

Catalogue Solar Monitoring Station

Integrated system for PV Site Evaluation and PV Performance Monitoring



Outline

1. Welcome	3
1.1 Changing demands	4
1.2 Application	5
2. Solar Monitoring Station	6
2.1 Unique system	6
3. System components	8
3.1 Sun Tracker	9
3.2 Pyrheliometer/ DNI Sensor	10
3.3 Pyranometer	11
3.4 Grating Spectroradiometer	14
3.5 Solar Power System	15
3.6 Data Acquisition System	16
3.7 Meteorological Sensor	17
3.8 Total Sky Imager	18
3.9 Solar Monitoring Station configuration	19
4. Global Solar monitoring station.....	210
5. Services	211

EKO's SMS is a fully integrated system for PV Site evaluation and PV Performance

1. Welcome

EKO Instruments unique **Solar Monitoring Station (SMS)** is your primary reference to collect high quality solar irradiance data on site. This Innovative and turn-key system provides all fundamental solar radiation and meteorological parameters needed to contribute to a successful analysis and assesment of the solar resource and PV potential. The SMS can be freely configured to meet all client- and market-specific demands.

As an alternative to the advanced SMS the Global Solar Monitoring Station (SMS-G) for only global radiation measurement is a turn-key but economic solution for site resource assessment.

It is the aim of EKO Instruments to help clients get ahead by developing turn-key research solutions and services for the Photovoltaic and Meteorological markets. With our high level of know-how and latest technologies used in the Photovoltaic measuring equipment and Solar Radiation Sensors we aim to extend clients solar research capabilities in function, accuracy and quality.

Discover the best geographical locations for the exploration of solar power. Prove that the PV power system performs optimally and maximize its profitability. Comply to governmental legislation and provide bankable solar data to the investors.

1.1 Changing demands

The worldwide rapidly growing energy demand and exploration of fossil and renewable energy sources is one of the most important economic and ecologic challenges we face nowadays.

Legislation

Since solar energy turned into a viable alternative to traditional electrical power resources, more and more countries subsidize the installation of solar power plants. Governments do however require periodical accountability. That calls for solar radiation and PV module energy efficiency data, so called conclusive or bankable data.

Investments

Investors and owners of solar power plants are keen to determine the cost versus yield efficiency of PV modules as this provides realistic insight into the return on their investments. Gathering highly accurate solar radiation data is essential to this process.

Quality standards

Within the PV industry technological developments occur at a rapid pace. Clients expect the latest innovations to be present in the products they buy. Also the products must meet their specific requirements and comply with quality standards defined by institutions such as ISO, IEC and ASTM.

The SMS facilitates living up to these changing demands and beyond.

1.2 Application

EKO's Solar Monitoring Stations are designed for **field research** and **on-site evaluation** of solar irradiance conditions at solar power sites (PV, CPV, CSP). It is used as the reference to validate solar power resources and contributes to primary development of more efficient solar cells.

Accurate solar energy statistics are necessary to determine the solar power potential and whether or not a site is suitable to built a solar power plant.



Even at high sunny places, the composition of the atmosphere strongly affects the solar spectral distribution, which will impact on the energy yield and influences the decision for which cell type to be used at a particular site.

Also the ground surface is of great influence. For example, radiation reflects more on snow than on grassland, so the yield efficiency during the year will fluctuate with the season. The SMS accurately pinpoint the solar prospect for certain sites, taking into consideration all environmental factors that affect solar power yield.

Monitoring a PV system by providing reliable data is a valuable asset with respect to quality assurance. Solar cell and module manufacturers also use the SMS as a reference for module life time performance testing outdoors.

Whereas Engineering Procurement Construction (EPC) contractor that build solar power plants use efficiency data provided by the SMS to check if accomplished solar power plants work according to the anticipated module performance specifications.

2. Solar Monitoring Station

To configure a complete solar monitoring station and decide which configuration will be best is not an easy task. It will be time consuming and requires the right expertise like:

- Selecting various components that must be compatible with each other;
- Matching the overall system measurement accuracy or uncertainty versus expectations or requirements;
- Getting the measurement values nicely synchronized in one data-file.

Based on your demands and our expertise, we developed a sophisticated fully integrated Solar Monitoring System.



2.1 Unique system

Turn-key

One provider one solution. The SMS combines pre-qualified compatible components, which have been optimized to create full flexibility. The station is pre-composed, but can be freely configured to meet all client- and market-specific demands.

Easy to use

Research experts don't require specific expertise for installing and operating the SMS. The system data can be easily retrieved and is compatible with most common software programs.

High quality

Maximize the measurement accuracy. State of the art sensors enable end users to achieve their primary research goals.

Obtain the best monitoring solution, simply outsource all configuration tasks and stay focused to solar research

Autonomous

Unattended and remote operation. The SMS is equipped with durable solar and meteorological sensors to guarantee reliable operation and data retrieval at any place on earth. In combination with the solar power system it can be autonomously used at off-grid sites.

Radiation and meteorology

Measure all parameters. Depending on its composition, the Solar Monitoring Station combines all functions to measure radiation components (Global, Direct and Diffuse) and other meteorological parameters (Wind speed, Wind direction, Relative humidity, Atmospheric pressure, Temperature and Cloud cover).

Tailor-made

Customized data format. The SMS data logger will be pre-programmed with a software routine that meets the customer desired data format.

3. System components

Depending on the measuring parameters and required accuracy the SMS can be composed with different components.



3.1 Sun Tracker

STR-21G / STR-22G

From sun rise to sun set EKO's compact Sun-Tracker guarantees accurate sun tracking and pointing of the attached solar sensors.

The 2-axis tracker automatically adjusts to the sun's position due to the sun sensor closed-loop control system; even if the tracker is not oriented or leveled properly.



- Compact, high tracking precision, durable and maintenance free
- Four quadrant sun sensor for closed loop control
- RS-232 serial interface for extended position control and status information
- GPS supported fully automated set up procedure
- 24 VDC low power version available

The Sun Tracker comes with a large size tripod that offers a stable platform for all measurement equipment and puts the solar sensors at a recommended height of 1,75m above the ground.

With the built-in GPS receiver the sun tracker automatically find the solar position and will accurately synchronize the time stamp of the SMS.

Model	STR-21G Single Arm	STR-22G* Double Arm
Pointing accuracy	< 0.01° (Solar Elevation: 0 to 87°)	
Torque	12 Nm	24 (12+12) Nm
Payload	7kg balanced	15kg balanced
Environmental Protection	IP65	
Operating Temperature	-40°C to +50°C	
Communication/interface	RS-232C, 9600bps, 8N1, USB converter	
Dimensions	430(W) x 380(D) x 440(H) mm	
Weight	14.5 kg	15.5 kg
Power requirement	AC 100 to 240V, 50/60Hz, 20W DC 18 to 30V, 15W for DC optional Sun Tracker	

* STR-22G is used in combination with the MB121/122 shading assembly for diffuse measurements.

3.2 Pyrheliometer/ DNI Sensor

MS-56

The ultra fast high precision pyrheliometer detects quick solar radiation changes caused by clouds and aerosols. The ISO 9060 first Class pyrheliometer is a high quality DNI (Direct Normal Incidence) solar radiation sensor with secondary standard specifications.



- Fast response time for instantaneous DNI measurements
- Temperature compensation to minimize detector temperature dependency
- Thermally balanced detector for improved stability
- Low-power 12V window heater prevents dew-deposition or condensation
- Ultra stable detector design and fabrication

In combination with the sun tracker it is used as a reference instrument to measure the direct solar irradiance component which contributes for 80% of the total solar power.

Model	MS-56
Response time (95%)	< 1 sec
Non-Linearity (100-1000W/m ²)	< ±0.2 %
Zero offset (response to 5 K/h change in ambient temperature)	< ±1 W/m ²
Tilt response	< ±0.2 %
Temperature dependency (-20 to +50°C/@20°C)	< ±0.5 %
Non stability (Change per year)	< ±0.5 %
Expected daily uncertainty	< ±1 %
Sensitivity (nominal)	10-20 μV/W/m!
Detector impedance @25°C (nominal)	4 to 6 kΩ
Operating temperature	-40°C to +80°C
Calibration traceability (ISO9847)	WRR
Outer dimensions (Length x Diameter)	217 x 55 mm
Weight	0.6 kg
Full opening view angle	5° ±0.2° (acc. to WMO)
Slope angle	1° ±0.2° (acc. to WMO)
Window heater power	DC12V / 0.5W

3.3 Pyranometer

MS-802 / MS-402 / MS-410 / MS-602

EKO's thermopile pyranometers are used for a variety of applications for routine operation to the most demanding solar measurements of global horizontal (GHI), in plane with the module and diffuse radiation (DHI). The high quality broad band MS-series pyranometers are designed as a solar radiation reference for all photovoltaic research applications.

MS-802

The MS-802 highest class ISO 9060 Secondary Standard pyranometer is a reference solar sensor to measure global radiation with the best performance. Its robust brass mechanical construction makes it a durable sensor suitable to be used in harsh environments in a wide ambient temperature range.



- Fast Response time (95% < 5s)
- Temperature compensated in a wide temperature range
- High quality double optical glass domes for proper cosine response
- MS-802F is a MS-802 with 12 VDC ventilation system to prevent any possible influence of frost, snow and dust.

MS-402

The design of the MS-402 ISO 9060 First Class pyranometer is nearly identical to the Secondary standard MS-802. It is most suitable for routine global, diffuse and Global Normal incidence (GNI) irradiance measurements.

- Response time (95% < 8s)
- Temperature compensated in a wide temperature range
- High quality double optical glass domes for low zero offset
- MS-402F is a MS-402 with 12 VDC ventilation system to prevent any possible influence of frost, snow and dust.

MS-410

The MS-410 pyranometer measures the broadband global solar irradiance. The MS-410 is perfectly suited for the solar radiation flux in horizontal or tilted configurations. The EKO MS-410 provides a perfect balance between cost-effectiveness and quality.



- Light weight Aluminum housing
- Double dome for low zero offset
- Low temperature dependency detector

MS-602

The MS-602 pyranometer is the smallest true thermopile pyranometer within the MS-series. It is the most economic measurement solution for global solar radiation measurements of the full solar spectrum. MS-602 meets the ISO 9060 Second Class performance criteria, however it has an excellent temperature dependency, which can only be found with higher-class pyranometers.



- Most economic true thermopile solution
- Low temperature dependency detector

Specifications MS-Series

Model	MS-802 / (MS-802F)	MS-402 / (MS-402F)	MS-410	MS-602
ISO 9060	Secondary Standard	First Class	First Class	Second Class
Response Time (95%)	< 5 sec	< 8 sec	< 18 sec	< 17 sec
Non-Linearity	< 0.2 %	< 0.2 %	< 1%	< 1.5 %
Zero Off-Set A	< 6 W/m ²	< 6 W/m ²	< 6 W/m ²	< 10 W/m ²
Zero Off-Set B	< 2 W/m ²	< 2 W/m ²	< 2 W/m ²	< 6 W/m ²
Non stability (Change per year)	< 0.5 %	< 0.5 %	< 1.5%	< 1.7 %
Directional Response	< 10 W/m ²	< 20 W/m ²	< 20 W/m ²	< 25 W/m ²
Spectral Response	< 1 %	< 1 %	< 1 %	< ± 1 %
Temperature Response	< 1 %	< 2 %	< 2 %	< 2 %
Tilt Response	< 0.2 %	< 0.2 %	< 2 %	< 2 %
Outer dimensions (Length x Diameter)				
Weight				
Calibration Traceability	WRR			
	Measurement application			
Global (GHI)/ Tilted	■	■	■	■
Diffuse DHI (Sun Tracker Shading device)		■	■	
	Measurement uncertainty			
Daily Total (95%)	< 2.5%	< 3.5%	< 5.5%	< 7.5%
	Application environment			
High ambient temperature	■	■		
Low ambient temperature	■	■		

3.4 Grating Spectroradiometer

MS-700

The compact all weather MS-700 spectroradiometer is unique in many ways. In the SMS it is used as reference instruments for spectral irradiance measurements. At the inside an advanced spectrometer covers a spectral range from 350nm - 1050nm and guarantees a stable output over time.



- Suitable for permanent outdoor usage
- Excellent long-term stability of detector array
- Cosine response due to integrated diffusor and optics
- Low temperature dependency
- Fully controllable by data logger
- High quality calibration and NIST traceable
- DNI version with collimating tube available

The detector unit is temperature controlled at a fixed temperature to maximize the performance in a wide operating temperature range. For solar spectral research, optimizing solar cells and quality assurance on site it is a valuable component that can be adopted to the SMS. It is fully controlled by the data-logger through the serial command interface without the need for a separate PC.

Model	MS-700
Temperature control	25 ± 5°C controlled
Temperature response	±1.0% (range of -20 to +50°C)
Communication interface	RS-232C
Directional response	<±7%
Power requirements	AC 100 to 240 V, 50/60Hz, 50W
Spectral resolution (FWHM)	10nm (data file), 3.3nm (measurement)
Wavelength range	350 to 1050 nm
Weight	4.0 kg
Stray light	< 0.1 %
Exposure time	5 ms to 5 sec, automatically adjustable
Operating temperature	-20°C to +50°C

3.5 Solar Power System

The solar power system is a perfect solution for rich sunny sites where grid power is absent but electrical power is required to power the SMS. Driven by solar power two high efficiency PV panels and back-up batteries provide electrical power to the SMS during daytime and nighttime and extend the operation for several days. When the back-up battery pack gets exhausted the system will shut down in a controlled manner and will automatically recover when the batteries are recharged.



- High energy yield 160 W_{peak}
- Long battery life due to advanced MPPT charger controller
- Adjustable frame to optimize energy yield

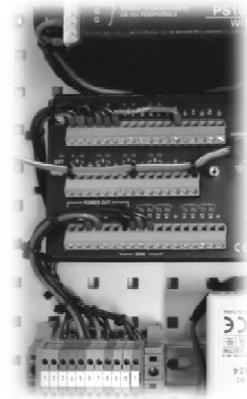
Due to the 160 W_{peak} PV modules and efficient MPPT booster charger, batteries will be recharged much faster than standard commercial back-up power systems.

The Solar Power System includes an AGM 110 Ah 24 VDC battery pack and charger, which are accommodated in an IP-65 enclosure and mounted at the backside of the SMS frame. The 160 W_p solar modules will be orientated south and can be tilted between 25 and 60 degrees solar elevation for a maximum power yield.

Model	SPS-160
Operating temperature	-20°C to +80°C
Weight	100 kg
Battery power capacity	110 Ah / 24 VDC
Back-up battery life	3 days (30 W) / 6 days (15W)

3.6 Data Acquisition System

All sensors that are part of the SMS are connected to the Campbell Scientific CR-1000 multi channel data logger that measures and stores all sensor data according to the customer data format. The CR-1000 is used for its low power consumption, reliability and versatility. The standard internal 4 Mb flash memory gives sufficient capacity to store all data, however memory can be expanded depending on the system requirements.



- Real-time clock by Sun Tracker GPS
- Accurate measurements due to background system calibration and temperature compensation.
- Gas Discharge Tube (GDT) protected inputs against surge
- No data loss due to battery-backed SRAM memory
- Optional communication: TCP/IP, email, FTP, web server.

Various optional data interfaces (Ethernet, GPRS) are available, so that data can be accessed or collected by a PC from any remote location on earth. The data-acquisition system runs from non-interrupted battery power, which is provided by a back-up battery and charger.

The standard Loggernet software provides full flexibility to the operator. The SMS data logger is pre-programmed with our standard measurement routine and can be adapted according to all customer needs. The data acquisition system is pre-configured, cables are pre-connected to the IP-65 enclosure which can be mounted to the pole of the Sun tracker tripod.

Model	CR1000
Analog Inputs	16 single-ended or 8 differential
Communications/Data Storage Ports	1 CS I/O, 1 RS-232, 1 parallel peripheral
Switched 12 Volt	1
Analog Voltage Accuracy	$\pm(0.06\%$ of reading + offset), 0° to 40°C
Analog Resolution	0.33 μ V
Temperature Range: Standard	-25° to +50°
Memory(SRAM)	4 MB (CPU usage, program and data storage)
Back-up battery / DC charger	PS-100

3.7 Meteorological Sensor

WS300, WS500, WS600

The WS-series of Lufft GmbH combines several meteorological parameters like air temperature (T), air pressure (Pb), relative humidity (H), wind direction (Wd), winds speed (Ws) and precipitation (PR) in one compact housing.



- Integrated design with ventilated radiation protection
- UMB, SDI12 serial interface
- Low power consumption

Also the SMS benefits from its low power and easy serial interfacing capabilities, as it requires only one communication channel on the data logger.

Model	WS300	WS500	WS600
	Operating Temp.		
	-50°C to 60°C		
	Operating power		
	24 VDC +/- 10% < 4VA(without heating)		
	Heating		
		20 VA at 24 VDC	40 VA at 24 VDC
	Principle		
	NTC		
T	Measuring range		
	-50°C to 60°C	-30°C to 70°C	-50°C to 60°C
	Accuracy (-20°C...+50°C)	±0.2°C	±0.2°C
	Principle		
	capacitive		
RH	Measuring range		
	0% to 100% RH		
	Accuracy		
	±2% RH		
	Principle		
	MEMS capacitive		
Pbar	Measuring range		
	300 to 1200 hPa		
	Accuracy		
	±1.5hPa		
	Principle		
	Ultrasonic- 2.4Ghz		
Wdir	Measuring range		
		0...359.9°	0...359.9°
	Accuracy		
	±3°		
	Principle		
	Ultrasonic- 2.4Ghz		
Wspeed	Measuring range		
	0...60m/s		
	Accuracy		
	±0.3m/s or ±3% (0...35m/s)		
	Resolution		
	0.01mm		
PR	Measuring range		
	drop size		
	0.3...5mm		
	Reproducibility		
	typ. >90%		

3.8 Total Sky-imager

SRF-01



Including the Total Sky Imager into the SMS, the station can be used for solar forecasting, weather and cloud observations, grid power management and evaluating PV performance. The Total Sky Imager is a fully automatic imaging system that captures cloud cover of the total sky.

- 180° field of view for image of the sky
- Automatic heater ensures clear photo's
- Weather proof housing prevents influence of all weather conditions
- Standalone (8 GB internal non volatile memory) or remote controlled detection system via TCP/IP network

Since clouds and aerosols substantially contribute to the attenuation of solar irradiance at ground level, the sky imager provides quantitative data of the sky conditions on site. When sky images are captured, cloud fraction is automatically calculated by the software. The cloud camera can also be used to monitor the solar position and detect potential shading obstacles at the PV site. The software gives much flexibility and functions for example to define the area of interest by horizon masking and zenith masking.

Model	SRF-01
Controller	Embedded PC
Connection	TCP/IP (Network cable, 10m standard)
Communication Interface	TCP/IP (Only in combination with DAQ Ethernet interface)
Digital camera	color, 2 Mpixel
Sky picture format	JPEG
Data volume	~60MB/day (1 picture @ 10min)
Operating System	Win XP, Win Vista, Win 7, Linux
Dimensions	200mm(W) x 200mm(D) x 200mm(H)
Weight	3 kg
Power requirements	12V/1A (3W/6W (Heating Off/On))
Dome material	Glass
Housing	Weatherproof

3.9 Solar Monitoring Station configuration

The Solar Monitoring Station is a plug and play system. All systems are set-up and pre-programmed according to clients needs and wishes. The diagram below summarizes the possible options for composition of the solar monitoring station, based on application and desired parameters.

	SMS component	Model	Definition
Sun Tracker	Sun Tracker	STR-21G	Single arm tracker with pyrhelimeter mount
		STR-22G	Double arm tracker with pyrhelimeter mount
		MB-121	One ball shading assembly and mounting plate (1 pos.)
		MB-122	Two ball shading assembly and mounting plate (2 pos.)
	Large Size Tripod	LTP-130	130 cm Tripod
		SSA-01	Sensor Side Arm (single arm)
		DSA-02	Sensor Side Arm (double arm)
		PMP-01	Pyranometer mounting plate (MS-802, 402, 410, 602)
	PMP-01	Pyranometer mounting plate (MS-802F, 402F)	
Radiometers	Pyrhelimeter	MS-56	ISO First Class DNI sensor
	Pyranometer	MS-802	ISO Secondary standard
	Pyranometer	MS-402	ISO First Class
	Pyranometer	MS-410	ISO First Class
	Pyranometer	MS-602	ISO Second Class
Solar Power System SPS-01	Battery	POB-110	AGM (2 x) 110 Ah (24 VDC)
	PV modules	PVM-80	(2x) 80 Wp PV modules
	Battery charger	SNS-15	MPPT charger
	Enclosure	ENC-480	IP 65
	Frame	BFR-01	Battery frame
	Frame	MFR-01	Adjustable PV module frame
DAQ system CR-1000	Datalogger	CR-100	CR-1000 Datalogger, RS-232 com
	Back up battery	PS-100	PS-100 (7 Ah / 12V)
	Power supply	POS-24VDC	
	Software	Loggernet	Loggernet PC Operating software (Windows)
	Enclosure	ENC-380	IP 65, Cable glands, Screw terminals, Mounting
	Ethernet Interface		(Optional)
	GPRS Interface		(Optional)
Meteo Sensor	Meteorological sensor	WS300	Temperature, Humidity, Pressure
		WS500	Temperature, Humidity, Pressure, Wind speed / Direction
		WS600	Temperature, Humidity, Pressure, Wind speed / Direction, Precipitation
	Cloud Camera	SRF-01	Cloud fraction

4 Global Solar Monitoring Station

The Global Solar Monitoring Station (SMS-G) for only global radiation measurement is a turn-key but economic solution for site resource assessment. The datalogger with integrated battery, GPRS interface and standard PC software gives easy access to the meteorological and MS-series pyranometer data measured at remote sites. The system is delivered with a tripod and mountings for quick installation and set-up.

Model	CH-4 DAQ
Analog Inputs	4 single-ended
Communications/Data Storage Ports	GPRS / SD card 2 GB
Switched 12 Volt	1
Analog Resolution	0.5 μ V
Temperature Range: Standard	-20° to +50°
Memory	SD card 2 GB (1.000.000 Values)
Back-up battery / DC charger	NiMh, 10Ah integrated
Solar power pack SPP-15	*Optional 15W PV module and charger
Software	*Optional extended software



Model		WMT 52
Wdir	Operating Voltage	5 - 32VDC / 3 mA @ 12V
	Operating temperature	-50°C to 60°C
	Principle	Ultra sonic
	Measuring range	0...360°
Wspeed	Accuracy	\pm 3°
	Principle	Ultra sonic
	Measuring range	0...60m/s
	Accuracy	\pm 0.3m/s or \pm 3% (0...35m/s)



Model		DKRF-300
T	Operating temperature	-50°C to 60°C
	Principle	NTC
	Measuring range	-50°C to 70°C
	Accuracy	\pm 1°C
RH	Principle	Capacitive
	Measuring range	0...100%
	Accuracy	\pm 1%



5. Services

Deliverables

In general it takes about 8 weeks to dispatch the system to the client. All necessary hardware will be delivered as sub-assemblies that are easy to set-up. Just follow a simple installation procedure, connect the cables and start downloading solar data within a few hours.

Guarantee

All EKO solar measurement instruments undergo extensive testing and are delivered to the client with a quality certificate of function compliance.

Consultation & Application Support

EKO provides consulting services regarding the system configuration, data analysis and evaluation methods.

Maintenance

EKO recommends customers to enter a maintenance contract for recalibration services in order to guarantee function and performance.

Re-calibration & Repair Services

It is recommended to recalibrate the instruments once every 2 years for maintaining the sensors in most accurate condition. In case any defects occur, please contact a local EKO office.

Training

EKO offers training on request, both in-house and at a specific location.

Benefit from tailored consulting services regarding system design, data analysis and evaluation methods.

EKO INSTRUMENTS “Quality in Technology”

The company originated in Japan, at the heart of high-tech innovations in renewable energy offer high-quality Photovoltaic and Meteorological measurement instruments, calibration and other customer services.

For many years our experience and knowledge is used in the development and improvement of our products. With offices in Japan, Europe and the USA our products and services are now being used by clients worldwide. EKO Instruments Europe has a strong scientific and technical background, which provides a well-founded understanding of the markets in which we operate and the challenges our clients deal with.

It is our ambition to be consistently engaged with innovative, smart and better solar measurement solutions to meet our clients' demands.

EKO strives to constantly develop through partnerships with clients, leading companies and research institutes, and also participate in international projects and research programs. That way, the EKO knowledge base will be further strengthened and applied to our products and services.

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EKO Instruments B.V. reserves the right to apply technical modifications and / or replace products to the Solar Monitoring Station without prior notice.

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