

34.5/115 kV Solar Power Plant & Substation Senior Design Project

Senior Design Team 18 - May 2024

Siti Mohd Radzi, Baylor Clark, Eduardo Jimenez-Tzompaxtle,
Chicheng Tang, Eli Schaffer, Liam Gossman



BLACK & VEATCH



Agenda

- Safety Moment
- Site Visit
- AutoCAD Drawings
- Voltage Drops



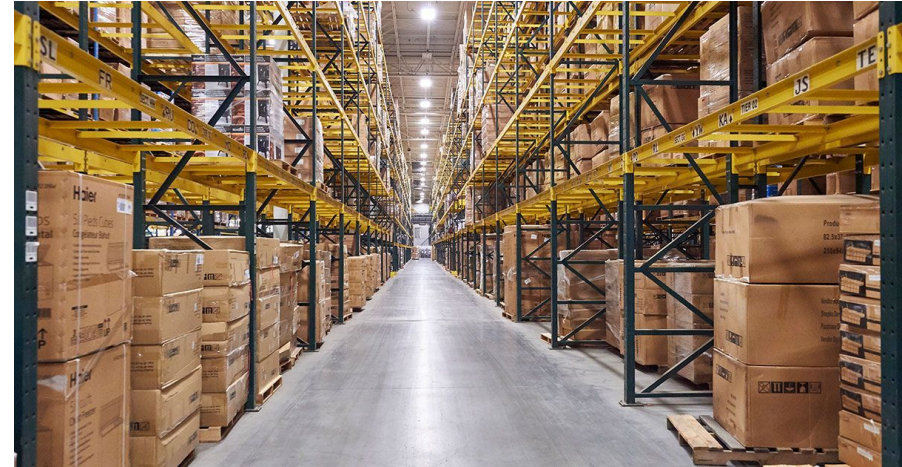
Safety Moment - Piling Stocking and Shelving Hazards

Hazards of improper stocking

- Back injury
- Stricken by equipment or accessories
- Damage to items or racking systems
- Improper securing items cause injury

Preventing hazards

- Correct form of lifting objects
- Heavier items on the lower or middle section
- Sack items on even flat surfaces
- Keep pathways and aisles clean



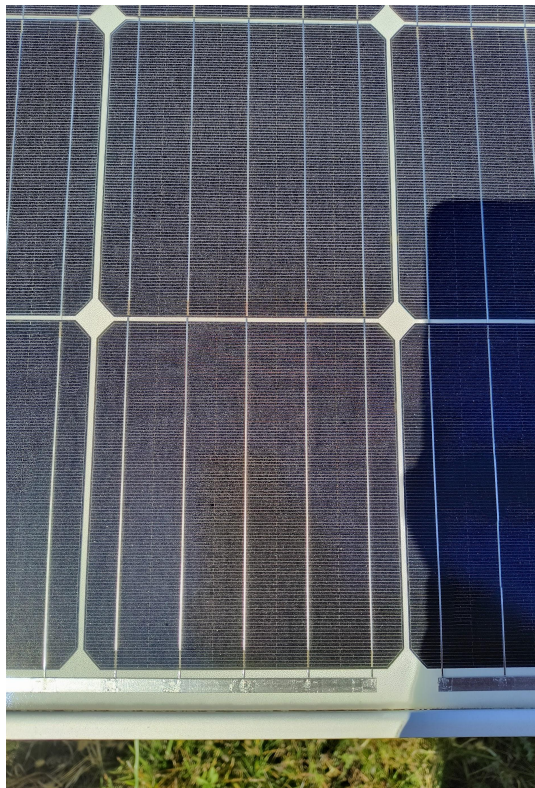
[Link to Image](#)

STATE

Ames Solar Site Visit



Ames Solar Site Visit



Project Title

LOVINGTON, NM SOLAR ARRAY

SPEARS RD & STATE LINE RD, LOVINGTON, NM 88260



PROJECT LOCATION MAP

GENERAL NOTES

1. NOTES

SHEET LIST TABLE

SHEET NUMBER	SHEET TITLE
S100	PROJECT TITLE
S100	SITE PLAN
S101	SITE DETAILS
P1000	SOLAR DESIGN PLAN
P1001	PLACEHOLDER
P1002	SOLAR DESIGN DETAIL
FUTURE	FUTURE
FUTURE	FUTURE
FUTURE	FUTURE

PROJECT EQUIPMENT

TYPE	QUANTITY
PRODUCT	QUAN
PRODUCT	QUAN
PRODUCT	QUAN
PRODUCT	QUAN
PRODUCT	QUAN
PRODUCT	QUAN
PRODUCT	QUAN
PRODUCT	QUAN
PRODUCT	QUAN
PRODUCT	QUAN

General Notes

SIGNATURE & SEAL

REVISIONS

NO.	DESCRIPTION	DATE

IOWA STATE UNIVERSITY
COLLEGE OF ENGINEERING

4100 MARSTON HALL
503 HOWELL STREET
AMES, IA 50011

BLACK & VEATCH

LOVINGTON, NM 88260
(SEA COUNTY)

DATE	BY	CHKD

- Change map size
- Add title block info
- Update sheets
- Add Project info



Panel Datasheet

ZXM7-SHDB144 Series | Zshinesolar 10BBHALF-CELL (6cell)
Monocrystalline PERC PV Module

ZNSHINE SOLAR

(DIMENSIONS OF PV MODULE(mm))

I-V CURVES OF PV MODULE(330W)

P-V CURVES OF PV MODULE(330W)

ELECTRICAL CHARACTERISTICS | STC*

Nominal Power (P _{max}) ⁽¹⁾	330	335	340	345	350	355
Maximum Power Voltage (V _{mp}) ⁽²⁾	41.19	41.38	41.50	41.70	41.88	42.10
Maximum Power Current (I _{mp}) ⁽²⁾	12.91	12.96	13.02	13.07	13.12	13.19
Open Circuit Voltage (V _{oc}) ⁽²⁾	49.40	49.60	49.80	50.00	50.20	50.40
Short Circuit Current (I _{sc}) ⁽²⁾	13.65	13.71	13.77	13.83	13.89	13.95
Module Efficiency (%)	20.52	20.71	20.90	21.10	21.29	21.48

MECHANICAL DATA

Solar cells	Monocrystalline PERC
Cells orientation	144 (6x24)
Module dimension	2279*1134*30mm (with frame)
Weight	21.54 kg
Glass	3.2mm, High Transmission, AR Coated Tempered Glass
Junction box	IP 68, 3 diodes
Cables	4 mm ² , 300 mm (with Connector)
Connectors	MCR-compatible

ELECTRICAL CHARACTERISTICS | NREL*

Maximum Power (P _{max}) ⁽¹⁾	336.40	339.90	403.40	406.80	410.80	414.60
Maximum Power Voltage (V _{mp}) ⁽²⁾	39.28	39.42	39.50	39.60	39.70	39.76
Maximum Power Current (I _{mp}) ⁽²⁾	10.38	10.42	10.47	10.49	10.54	10.61
Open Circuit Voltage (V _{oc}) ⁽²⁾	46.20	46.38	46.50	46.70	46.90	47.10
Short Circuit Current (I _{sc}) ⁽²⁾	11.62	11.67	11.72	11.77	11.82	11.87

TEMPERATURE RATINGS

Temp ⁽¹⁾	40°C, 42°C	Maximum system voltage	1500 V DC
Temperature coefficient of P _{max}	-0.25%/°C	Operating temperature	-30°C~+60°C
Temperature coefficient of V _{oc}	-0.25%/°C	Maximum wind force	60 N
Temperature coefficient of I _{sc}	0.05%/°C	Front Side Maximum Snow Loading	Up to 3000Pa
Anti-Radiation Factor	75%/a	Rear Side Maximum Snow Loading	Up to 2400Pa

WORKING CONDITIONS

Temp⁽¹⁾: Maximum system voltage: 1500 V DC
 Operating temperature: -30°C~+60°C
 Maximum wind force: 60 N
 Front Side Maximum Snow Loading: Up to 3000Pa
 Rear Side Maximum Snow Loading: Up to 2400Pa

ELECTRICAL CHARACTERISTICS WITH 20% REAR SIDE POWER GAIN*

Front power (P _{max}) ⁽¹⁾	330	335	340	345	350	355
Total power (P _{max}) ⁽¹⁾	663	669	675	681	688	694
V _{mp} (P _{total})	41.20	41.40	41.60	41.80	42.00	42.20
I _{mp} (P _{total})	10.08	10.13	10.23	10.30	10.37	10.44
V _{oc} (P _{total})	49.50	49.70	49.90	50.10	50.30	50.50
I _{sc} (P _{total})	13.62	13.70	13.77	13.83	13.92	13.98

PACKAGING CONFIGURATION*

Pieces (Container/RATING)	36
Pieces (Container/RATING)	300

Notes: Specifications included in this datasheet are subject to change without notice. ZNSHINE reserves the right of final interpretation. © ZNSHINE SOLAR 2022 | Version: ZSMT-SHDB144-2203-0
 No special understanding or warranty for the suitability of special purposes being installed without our written consent is granted unless otherwise specifically committed by manufacturer in contract documents.

General Notes

SIGNATURE & SEAL

REVISIONS

NO.	DESCRIPTION	DATE

IOWA STATE UNIVERSITY
 COLLEGE OF ENGINEERING
 825 IOWA ST
 IOWA CITY, IA 52242-1519
 319-335-3000

BLACK & VEATCH

LOVELL DR. 5M BEND
 (IOWA COUNTY)

NO.	REVISION	DATE

- Change file location
- Add title block info



Combiner Box Datasheet

BHSZ 1500V AFCI Combiner BOX

Application

ZIBENY The Arc Fault Interruption Combiner Boxes monitor the current and voltage of each string and the temperature in enclosure. Its integrated automatic circuit breakers triggered when there is arc fault detected. So the PV DC strings will be shut down rapidly. The enclosure provides order PV system safety. The DC circuit breakers can be remotely controlled for easier system maintain.

Appearance Introduction

Type Instruction

B	H	T/S	Z	XX	/	CK	-	R
Manufacturer Code	Emergency Stop	Thermal Protection	Zero-current fault	EMF Number	Order Number	Rated voltage	Number of strings	

Model No.	BHSZ-6/1	BHSZ-15/1	BHSZ-18/1
Max Rated Voltage	1500VDC	1500VDC	1500VDC
Number of Input	6	12	18
Max Input Current Per Each String	15A / 15A / 25A / 25A / 25A		
Connection Type of Input	F100		
Input Cable Size	0M-8mm		
Max Output Current	100A / 125A / 250A	125A / 150A / 250A / 250A	250A / 250A / 315A / 350A
Connection Type of Output	MC4	Commutator	
DC Surge Arrester	4000VDC	T37114-4412 50kA, Impulse 50kA, Upper 1000VDC	
Voltage of Monitoring Device	48VDC	48VDC	48VDC
Voltage of Controller	24VDC (Built-in Power Supply)		
Enclosure	Powder Coated Galvanized Steel	Alu	
Protection Degree	IP65	IP65	
Ambient Temperature	MEW-13 (F60)	-35°C ~ 65°C	
Humidity	0-95%		
Altitude	<2000m (Working > 2000m)		
Installation method	Vertical / Horizontal		
Standard	IEC61851-1 IEC61851-2 IEC61851-3 EN50428		

ZIBENY

General Notes

SIGNATURE & SEAL

REVISIONS

NO.	DESCRIPTION	DATE

IOWA STATE UNIVERSITY
COLLEGE OF ENGINEERING
2525 STATE ST
AMES, IA 50010
WWW.ISTATE.EDU
FOR MORE INFORMATION, VISIT
WWW.ISTATE.EDU/ENGINEERING
OR CONTACT THE COLLEGE OF ENGINEERING
AT 515.281.2121

BLACK & VEATCH

LOVINGTON, NM 86506
(ISA COUNTY)

NO.	DATE	BY	CHKD

- Change file location
- Add title block info

11/13/2024 10:10

11/13/2024 10:10

Skid Inverter Datasheet

12/20/2016

PRODUCT FLYER FOR PV5980-MWS ABB SOLAR INVERTERS

PV5980-MWS

Solar Inverters
Like other ABB central inverters, the PV5980 has been developed on the basis of decades of experience in the industry and proven technology platform. Unrivaled expertise from the world's market and technology leader in frequency converters is the hallmark of this solar inverter series. The PV5980 inverter is one of the most efficient and cost-effective ways of converting the direct current (DC) generated by solar modules into high quality and CO₂ free alternating current (AC) that can be fed into the power distribution network. Two ABB central inverters are used in the ABB megawatt station. The inverters provide high conversion efficiency with low auxiliary power consumption with very low maintenance need.

Transformer
The ABB megawatt station includes an ABB vacuum cast oil dry type or alternatively ABB oil immersed transformer. The transformer is designed to meet the reliability, durability, and efficiency required in PV applications. It is specifically designed and configured for ABB solar inverters to provide the best performance throughout the lifetime of the plant.

As a major global transformer manufacturer, ABB offers a wide range of transformers. Alternate power transformers are available to meet customer requirements. All ABB's transformers are manufactured in accordance with the most demanding industry and international standards.

Switchgear
ABB offers a complete range of medium voltage switchgear for secondary distribution, including air-insulated and gas-insulated switchgear. The ABB megawatt station is equipped, as standard, with the widely proven ABB Sulfiting SF₆-insulated switchgear. Other switchgear are also available.

A sealed steel tank with constant atmospheric conditions ensures a high level of reliability as well as personnel safety. The virtually maintenance-free system comes in a compact and flexible design that allows for a versatile switchgear configuration. As an option ABB's gas-insulated Sulfiting and air-insulated Unisec switchgear are also available.

Technical data and types

Type designation ¹⁾	30399VA, 4-wire star	38189VA, 3-wire star	4000VA, 4-wire star	41829VA, 4-wire star
Maximum rating	4000 kVA	4000 kVA	4000VA	4000 kVA
Input (DC)				
Maximum input power (P _{max})	24200 kWp	2x 2000 kWp	2x2000 kWp	2x2434 kW
DC voltage range, max (U _{DCmax}) @ 25 °C (122 °F)	850...1300V	893...1300 V	935...1300V	978...1300 V
(@ U _{DC} @ 50 °C (122 °F))	150...1300V	893...1300 V	935...1300V	978...1300 V
Maximum operational DC voltage (U _{DC})	1300 V	1300 V	1300 V	1300 V
Number of protected DC inputs (per unit)	2nd type 2 (4x opt)			
Number of string trackers	2			
Output (AC)				
Inverter type (2x ABB central inverter)	PV5980-58-18189VA-L	PV5980-58-1809VA-L	PV5980-58-2000VA-K	PV5980-58-2000VA-L
Nominal AC output power (S _N) @ 50 °C (122 °F)	3636 kVA	3818 kVA	4000VA	4182 kVA
Maximum AC output power (S _{max}) @ 35 °C (93 °F)	4000 kVA	4000 kVA	4000VA	4000 kVA
Medium voltage range (U _{AC})		12 kV to 18 kV ²⁾		
Output frequency	50/60 Hz ³⁾			
Harmonic distortion, current ⁴⁾	< 3%			
Power factor compensation (power)	Yes			
Transformer type	ABB Vacuum cast oil dry type (AFL) or ABB Oil immersed type (OMAN)			
Medium voltage switchgear type ⁵⁾	ABB Sulfiting SF ₆ insulating Gas, Oil or CO ₂			
Efficiency	Painted steel outdoor enclosure, IP54, DC connection protection			
Efficiency				
Maximum converter temp	90 °C			
Euro-std (inverter only)	90 °C			

¹⁾ Where a maximum voltage level, see transformer type, oil or dry
²⁾ Nominal voltage @ 10 kV to 18 kV based on an option
³⁾ At number power
⁴⁾ Other ABB switchgear types available on application

PRODUCT FLYER FOR PV5980-MWS ABB SOLAR INVERTERS

ABB megawatt station design and grid connection

Technical data and types

Type designation ¹⁾	30399VA, 4-wire star	38189VA, 3-wire star	4000VA, 4-wire star	41829VA, 4-wire star
Maximum rating	4000 kVA	4000 kVA	4000VA	4000 kVA
Power consumption ²⁾				
Maximum power consumption	4000 W	4000 W	4000VA	4000 kVA
Standby power consumption	400 W	400 W	400VA	4000 kVA
Auxiliary voltage for customer use	3~ 400V/50 Hz up to 40 kVA			
Dimensions and weight				
Width/height/depth, mm	1230 mm/2000 mm/2440 mm (40" HC container dimensions)			
Weight (approx.)	> 38 t			
Environmental data				
Degree of protection	Inverter IP30/IP54, IL Type 3K, IP44/54 KMG and dry type transformer housing			
Ambient temperature range (range/altitude) ³⁾	-20 °C to +50 °C			
Maximum altitude (above sea level) ⁴⁾	1000 m			
Relative humidity, non-condensing	5% to 95%			
User interface and communications	Inverter's control panel and PC interface through ABB Drive Studio			
Local user interface	Yes			
Fieldbus connectivity	Modbus RTU, TCP, Ethernet, I/P, Profibus			
Product compliance	IEC 60364, IEC 61850-3, IEC 60502-3			
Conformity	ABB Sulfiting SF ₆ insulating Gas, Oil or CO ₂			
Grid support	Reactive power compensation ⁵⁾ , Power reduction, LVWT, HVWT, Fault			

¹⁾ A 30399VA with oil type transformer, 4 1700 W with dry type transformer
²⁾ Excepted power range request
³⁾ Higher altitude option required
⁴⁾ Also depending on type

Signature & Seal

REVISIONS

NO.	DESCRIPTION	DATE

BLACK & VEATCH

LOVELAND, NM 8000
SEA COUNTY

LOVELAND, NM 8000
SEA COUNTY

- Change file location
- Add title block info



Layout of Array

General Notes

SIGNATURE & SEAL

REVISIONS

NO.	DESCRIPTION	DATE

IONIA STATE UNIVERSITY
COLLEGE OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
EDWARD J. MURPHY HALL
410 MARSHALL HALL
550 MARSHALL ROAD
AMES, IA 50011

BLACK & VEATCH

LOWINGTON, IA 50260
LEA COUNTY

CHECK	DATE

- Add title block info



Autocad Site Plan Update



General Notes

SIGNATURE & SEAL

REVISIONS

NO.	DESCRIPTION	DATE

IOWA STATE UNIVERSITY
COLLEGE OF ENGINEERING

4100 HANSTON HALL
533 MORSELL ROAD
AMES, IA 50011

BLACK & VEATCH

LOUINGTON, NM 88260
BSEA COUNTY

DATE	BY
10/06/2021	
11-21	

SITE PLAN

1" = 30'



Voltage-Drop calculations

- In accordance with the National Electric Code (2017 NEC 210.19), an ideally designed solar array should be able to keep voltage drop below 3%.
- Voltage drop reduces the efficiency of the solar energy system. Using small wires and having a long wiring run may lead to potential power losses and cause the solar energy system to not live up to its expected power needs. Even though it is impossible to completely eliminate voltage drop, minimizing it below 3% should be enough to eliminate any significant energy loss and maintain the solar efficiency.
- Parameters set up by referring to NEC Table 8 Conductor Properties and NEC AWG Chart

Excel Sheet for Voltage Drop



A1:F3 Voltage-Drop Calculation = <3%

	A	B	C	D	E	F	G	H	I	J	K	L	M
6													
7	DCB	Strings per rack	ISC for string	String length	String wire size	String conductor resistance	String resistance	Voltage drop of string	Voltage drop of string	IMP for jumper	Jumper Length	Jumper wire size	Jumper resistance
8	DCB##-##	per rack	Amp	feet	AWG	ohm/kft	ohm	Volts	Volts	Amp	feet	AWG	Ohm
9	DCB1-01	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
10	DCB1-02	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
11	DCB1-03	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
12	DCB1-04	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
13	DCB1-05	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
14	DCB1-06	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
15	DCB1-07	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
16	DCB1-08	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
17	DCB1-09	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
18	DCB1-10	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
19	DCB1-11	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
20	DCB1-12	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
21	DCB1-13	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
22	DCB1-14	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
23	DCB1-15	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			
24	DCB1-16	1	13.89	93	14/12	2.525/1.588	0.2348/0.1476	6.5234385	4.10266152	13.89			

	DCB	No. of Rack Inputs	IMP For DCB Circuit	Feeder Length	Feeder wire size	Feeder resistance	Feeder resistance	Voltage drop for feeder	Voltage drop for feeder	Voltage drop for circuit	VMP for circuit	Voltage drop for circuit
29	DCB##-##	#	Amp	Feet	kcmil	Ohm/kft	Ohm	Volt	per cent	Volt	Volt	per cent
30	DCB1	16	222.24								1500	
31	DCB2	16	222.24								1500	
32	DCB3	16	222.24								1500	
33	DCB4	16	222.24								1500	
34	DCB5	16	222.24								1500	
35	DCB6	16	222.24								1500	
36	DCB7	16	222.24								1500	
37	DCB8	16	222.24								1500	
38	DCB9	16	222.24								1500	
39	DCB10	16	222.24								1500	
40	DCB11	16	222.24								1500	
41	DCB12	14	222.24								1500	
42	DCB13	14	222.24								1500	
43	DCB14	16	222.24								1500	
44	DCB15	16	222.24								1500	
45	DCB16	16	222.24								1500	
46	DCB17	16	222.24								1500	

https://docs.google.com/spreadsheets/d/1FV_eP3owzE4OOfz0dbgijHGbeqEIAQ8JDo wW-ktVsm4/edit?usp=sharing

Feedback and Updates

- Looks good
- Include as much as we can w/ Details
- Possible 1-axis tilt or fixed - next week - Chicheng
- Liam - Overall Array Layout
- Eli - Sheet Setup/Title
- Baylor - Site Plan
- Eduardo - Typical Array Layout
- Bell - Voltage Drops (if applicable)/Cost Analysis

