APPENDIX-1

DISPLAY FAULT ANALYSIS

The second line of the screen shows the alarms that have been raised. If no alarms are active, the message. 'No Faults' is shown. The possible faults and their meanings are as follows:

Sl. No	DISPLAY FAULT	MEANS	CAUSE	ACTION
1	**LO AC Volts**	Low Mains Voltage.	The voltage on the grid source that was on-line was too low and out of range and the source has been disconnected.	**1.** Check whether Mains is available or not. **2.** If fault remain persists contact our Technical personnel.
2	**HI AC Volts**	High Mains Voltage	The voltage from the source that was on-line was too high and out of range and the source has been disconnected.	**3.** Some time grid voltage comes out of range. And cross the maximum permissible voltage. Check the voltage and wait till mains come within range.
3	**HI Inverter Volts**	The inverter voltage became high and out of range.	The fault could have been caused by the inverter voltage tolerance settings being narrower than the source voltage tolerance and the inverter was set up to track the source voltage.	**4.** Reduce your source high voltage tolerance. The inverter may not operate continuously at more than ±2% of its nominal voltage rating (at standalone mode) and +10%/-20% (In synch mode). **5.** Menu/factory setting/Min Mains voltage and Max Mains Voltage. **6.** Contact our Technical Support **7.** Note: The inverter will attempt restart 3 times after every 1 minute to clear this fault. If fault is not cleared the inverter will shut down.
4	**Inv. Trip**	The Inverter current exceeded its safety limit.	Sometime system get abrupt changes in itself, it can be due to high current change during synchronization, short circuit at connected load, battery beyond to its DOD level, Overload.	**8.** Make sure if there is no any short circuit. It can be damage system. **9.** Check DC voltage, whether it is above to its end cell voltage. **10.** Press Reset button on main display. System will try to start again. **11.** Contact our technical personnel, if needed. **12.** Note: The inverter will attempt restart 3 times after every 1 minute to clear this fault. If fault is not cleared the inverter will shut down.
5	**HI AC Load**	The apparent power of the load exceeded the overload limits	The load on the inverter exceeds the inverter rating. The inverter will have stopped to prevent overheating or damage to itself.	**13.** Reduce Load and press Reset button. **14.** If problem continue contact to our technical personnel. **15.** Note: The inverter will attempt restart 3 times after every 1 minute to clear this fault. If fault is not cleared the inverter will shut down.
6	**HI AC AMPS**	The Inverter current exceeded beyond limit.	The system has detected a high current or dc voltage disturbance and has temporarily shut down. This fault is similar to a current limit fault except that it could not be traced to a specific line. This fault could also be caused if the battery voltage rises	**16.** Carry out Fault Reset **17.** Contact Technical Support. **18.** Note: The inverter will attempt restart 3 times after every 1 minute to clear this fault. If fault is not cleared the inverter will shut down.

			above the hardware protection but is still below the high dc voltage setting.	
7	**LO DC Volts**	Battery is heavily discharge d	This fault could be occurs when there is no Solar and grid available for many time. Internal losses of the battery down its gravity. Then battery is not able to start the inverter.	**19.** Charge battery immediately to prevent permanent damage.
8	**HI DC Volts**	The Battery voltage sensing is reporting an invalid measurem ent.	The battery voltage has exceeded its safe high limit. The solar regulator will be tripped and if the fault persists the source will be masked. If the condition still persists the inverter is masked eventually.	**20.** Make sure that there are no external DC sources (solar/wind) that are not controlled by the HBD System that could cause the battery to overcharge. **21.** If fault continues contact Technical Support
9	**HI Temp**	Cabinet ambient temperatur e is high	The inverter heat sink temperature on this system is too high and the inverter has shut down to protect itself again permanent damage. System gets tripped and supply load in bypass mode.	**22.** Reduce the load for 15 minutes so that temperature can lower. **23.** Check for any wiring damaged. **24.** Contact our Technical personnel.
10	**Inv. Temp Sense**	The Inverter heat sink temperatur e is too high to operate the Inverter	The inverter heat sink temperature on this system is too high and the inverter has shut down to protect itself again permanent damage. System gets tripped and supply load in bypass mode.	**25.**. Reduce load and Wait 15 minutes for heat sink to cool and carry out Fault Reset. **26.** If fault continues contact Technical Support **27.** Note: The inverter will attempt restart 3 times after every 1 minute to clear this fault. If fault is not cleared the inverter will shut down.
11	**LO AC Freq**	Low AC Source Frequency	The frequency from the source that was on-line was too high and out of range and the source has been disconnected. If the source was a generator then the system will attempt to start and connect to it four times. If the fault is still present the system selects another generator as the source.	**28.** Repair or replace source. **29.** If fault continues contact Technical Support
12	**HI AC Freq**	High AC Source Frequency	The frequency from the source that was on-line was too high and out of range and the source has been disconnected. If the source was a generator then the system will attempt to start and connect to it four times. If the fault is still present the system selects another generator as the source.	**30.** Repair or replace source. **31.** If fault continues contact Technical personnel.
13	**Batt. Temp Sense**	High Battery Temperatu	The battery temperature is too high. The system should automatically reduce the battery voltage in an	**32.** Disconnect batteries **33.** Wait 15 minutes for battery to cool. **34.** If fault continues contact Technical

		re	attempt to regulate the battery temperature. This requires the battery temperature compensation and charge voltages to be set up correctly. If the temperature cannot be regulated the system will trip the solar regulator in an attempt to reduce the battery temperature. If still unsuccessful the system will mask the inverter and continue running off a source.	personnel.
14	**DC Offset**		The Inverter control is experiencing an excessively large DC offset.	**35.** Contact our technical personnel.
15	**COMMS Fail**	Communication fails.	The Inverter controller is not communicating with the supervisory system.	**36.** Open front door and check is the wire, FRC Cable for any loose or damage. **37.** Contact our technical personnel.
16	**MAINS Relay**	The Mains changeover relay is not engaging	‘-	**38.** Contact our technical personnel.
17	**Phase rotation**		There might be phase difference more than 120 degree between all three phases. System will not synchronize with grid.	**39.** Make sure there is proper phase difference between R,Y and B. **40.** Contact to our technical personnel.

APPENDIX-2

SYSTEM CONFIGURATION

1. Float & Boost Charging Setup

Path: Menu> Float & Boost Charging Setup
Press# Mode/Ack to enter sub menu. And use +/- buttons to set the parameter.
SECURED MENU CODE-100(default)

Parameter	Meaning	Value
Float Voltage	It is trickle charging voltage, which provides when battery gets full charge, to fulfill its internal losses and to keep battery at top up level.	Refer “Initial settings Chart”
Bulk Voltage	Bulk voltage provides until battery gets full charge at constant current.	Refer “Initial settings Chart”
Bulk Restart Voltage	Voltage at bulk cycle restarts.	Refer “Initial settings Chart”
Bulk Time out	Maximum amount of time to remain in bulk cycle	1 hour
Absorb time out	Total time of absorb charging	1 hour
Boost Voltage	This voltage provides periodically, It provides when battery get deep discharged or to equalize per cell voltage.	Refer “Initial settings Chart”
Auto Boost Time	Boost cycle time at which auto boost charging apply	30days
Boost Time out	Total time of boost charging	4 hour
Mains Volts Slow charging	Not for use	Do not change default value
Mains Volts stop charging	Not for use	Do not change default value
Charging eff.	Not for use	Do not change default value

2. ALARM & TRIP SETTING

Path: Menu> Press# (+/-) button>Alarm & Trip Setting.
Press# Mode/Ack to enter sub menu. And use +/- buttons to set the parameter.
SECURED MENU CODE-100(default)

Parameter	Meaning	Value
LO Volts Alarm	Battery low voltage Alarm	Do not change default value
LO Volts alarm time	Low voltage alarm duration	Do not change default value
HI Volts Alarm	Battery high voltage Alarm	Do not change default value
HI Volts Alarm time	Low voltage alarm duration	Do not change default value
Load threshold	It defines Minimum power before load is considered present (inverter) Minimum array power before disconnection (Grid Feed)	2% of rated capacity

3. BATTERY TEST SETUP

Path: Menu> Press# (+/-) button> Battery Test Setup.

Press# Mode/Ack to enter sub menu. And use +/- buttons to set the parameter.

SECURED MENU CODE-100(default)

Parameter	Meaning	Value
Battery test	Not for use	Do not change default value
Max. Impedance	Not for use	Do not change default value
Battery Test Cycle	Not for use	Do not change default value

4. INHIBIT & LATCH SETTINGS

Path: Menu> Press# (+/-) button> Inhibit & latchSettings.

Press# Mode/Ack to enter sub menu. And use +/- buttons to set the parameter.

SECURED MENU CODE-100(default)

Parameter	Meaning	Value
Temp comp Enable	Enable battery temperature compensation	Off
Boost Enable	Enable boost equalization	Off
Fahrenheit Enable	Temperature unit configuration	Off
Genset Enable	Enables automatic Genset changeover if mains is not present	Off
Flash Amber	Not for use	Off
Auto Batt Test	Not for use	Off
Auto Start	Enable inverter's automatic starting	On
Schedule Export	Enables automatically scheduled grid export	On
Schedule Charge	Enables automatically scheduled battery charging	On
Charge Inhibit	Enables automatic inhibit of battery charging	On
Schedule Island	Enables automatic grid disconnection	On
Monitor inputs	Not for use	Off
Aux. Batt Amps Sense	Not for use	Off
Island Needs mains present	Not for use	Off
Island initially	Not for use	On
AVR Enable	Not for use	Off
Backlight Timer	Display standby timing. Display light will be automatically off after 5 minute.	On
Extend Logging	Not for use	Off

5. SYSTEM DEFINATION SETUP

Path: Menu> Press# (+/-) button > System Definition Setup.

Press# Mode/Ack to enter sub menu. And use +/- buttons to set the parameter.

SECURED MENU CODE-100(default)

Parameter	Meaning	Value
Serial No.	System Serial Number	
Temp Comp Factor	Not for use	3.00mV
No. Cells	No. of cell of battery	Half of battery voltage
MPPT min	Minimum voltage at which MPPT start work	Refer “Appendix-8 or 9”
MPPT max	Maximum voltage at which MPPT can work	Refer “Appendix-8 or 9”
Global Scan period	MPPT tracking period	3600sec
New Security code	Here user can define its own secured code, if needed. Please contact to technical personnel before any change.	Do not change it without our permission

6. METER CALIBRATION

Path: Menu> Press# (+/-) button> Meter Calibration.
Press# Mode/Ack to enter sub menu. And use +/- buttons to set the parameter.
SECURED MENU CODE-100(default)

Parameter	Meaning	Value
Battery Volt Call	Not for use	Do not change default value
Batt. Amp. Call off sets	Not for use	5.0
Batt Amp. Cal	Not for use	5.0

7. COMMUNICATION SETUP

Path: Menu> Press# (+/-) button>Communication Setup.
Press# Mode/Ack to enter sub menu. And use +/- buttons to set the parameter.
SECURED MENU CODE-100(default)

Parameter	Meaning	Value
SMA Bus Enable	1	Off
ModBus Addr	Modbus Address of Supervisory	001
Baud Rate	For internal uses	9600
DNP3 Addr	Not for use	Do not change default value
Ethernet DHCP		
Local IP Addr		
Local IP Mask		
Gateway IP Addr		
Client IP Addr		
Client IP Mask		
SMTP Server IP Addr		
SMS Prefix		
SMS Suffix		
Access PIN CODE		
Report period		
Log Period		

8. AUTO SCHEDULE SETTINGS

Path: Menu> Press# (+) button (7 times)> Auto Schedule Settings.
Press# Mode/Ack to enter sub menu. And use +/- buttons to set the parameter.

Parameter	Meaning	Value
AC Charge On Lv1	It is minimum voltage at which grid start to charge battery system if battery is under voltage	Refer chart provided in “section 4.3”
AC Charge Off Lv1	It is maximum voltage at which grid start to charge battery system if battery is full charged.	Refer chart provided in “section 4.3”
Event1 Time *	*** Note : These features are available in selected models at extra cost. Extra hardware/ software modules are required to implement these features** Programs scheduled event to occur daily at the nominated time. The event can be charge inhibit (inhibit), charge, export, off, island or standby.	
Event 1 Type *		
Event 2 Time *		
Event 2 Type *		
Event 3 Time *		
Event 3 Type *		
Event 4 Time *		
Event 4 Type *		
Event5 Time *		
Event 5 Type *		
Event 6 Time *		
Event 6 Type *		
Event 7 Time *		
Event 7 Type *		
Event 8 Time *		
Event 8 Type *		
Export Watts	Maximum amount of real power that can be exported to the bus to maintain the Battery voltage.	Refer chart provided in “section 4.3”
Export VARs	Sets the number of constant VARs to inject during grid support mode.	0
Min SOC Export%	Sets the minimum state of charge that the battery is allowed to operate to during scheduled grid disconnect and scheduled grid export operation. This prevents excessive battery cycling, extending battery life.	0%
Min SOC Island%	The level at which inverter should stop feeding the load	0%
Charge Inhibit time	Sets the minimum number of minutes to inhibit the charging if the charge inhibit line is asserted and the released.	50 minute
Schedule test	Enables schedules to occur on every second day rather than every day. For testing purposes.	Off
Import Ramp time	Sets the number of seconds the system should take to ramp to maximum charging power.	60 Sec
Export Ramp Time	Sets the number of seconds the system should take to ramp to maximum export power.	4 Sec

9. **FACTORY SETTINGS**

Path: Menu> Press# (+) button (8 times)> Factory Settings.

Press# Mode/Ack to enter sub menu. And use +/- buttons to set the parameter.

SECURED MENU CODE-200(default)

Parameter	Meaning	Value
System Type	It define System Type	2
Max. Batt. Current	Maximum current permissible for battery charging. This set points control the maximum amount of combined renewable and Inverter charging current into battery.	"See "AAPENIX-3"
Nominal Voltage	It is the recommended operating voltage given by the manufacturer. It is always in safety region of rated voltage	240V
Min Mains voltage	It is minimum rated voltage at which system is designed. Below the minimum level of this parameter system does not connect with grid.	-20% of Nominal voltage
Max Mains voltage	It is maximum rated voltage at which system is designed. Below the minimum level of this parameter system does not connect with grid.	10% of Nominal Voltage
Min Mains Freq	It is minimum rated frequency at which system is designed. Below the minimum level of this parameter system does not connect with grid.	-5% of Nominal Frequency
Max Mains Freq	It is maximum rated frequency at which system is designed. Below the minimum level of this parameter system does not connect with grid.	5% of Nominal Frequency
Mains Loss delay	Not for use	Do not change default value
Balancing Current	Not for use	Do not change default value

APPENDIX-3

HOW TO SELECT OPERATING MODE OF YOUR CHOICE

In Chapter 7 of this manual, we have discussed in detail about the various OPERATING MODES available in Hybrid Inverters and their working. The three operating modes namely OFF GRID, HYBRID and HYBRID WITH EXPORT have their own advantages and disadvantages. Hence, each of them should be duly considered before setting.

The main purpose of this APPENDIX-3 is to discuss how we can switch from one OPERATING MODE to other. But first it is very important to understand when to choose any OPERATING MODE out of the three options available. Hence we will first discuss the pros and cons of each of the three modes:

1. OFF-GRID MODE:

1. Order of Priority here is PV > Battery > Grid.
2. Lesser consumption of grid power which is used only if PV and Battery are not able to meet the load demand.
3. Good for areas where grid is available all the time of the power cut is at a fixed time of the day. This is because grid should be available at the time when PV and battery are no more available.
4. Number of charge-discharge cycle of battery is high which may cause battery end-of-life to reach soon.
5. Incase of weak grid availability this may not be a good option. Grid may be available when battery is getting discharged. Once batteries are drained, grid may or may not be available. This may lead to complete black outs.
6. Chances are high that battery may remain in shallow charge condition ultimately leading to shorter battery life.
7. In case of rainy season, grid shall charge battery and once charged, inverter shall take over and again batteries shall get discharged. Hence the overall losses involved due to Power Electronics are double. Hence to deliver the same units to the load, more grid units shall be consumed.

2. HYBRID MODE:

1. Order of Priority is PV > Grid > Battery.
2. Grid power will be given preference over battery in case PV power is not able to meet load demand
3. Grid output synchronizes with inverter output and hence shares the load demand.
4. Battery remains in top of charge as long as grid is available and hence has a longer life.
5. Lesser number of charge discharge cycles increases the battery life.
6. Lesser chances of power blackout because battery is always the last alternative.
7. Better system efficiency because PV charges the battery and grid caters to loads and hence inverter conversion efficiencies are not involved in normal scenario.
8. In this mode, surge loads do not cause any stress on inverter or battery as the peaks of the surge is shared by the grid supply.
9. In case of widely varying Grid, load end voltage varies just like the Grid voltage. This is because the inverter voltage tracks the grid voltage for synchronization. This may not be good for some sensitive appliances. A fix to this problem is by reducing the grid window range as per requirement.
10. Grid units consumed may be high in areas where there are no power cuts and loads are also partial. Solution to this is the following discussed mode.
11. In case of partial loads and battery charged, there are chances that PV power is available but not getting utilized. This will lead to poor PV generation as power export is not allowed.

3. HYBRID MODE WITH EXPORT:

1. Order of Priority is PV > Grid > Battery along with export of PV power allowed.
2. This mode is same as hybrid mode with the additional feature of allowing PV power being exported beyond the grid terminals. To explain this further, PV power will be used to charge battery and cater to loads. In case of deficit, grid will share the burden. In case PV power is excess and not being utilized then it will be exported in to the grid terminals.
3. This mode should be permitted only if net metering is allowed in the building or the over load building loads are very high as compared to the PV connected so that all the PV power is consumed within the building and no PV power is exported beyond the utility meter.
4. This mode gives excellent PV generation because of the export feature.

5. In case there are a lot of captive loads (not connected directly to PCU) then can also utilize the PV power as long as grid is available and the PV power is excess.
6. In case of weak grid areas (where supply voltages are low), this mode tends to stabilize the Grid supply.
7. In case DG is connected and PV excess power available, then PV power may be fed through grid terminals to the Grid and may incur damages.
8. In this mode, battery power is never exported to grid unless commanded externally (available in selected models only).

Since the MODES OF OPERATION are now clear, we can discuss how the user can switch from one MODE to other MODE by using the DKU module along with a few other hardware changes.

Apart from this it is important to locate the MASTER CARD provided on the control panel which houses the necessary jumpers for change in MODE settings. The location of this MASTER CARD has been kept slightly off-the –access so as to avoid unwanted changes done. Please contact the manufacturer to locate this card in case of problem. It is generally hosed close to other electronics.

Please turn off Load, Grid and PV MCCB whenever changes are being made to the MODE OF OPERATION. Only battery MCB/ MCCB should be on when changes are being made in MODE OF OPERATION. This process may take a maximum of 5-10 minutes.

Refer the below chart to implement the changes.

S. No.	Existing Mode	New Mode	Changes in DKU**	Jumper change in New Card	Remarks
1	Off-Grid	Hybrid	Please refer table 4a,4b,4c for setting. Only change **Ac charge start,Ac charger stop** setting.	Ensure jumper is connected to JMP5 pin 2 and 3 in CC21 (SEPL-24V1) Ref. fig – 3.a	
2	Off-Grid	Hybrid with Export	Please refer table 4a,4b,4c for setting. Only change **Ac charge start,Ac charger stop** setting.	No change in jumper	
3	Hybrid	Off-Grid	Please refer table 4a,4b,4c for setting. Only change **Ac charge start,Ac charger stop** setting.	No change in jumper	
4	Hybrid	Hybrid with Export	No change in DKU	Remove the jumper from JMP5 in CC21 (SEPL-24V1) Ref. fig – 3.a	
5	Hybrid with Export	Off-Grid	Please refer table 4a,4b,4c for setting. Only change **Ac charge start,Ac charger stop** setting.	No change in jumper	
6	Hybrid with Export	Hybrid	No change in DKU	Connect the jumper to JMP5 pin 2 and 3 in CC21 (SEPL-24V1) Ref. fig – 3.a	

- ****To Enter in DKU setting please refer 5.3.5 CHANGE OF SETTINGS:** AUTO SCHEDULE SETTING SECTION

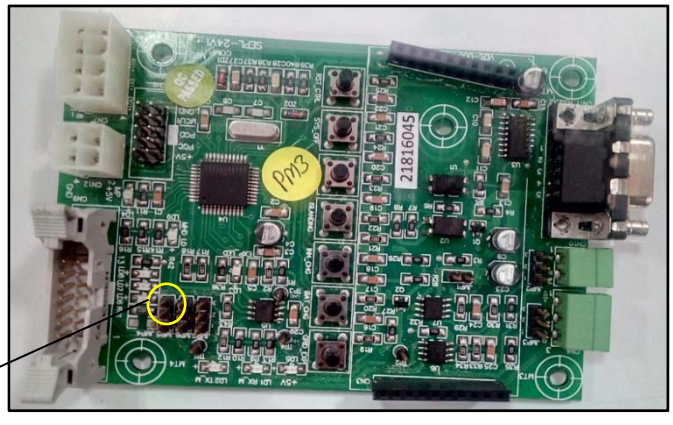

Figure-3.a

APPENDIX-4

FORMULAE TO DETERMINE VARIOUS INPUTS/ OUTPUT PARAMETERS

The manufacturer has the right to define the permissible values of various current, voltage and power parameters at input and output. These parameter values can be generalized over the entire range of Hybrid Inverters through some fundamental guidelines and formulae. The same have been brought out clearly in the below list.

PARAMETER	FORMULAE
1.SOLAR CHARGE CONTROLLER(SCC)	
No. of MPPT Channel	Single Channel ≤ 50Kw Three Channel > 50Kw
PV peak capacity	1.10*Nominal PV capacity ≤ 10Kw 1.07*Nominal PV capacity > 10Kw
Max I/P Amps per channel	$\frac{\text{Overall Nominal PV Capacity (KW)X1000}}{\text{No. of MPPT Channel MPPT Min Voltage}}$
Max Battery Amps during PV charging (Per Channel)	$\frac{\text{Nominal PV Capacity MPPT Charger EfficiencyX1000}}{\text{No. of MPPT Channel Bulk Voltage/cell*No. of cellX100}}$
Max SCC O/P Amps	$\frac{\text{Nominal PV Capacity*MPPT Charger EfficiencyX1000}}{\text{No. of MPPT Channel*Float Voltage/cell*No. of cellX100}}$
2. SOLAR INVERTER	
Output Amps per phase	$\frac{\text{Overall Nominal inverter Capacity(W)X1000}}{\text{No. of Phases * Nominal output voltage}}$
3. GRID CHARGER	
Max Battery Amps during Grid Charging	$\frac{\text{Nominal Inverter Capacity*Grid charging efficiencyX1000}}{\text{Bulk Voltage/cell*No of CellsX100}}$

Note:

1. The manufacturer has the right to define the technical parameters of the machine and the same been declared in the datasheet of product.
2. All HBD range inverters follow general criteria to define permissible value of the circuits voltages and power at input and output.
3. All these values are provided to the costumer at preorder stage in form of product datasheet.
4. In case, there is confusion as to how a particular value has been achieved. Please refer above formulae
5. Please be noted that manufacturers holds the right to change these values without any prior information to the custumers.
6. The formulae given here are valid for standard machine only.

APPENDIX-5

CABLE SIZING CHART FOR INPUT/ OUTPUT CONNECTIONS

Cables selection at Input and Output is the most important exercise because a wrong selection of cable sizes will not only effect the efficiency of the plant but also lead to heating and fire hazards in the long run. Under sizing of cables has been a common cause of failure of Inverter machines, so no matter how much calculation has been done in machine sizing, if cable selection is not proper, it is prone to failure.

Some important parameters to be kept in mind while cable sizing are as below:

1. Lower is the size of the cable, more are the power losses and lower is the efficiency. Hence always opt for higher thickness of cables.
2. Lesser are the cable distances, lesser are the power losses and more is the efficiency. Hence, always try to minimize the distance of cables from machine to other components such as AJB, Battery, ACDB etc.
3. More is the current in any path, more are the losses. Hence always bother about the sizing (gauge and length) of higher current paths first.
4. DC side losses are always higher than the AC side losses. Hence always give preference to minimize DC side losses through #1, #2 and #3.
5. Inverter machines are provided with copper type connectors. SO, always give preference to copper conductors and avoid using aluminum conductors.
6. In case of aluminum cables, ensure to use bimetallic lugs while making connections on the inverter side.
7. Always check the permissible conductor size/ Lug size mentioned in the datasheet of any Inverter. Using a matched lug size is very important for proper current flow. If not proper, it may lead to fire hazards ultimately.
8. Routing of cables also has an effect on the sizing depending upon weather the route is through open or enclosed in cable tray.
9. Always route the DC and AC cables separately as it may hamper EMI/ EMC performance of the machine.
10. In case of 3 Phase inverters never use a 3 ½ core cable because this inverter supports imbalanced loads on the AC side. Hence neutral wire should always be sized at least 1.25 times the phase current.
11. Follow proper IEC standards for cable sizing in AC and DC. Sample chart has been shown below for the AC and DC cable sizing. In case the lengths are more than 10 meters, always opt for one size higher. Please be noted that values given in the chart are just for reference and user shall be entirely responsible for the selection.

Wiring Chart As per IEC-3961-Part-V

S. No	Wire Cross Section Area	Single Phase AC/DC (Ampere)	Three Phase (Ampere)
1	1	12	12
2	1.5	16	15
3	2.5	22	20
4	4.0	29	26
5	6.0	37	33
6	10	51	45
7	16	68	61
8	25	86	78
9	35	110	99
10	50	145	135
11	70	215	185
12	95	260	230

APPENDIX-6

PV MODULE ARRAY SERIES-PARALLEL ARRANGEMENT

Hybrid Inverter machines are basically DC coupled Solar inverters which have an inbuilt but separate MPPT solar Charger between the PV and the Battery. This Solar MPPT charger is of Buck type which strictly means that PV power will be extracted only when the PV voltage is higher than the battery voltage at that instant. Hence, the series parallel arrangement becomes very important for proper functioning and best generation results.

So, before we present the PV sizing chart, we would like to highlight a few points about the series-parallel arrangement of PV modules.

1. Always keep information handy about the PV module you are going to use. This includes: Open-Circuit Voltage (Voc), MPPT Voltage (Vmp), Short-Circuit Current (Isc), MPPT Current (Imp), Module Power (Pmp) and no. of cells in PV module used.
2. Always refer the Inverter datasheet while designing the series parallel arrangement. The parameters of importance include:
   - PV Nominal Capacity (Total)
   - No of MPPT Channels
   - Per Channel PV Capacity (Nominal/ Peak)
   - Max. Open Circuit PV Volts (Voc)
   - MPPT Voltage Range
   - PV Minimum Voltage
   - Max I/P Amps per channel
9. More are the number of modules in series, higher is the plant efficiency and higher is the generation from PV modules. But there is a limit to maximum number of modules mentioned in the inverter datasheet.

10. Never exceed the Max. Open circuit Voltage permitted by the inverter datasheet. This value is mentioned as Max. Open circuit PV Volts (Voc) in the inverter datasheet

11. Open circuit voltage of PV module increases in cold season due to module characteristics and hence always keep a margin between the System Voc and permissible Voc mentioned in the datasheet.

12. The number of strings in parallel should always be kept as low as possible. Also, the summation of all the string currents should always be less than than the Max I/P amps per channel mentioned in the datasheet of inverter.

    /. In case of multi MPPT channel designs (above 50KVA generally) distribute the no of modules equally among all the 3 MPPT channels for better generation.

13. In case of multi MPPT channels ensure 3 separate PV fields are made. That is, do not combine all the PV modules in a single AJB and then bring 3 separate set of cables for 3 MPPT chargers in Multi MPPT inverters. This will hamper the PV generation as MPPT function will not take place at all.

14. Series parallel arrangement of PV modules is dependent on the inverter being used. It may differ from one make of inverter to other. Please consult the Inverter manufacturer before usage for proper generation.

15. Below is a general chart for series parallel arrangement depending upon the capacity of Hybrid Inverter.

PV CONFIGURATION CHART

BATTERY VOLTAGE	NOMINAL PV CAPACITY PER CHANNEL	PEAK PV CAPACITY PER CHANNEL	TOTAL MODULES	250Wp/ 60 CELLS		250Wp/ 72 CELLS	
				MODULES IN SERIES	NUMBER OF STRINGS	MODULES IN SERIES	NUMBER OF STRINGS
48	2000	2200	8	4	2	3	3*
	3000	3300	12	4	3	3	4
	4000	4400	16	4	4	3	6*
96	4000	4400	16	8	2	6	3*
	5000	5500	20	7	3*	7	3*
	6000	6600	24	8	3	6	4
	8000	8800	32	8	4	7	5*
120	6000	6600	24	8	3	6	4
	8000	8800	32	8	4	7	5*
	10000	10700	40	8	5	7	6*
	12500	13375	50	7	7*	7	7*
	15000	16050	60	8	8*	7	9*
240	10000	10700	40	14	3*	13	3*
	12500	13375	50	14	4*	13	4*
	15000	16050	60	15	4	12	5
	20000	21400	80	16	5	12	7*
	25000	26750	100	15	7*	13	8*
	30000	32100	120	15	8	12	10
	35000	37450	140	14	10	13	11*
	40000	42800	160	16	10	13	13*
	45000	48150	180	15	12	12	15
	50000	53500	200	15	14*	12	17*

Note: In these cases it is not possible to achieve the exact kWp capacity using the said series-parallel combination. Hence the achieved kWp capacity is slightly more or slightly less than the required kWp capacity.

APPENDIX-7

BATTERY CHARGING CURRENT AS PER BANK SIZE

Battery charging is an important feature of hybrid inverters. The charging voltage and more importantly charging current depends on the battery type and battery capacity connected.

Since all hybrid inverters are dispatched with some standard settings assuming a certain size of battery bank, it is very important to discuss these assumptions in detail. The user is requested to check if the actual battery size matches this and in case not, then change the current settings to match the size battery bank installed. These settings have already been discussed in the INITIAL SETTINGS CHART but here we would stress on the battery current settings as per the bank size.

To decide the battery charging current please contact your battery manufacturer. However as a thumb rule, find the AH capacity of your bank and divide it by 10. The value you arrive at is the charging current you need to set on DKU.

The default setting assumes a certain battery bank size. The value of battery bank has been assumed for a **4 hour** back up at **100% load** for Inverter of any size. For e.g. for a 48V/ 3KVA inverter, battery bank of 400AH has been assumed because if 3KW load is connected then this bank will give a back up of 4 hours.

The calculation of how this value is reached is based on assumptions and is conditional. The manufacturer does not guarantee any such back up duration and shall not be held responsible what so ever. The below chart lists out the battery bank capacities assumed for various inverter sizes.

SYSTEM TYPE	SYSTEM RATING	BATTERY AH
Single Phase	48V-3KVA	400AH
	96V-5KVA	400AH
	96V-6KVA	400AH
	96V-8KVA	400AH
	120V-8KVA	400AH
	120V-10KVA	500AH
	240V-10KVA	300AH
	240V-12.5KVA	300AH
	240V-15KVA	400AH
	240V-20KVA	500AH
	240V-25KVA	600AH
Three phase	120V-10KVA	500AH
	120V-12.5KVA	500AH
	120V-15KVA	600AH
	120V-20KVA	800AH
	240V-10KVA	300AH
	240V-12.5KVA	300AH
	240V-15KVA	300AH
	240V-20KVA	400AH
	240V-25KVA	500AH
	240V-30KVA	600AH
	240V-40KVA	800AH
	240V-50KVA	1000AH
	240V-60KVA	1200AH
	240V-80KVA	1600AH
	240V-100KVA	2100AH

NOTE: (1) Above battery AH have been calculated for a back up time of 4 hrs. @100% load

(2) Incase your inverter is not listed in the above chart, please contact manufacturer.