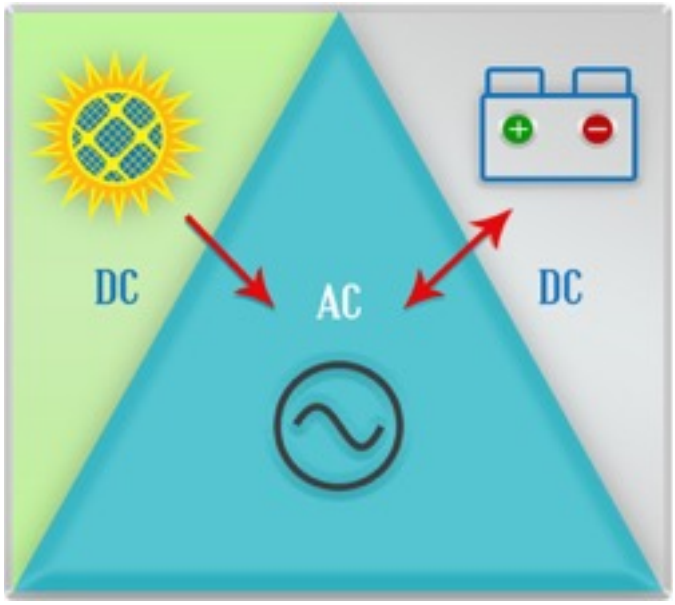
Overview

This concept paper addresses the feasibility and features of an ideally reliable and environment friendly AC power source suitable for critical loads like Railways operation, where outage is not acceptable. We propose a gang of parallelly connected synchronous hybrid inverters which can connect to the same AC bus, same solar photovoltaic bus as well as same DC battery bus. Individual inverters can be added or shut down without affecting the load. The power flow shall be balanced to maximise usage of solar energy and save utility mains energy. With advent of modern DSPs and IGBTs / MOSFETs the possibility of such a power supply is a reality. Following is a detailed discussion on this subject.

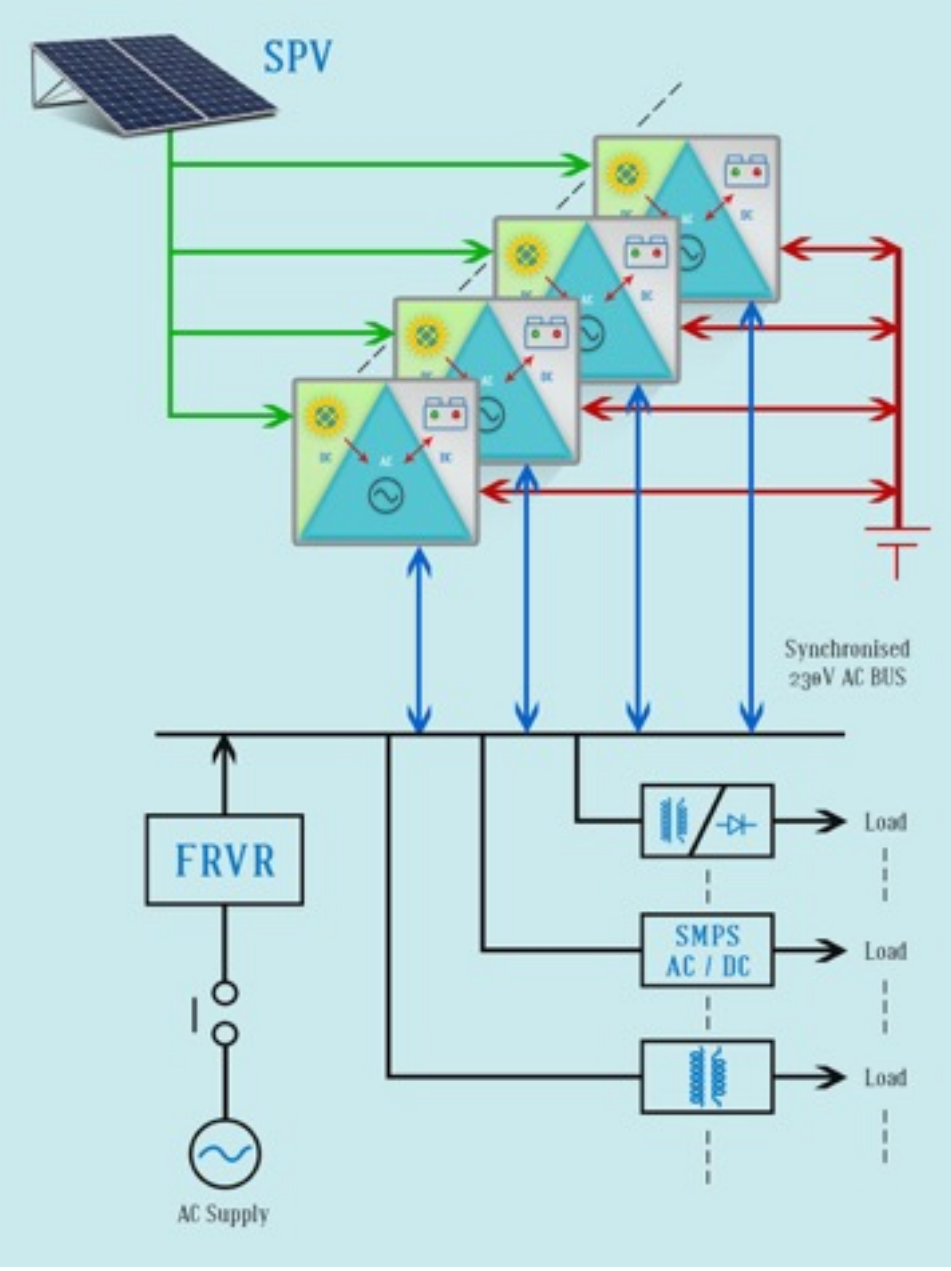


Proposed Features of the ideal Power Supply

- The power supply shall be able to charge a battery system i(in Float / Boost mode) as well as supply the connected AC load when utility or solar power is available with solar power being used on priority. If neither is available, the inverter shall supply the AC load from battery power. The power supply shall be able to dynamically balance the AC power extracted from utility mains and DC solar input giving a preference to solar input, thus saving utility mains electricity charges.
- The power supply shall be made of individual inverters (synchronised hybrid inverters) such that they can share the load on the AC bus catering to the connected AC load. The individual inverters shall be suitable to

be replaced in case of faults, without disconnecting the connected load. Additional inverters shall be possible to be added to cater to added loads without any interruption.

Such a configuration is shown below:



The above configuration shows an utility mains supply input through a suitable rated FRVR (ferro resonant voltage regulator) supplying an AC bus. The same AC bus is also fed by the inverters from a battery system as well as SPV (solar photo voltaic cell). There are multiple synchronised inverters working in parallel n+1 redundant configuration. All the connected loads like transformer-rectifier units, SMPS units, Step down transformers take input power from the AC bus. The inverters are capable of inverting voltage from SPV or battery to the AC bus. They are also capable of charging the battery from SPV or AC bus when power flows in the opposite direction.

Case studies for different power flow conditions.

CASE 1: No solar power available, utility mains available, battery on float charge.

The inverters in such case shall share the float charge current to keep the batteries afloat.

CASE 2: No solar power available, utility mains available, battery charging.

In such case, the inverters shall share the boost charge current amongst them keeping in view that the AC bus voltage do not drop and is sufficient to cater to the connected load. The boost charge current shall not only be limited by the battery AH capacity but also the availability of the power margin of the FRVR after catering to the load.

CASE 3: Abundant solar power available, utility available, battery on float charge.

In such case, the inverters shall supply the load predominantly from the solar power and utility power may only make up for some marginal requirement.

CASE 4: Abundant solar power available, utility mains available, battery charging.

In such case, the inverters shall charge the battery from solar power and if possibly shall also share the load with the utility power.

CASE 5: Limited solar power available, utility mains available, battery on float charge.

In such case, the inverters shall use the limited power available to keep the batteries on float charge and use any extra power available to share the connected AC load with the utility mains.

CASE 6: Limited solar power available, utility mains available, battery charging.

In such case, the limited solar power shall be utilised for battery charging. The balance charging current shall be derived from utility mains keeping in consideration that the connected AC load has sufficient power.

CASE 7: No solar power available, utility mains not available, battery discharging.

In such case the inverters shall convert the battery energy to AC energy and cater to the connected load. When the utility power restores, the inverters shall re synchronise with the utility mains before the utility mains contractor connects to the system.

CASE 8: Abundant solar power available, utility mains not available, battery charging.

In such case, the inverters shall cater to the connected load and also charge the battery. Supply to the load shall be given priority over battery charging.

CASE 9: Limited solar power available, utility mains not available, battery discharging.

In such case, inverters shall try to supply the connected load drawing power from the solar power as well as battery power. It shall give precedence for usage of solar power over battery power to cater to the connected load.

ADVANTAGES

1. The inverters shall share work in synchronism and share the load. Thus if one inverter fails, that can be taken out of the system and replaced with another without any outage of the loads connected to the AC bus.
2. As the AC bus is synchronous, there is no changeover time or bus switching delays, while switching from one power source to another. In fact, the load is being dynamically balanced from different sources. There shall be no chance for interruption of sensitive fail safety systems like axle counters etc.
3. The SPV based DC bus charging shall be based on MPPT algorithm to maximise the extraction of solar energy.
4. Optimum usage of solar energy, maximum saving of utility grid energy can be achieved by proper configuration of the system.
5. The system is easily scalable for increase load by introducing additional inverters.
6. The power supply configuration is general in nature and can be used for uninterrupted quality power source for all emergency requirements.

CONCLUSION

With advancement of DSP based power control in the last 5 years, such ideal power control systems have got feasible in present day. If proven, this type of system has a potential to make the best of reliability as well as best usage of solar power. The future of AC reliable power systems shall belong to such synchronous hybrid inverter based power supply configurations.