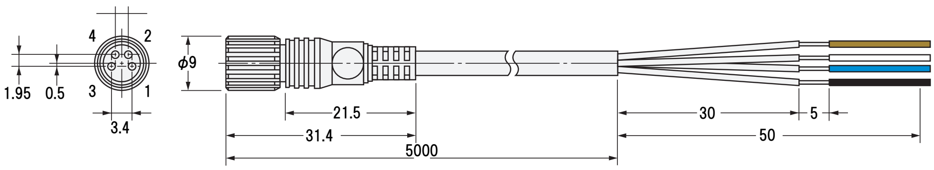
○Differential connection
Ideal connection is the differential connection and it is brown and blue are separated wire.
Brown/Power (DC GRAND)
White/Signal+
Blue/Power+ (+12VDC)
Black/Signal-

○Case of single end connection
Inside of some data logger, the wiring is single end connection. (Brown and black wires are common). In this case, output of MIJ-14 will shift to about +2.5mV (=+2.5μE) . This mean measuring value must be equal to output minus 2.5mV. The same shifting value will occur both zero and span. It is equal to B of Y=AX+B (MIJ-14 consider A=1)

E.g.: 1) Span : Measuring value is 2002.5-2.5=2000.0μE when output is 2002.5mV
E.g.: 2) Zero : Measuring value is2.5-2.5mV=0μE when output is 2.5mV

Brown/Power (COM GRAND)
White/Signal+
Blue/Power+/ (+12VDC)
Black/Signal (COM GRAND)

The value mentioned above is in the case of using 5m standard cable so if extend the cable then the value will change. For easy method, put sensor at dark environment then that value can be regard as shifted value.



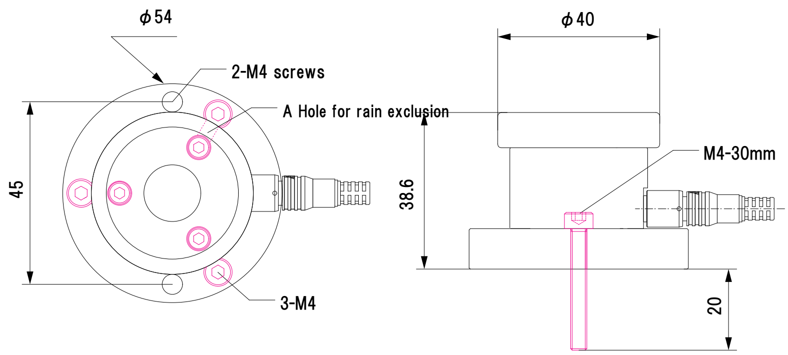
Differential Wireing
1.BROWN / POWER DC GRAND
2.WHITE / SIGNAL POSITIVE+
3.BLUE / POWER +12VDC
4.BLACK / SIGNAL GRAND-

Single-End Wireing
1.BROWN / POWER COM GRAND
2.WHITE / SIGNAL POSITIVE+
3.BLUE / POWER +12VDC
4.BLACK / SIGNAL COM GRAND-

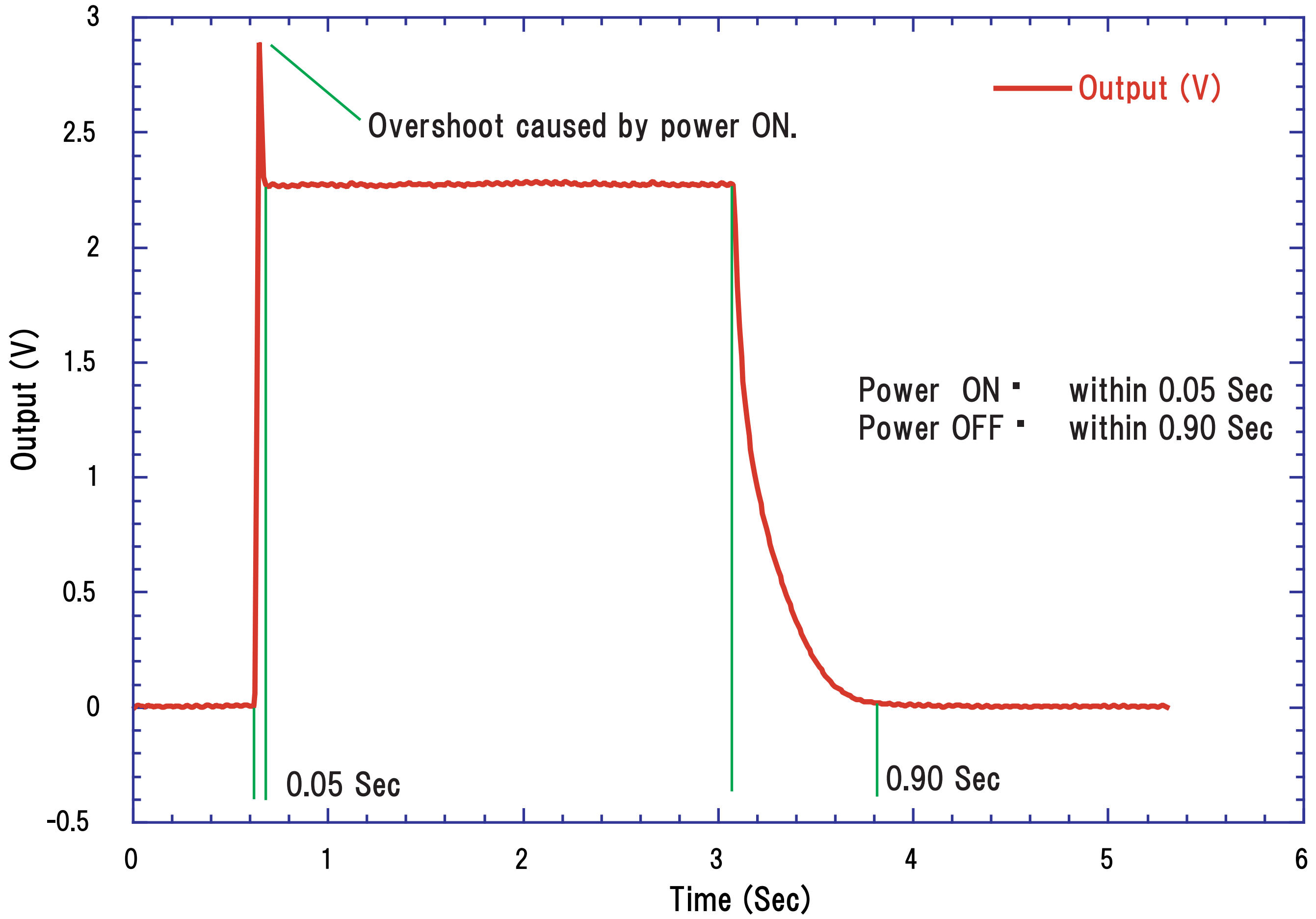
○・Suggested wiring for measuring under the tree canopy (A Hint to measurement using data logger.)
SN is good in MIJ14 series' SN is one of the good thing and special feature, but it depending on resolution of data logger for actual measuring. To measure 2600μE as full scale it requires to set ±5V scale for data logger ; it is possible that with low intensity of resolution 1.22μE in the case of 13bit. In this case, it will spend 2ch. For instance, set range ±5V for 1ch of MIJ14 and set ±20mV for 2ch of MIJ14 then connect the separated output for both channel. Therefore, 2ch will not be able to record when output is larger than 20μE but there is the advantage that it can measure with resolution of 1ch 1.22μE and resolution of 2ch 0.0048μE. The important point is that it is only be able to use in the case of using all channel isolated typed logger.

AD bit	10bit(1024)	12bit(4096)	13bit(8192)	14bit(16384)	16bit(65536)	18bit(262144)
±20mV scale mV/digit	0.0390625	0.009765625	0.004882813	0.002441406	0.000610352	0.000152588
±5V scale mV/digit	9.765625	2.44140625	1.220703125	0.610351563	0.152587891	0.038146973

<Set Up>
Set up must be done certainly and need to be fixed horizontally. The base of MIJ-14 will work as the level. Set level with three M4 screws which positioned at 120° . For fixing use 30mm long two M4 screws. As showing below P.C.D of fixed threaded screw hole is 45mm. For the fixed agent, make φ4～5mm holes at distance of 45mm or make holes of M4 internal-thread then fix.



<Start Up Time & Fall Time（Take care of pre-heating time）>
For valid output value it will be valid value 0.05 sec after turn on the MIJ14 series. MIJ14 have specific characteristic that it will take 0.90 sec to make output zero after turned off.



Response time to stable when the sensor powered ON and OFF.
(Be care. This is not responce for the light intensity chage.)