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ULTIMATE SERVICE ASSOCIATES
A NORTH AMERICAN SITE SERVICES CO.

The ultimate solution for maintaining your nationwide generator network

Types of Transition Between Power Systems Having AC and DC Components

1.0 Introduction:

As electrical power consumers become more intolerant of any power lost, even for periods that can be measured in nanoseconds, more consideration has been given to the time to transition between power supplies and the required transition method. Traditionally an Automatic Transfer Switch (ATS) was used to transfer, via mechanical and electrical contacts, power between the Utility (primary source) and an engine-driven generator set (standby power source). However, with the adoption of more renewable energy sources and Microgrid systems operating in conjunction with the Macrogrid, that frequently transition between various power sources, some of which are AC, but also renewable energy that initially has a DC component. Merging and switching between DC components differs from a purely AC-powered system

This information sheet discusses the various technologies applied to transition connected loads between AC and DC power sources, how AC and DC voltages are changed, and using the DC component to ensure power is not lost during the transition.

UPS Arrangement Switching All Power Inputs at the DC Side Using Rectifiers and Inverters

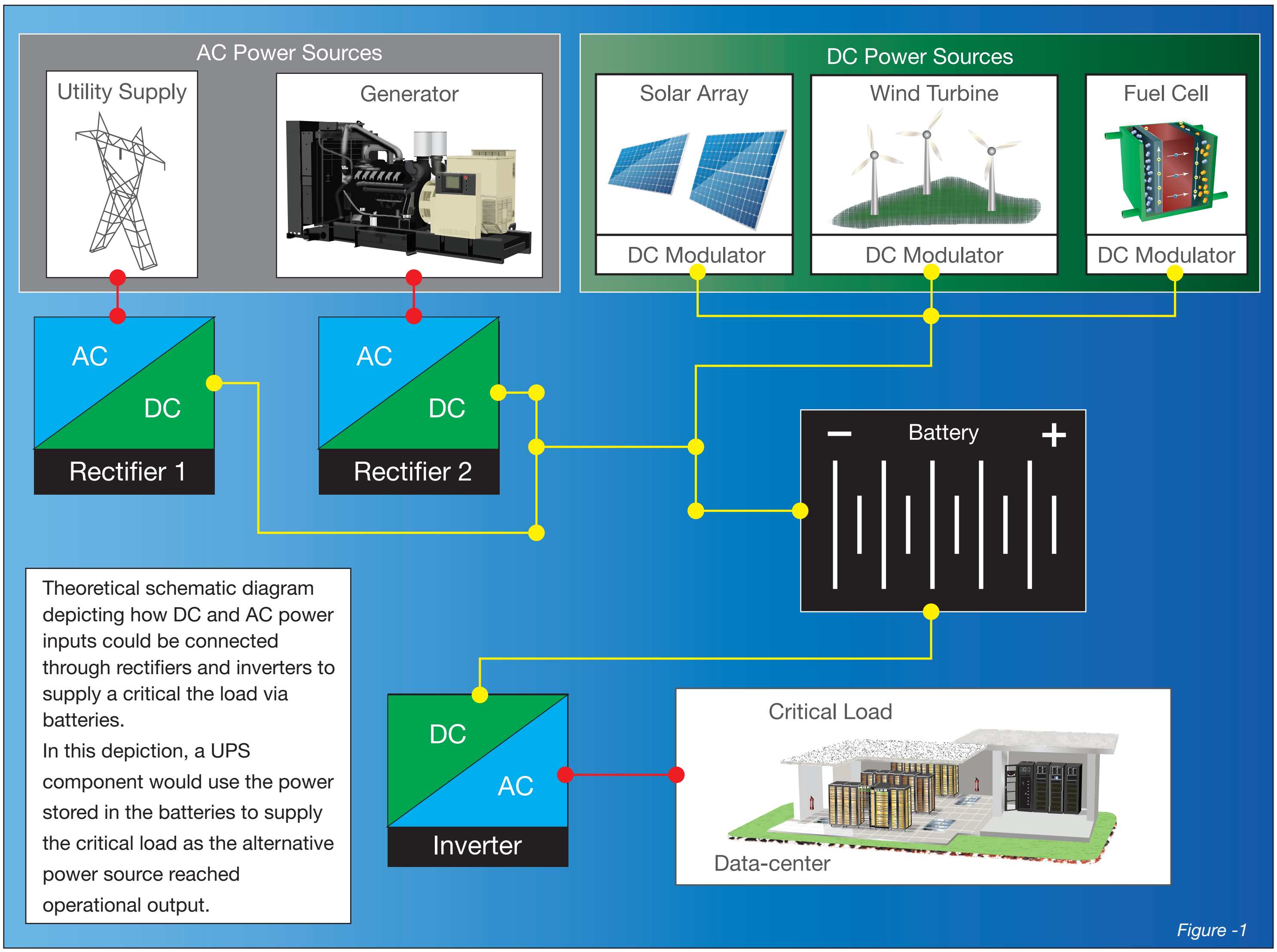

Figure -1

To fulfill our commitment to be the leading network service provider in the Power Generation Industry, the USA, Inc. team maintains up-to-date technology and information standards on Power Industry changes, regulations and trends. As a service, our **Information Sheets** are circulated on a regular basis, to existing and potential Power Customers to maintain awareness of changes and developments in engineering standards, electrical codes, and technology impacting the Power Generation Industry.

2.0 Considerations for Switching Between AC Primary and Secondary Power Supplies:

In a traditional Utility Grid, the power fed to the load is alternating current (AC), not direct current (DC). An AC system's load, single phase or three, must be switched to AC secondary power source with the equivalent AC waveform and voltage.

Unlike DC, which is a flat line with current flowing in one direction, no two AC power outputs and loads can be connected unless each of their waveforms are in sync, as AC alternates between positive and negative.

In a traditional AC transfer switch (manual or automatic), without any paralleling technology, the load can only be fed through the contactors on the primary power side or those on the secondary power supply. The contactors are mechanically and electrically interlocked to avoid dual feed to the load, but switching from one to another causing a delay.

Transitioning from between power sources using the following terms:

- Break-Before-Make - Here, the primary contactor feeding the load is disconnected (open) before the secondary contactor is switched to the load (closed), and vice-ser-versa.
- Delayed Transition - This is the same as Break-Before-Make, but the time for the other contactor coming online is delayed long enough for inductive (motor) loads to dissipate any residual voltages built up in the motor that could cause a large inrush of current when the switch closes on the alternate source.
- Make-Before-Break - In this case, the incoming contactor is closed before the outgoing contactor opens. This is called Closed Transition. This is for clients who do not want power shut to devices while transitioning. However, it does result in momentary paralleling of the two power sources, not necessarily in sync, and the utility company should approve its adoption.
- Soft-Load Transition - This transition is also Make-Before-Break. However, in this case, the incoming power source is paralleled with the outgoing power before its contactor is closed and before the outgoing contactors switch to the open position.
  This option is chosen when the two sources can be paralleled for some time. It is a more sophisticated arrangement and adopted when there is extensive monitoring of the condition of the various power sources, beyond just voltage, because of the sensitivity of the connected load. It is also the most expensive.

3.0 The Role an ATS Plays When Paralleling AC Power Sources:

ATS and bi-pass isolator switches were developed to switch from one AC input to another. With AC power, the electrical current in one cycle goes from zero at zero degrees to maximum positive power, at 180 degrees, to maximum negative, at 270 degrees, then returns to zero at 360 degrees. The AC flow follows a sinusoidal sine wave.

When switching from one AC power source to another AC source, an ATS ensures only one of the AC power supplies can be connected to the load. This avoids the potential mechanical and electrical damage to generators and connected loads due to the improper matching/paralleling of AC source phases, voltages, and frequencies. *(See information sheet on paralleling)*

When paralleling different AC power sources, a transfer switch between the load and the connected sources assures reliable load transfer only when both source's frequency and voltage differences are acceptable after paralleling.

4.0 DC Component of the Macro/Microgrid Using Renewable Energy Power Sources:

When electrification came about, there were two competing systems AC and DC. AC primarily became the dominant power source for homes, factories, commerce, etc., because of its ability to transform electromagnetism (transformer) to other voltages, higher or lower than the primary generated source. This was particularly important when transmitting electrical power over large distances. AC power can be converted to very high voltages and the relative loss of power over long distances when the voltage is transformed down to user voltage at the other end.

However, wind, solar, fuel cell, battery, and other renewable energy sources initially output DC power. Finally, the power fed into the Grid is converted to AC via inverters. *(See information sheet on inverters)*

5.0 Changing AC and DC Voltages and Switching Between Power Sources:

The required AC voltage generated is well established and can be defined by the electromagnetic design of the generator and transformers for distribution. However, DC power from renewable energy sources is a function of voltage generated by alternative technologies not necessarily related to that of connected Grid customers.

5.1 Changing/Switching AC voltages:

Changing voltages of AC systems is accomplished via a transformer, a single component. As AC current flows between positive and negative over a varying time, magnetic flux can be transferred to a secondary coil. *(See information sheet on transformers)* Switching between AC sources requires an ATS, and before merging, paralleling is required.

5.2 Changing/Switching DC voltages:

Changing DC voltage cannot be accomplished by a single component because DC current only flows in one direction. An inverter is used to change DC current, which comprises a group of electronic components that switch the voltage on and off by processes such as waveform modulation. When changing or merging from one DC power source to another, an ATS is not required because there is no issue with matching the various frequencies, voltages, and phases.

6.0 DC Providing Uninterrupted Power (UPS) and Switching Sources at the DC Side:

UPS systems already use inverters and rectifiers to provide uninterrupted power by charging a battery bank with enough DC power converted to AC power by an inverter to power the load while the system transitions to standby AC power.

Frequently microgrids and applications such as data centers already have DC renewable energy power sources with batteries and inverters designed and sized to power the connected AC load. If any AC power source, standby generator, is connected to the DC power sources via a rectifier, then switching between power sources will be at the DC output side before the power is converted to AC via and inverter. In a scenario such as this, the application would have a UPS component, and as switching between power sources is at the DC side, no ATS would be required.

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