Grid-Connected PV-Wind-Battery based Multi-Input Transformer Coupled Bidirectional DC-DC Converter for household Applications

Introduction:

Rapid depletion of fossil fuel reserves, ever increasing energy demand and concerns over climate change motivate power generation from renewable energy sources. Solar photovoltaic (PV) and wind have emerged as popular energy sources due to their eco-friendly nature and cost effectiveness. However, these sources are intermittent in nature. Hence, it is a challenge to supply stable and continuous power using these sources. This can be addressed by efficiently integrating with energy storage elements.

The interesting complementary behaviour of solar insolation and wind velocity pattern coupled with the above mentioned advantages, has led to the research on their integration resulting in the hybrid PV-wind systems. For achieving the integration of multiple renewable sources, the traditional approach involves using dedicated single-input converters one for each source, which are connected to a common dc-bus. However, these converters are not effectively utilized, due to the intermittent nature of the renewable sources. In addition, there are multiple power conversion stages which reduce the efficiency of the system.
**Existing system:**

The magnetic coupling approach is used to derive a multiport converter, where the multi-winding transformer is employed to combine each terminal. In fully isolated multiport dc-dc converters, the half-bridge, full-bridge, and hybrid structure based multi-port dc-dc converters with a magnetic coupling solution can be derived for different applications, power, voltage, and current levels. The snubber capacitors and transformer leakage inductance are employed to achieve soft-switching by adjusting the phase-shift angle. However, the circuit layout is complex and the only sharing component is the multi-winding transformer. So, the disadvantage of time sharing control to couple input port is overcome. Here, among multiple inputs, each input has its own power components which increase the component count. Also, the design of multi-winding transformer is an involved process.

**Drawbacks:**

- Circuit layout is complex and the only sharing component is the multi-winding transformer.
- Each input has its own power components which increases the component count.
Proposed system:

The grid-connected hybrid PV-wind-battery based system for household applications, which can work either in stand-alone or grid connected mode. This system is suitable for household applications, where a low-cost, simple and compact topology capable of autonomous operation is desirable. The core of the proposed system is the multi-input transformer coupled bidirectional dc-dc converter that interconnects various power sources and the storage element.

The proposed converter consists of a transformer coupled boost dual-half-bridge bidirectional converter fused with bidirectional buck-boost converter and a single-phase full-bridge inverter. The proposed converter has reduced number of power conversion stages with less component count and high efficiency compared to the existing grid-connected schemes. The topology is simple and needs only six power switches. The boost dual-half-bridge converter has two dc-links on both sides of the high frequency transformer. Controlling the voltage of one of the dc-links ensures controlling the voltage of the other. This makes the control strategy simple. Moreover, additional converters can be integrated with any one of the two dc-links. A bidirectional buck-boost dc-dc converter is integrated with the primary side dc-link and single-phase full-bridge bidirectional converter is connected to the dc-link of the secondary side.
Advantages:
- Less component count and reduced losses.
- Reduced number of power conversion stages.
- Inject surplus power into the grid and charge the battery from grid as and when required.

Applications:
- Household Application.
- Grid-connected hybrid PV-wind-battery system.
Block diagram:

The diagram shows a power supply system with the following components:

- Solar supply
- Wind supply
- Battery Storage
- Bi-directional BB converter
- Half bridge converter
- HF Transformer
- Inverter
- Load
- Isolation Circuit
- Driver circuit
- Buffer circuit
- Micro-controller circuit
- 5V DC Supply

The system includes various converter circuits and transformer connections to manage the power flow between different voltage levels.