A Comparison of Ferroresonant and PWM Inverter Technologies

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Abstract

The two most commonly employed inverter technologies in Uninterruptible Power Systems (UPS) today are pulse width modulation (PWM) and constant voltage ferroresonant transformer.

The underlying principles of ferroresonant transformer technology have largely remained unchanged over the years. A Ferroresonant Inverter is commonly referred to as a "passive regulating device." A simple square wave generator applies power to the primary winding of a ferroresonant constant-voltage transformer. Since the transformer is designed to operate in the saturation range of its operating curve, resonance in conjunction with leakage reactance converts the square wave to a sine wave. In addition, because the transformer core is saturated, it provides inherent current limiting, noise rejection and output voltage regulation without the need for feedback elements and circuitry.

On the other hand, a PWM Inverter is referred to as an "active regulating device." This technology was originally developed as a cost reduction program in order to allow UPS manufacturers to be more competitive in the very price sensitive computer room (EDP) marketplace. Because of the explosive growth in the EDP area, most UPS manufacturers have abandoned the philosophy of providing highly reliable, customized equipment for the much smaller and specialized industrial portion of the market, in favor of standard units that can be mass produced as inexpensively as possible. Some manufacturers striving to reduce overall physical size, removed the isolation transformer at the input of the rectifier module and other devices from their basic design.

PWM Inverters regulate by adjusting the "on-time" of the semiconductors (usually bi-polar transistors) controlling the width of the pulses in the switching bridge. The switching frequency of this type of inverter is between 30 KHz and 50 KHz and due to the fast switching speeds; turning off the device is crucial. If noise is introduced, a misfiring of the transistors occurs thus causing severe damage to the switching bridge. The control of voltage and current is achieved by adjusting the pulse width as required by load changes. The effects of these load changes are sensed and fed to the control logic circuitry through feedback circuits comprised of voltage and current sensing devices, thus adding design complexity.

In addition, the harmonics created by today's switching-mode power supplies can adversely affect the PWM's linear output power transformer by increasing its eddy current losses and due to the tight coupling between the input switching transistor bridge and the load, the high peak currents must be carried by the bridge switching transistors. PWM Inverters are more sensitive to non-linear currents and often must be oversized for proper operation.

The intricate design and large number of components drastically reduces the reliability of the PWM Inverter as compared to its Ferroresonant counterpart. The benefits of PWM technology, such as small physical size and low audible noise suits it to the originally intended application, which is the EDP environment. Computer rooms generally have air conditioning systems that regulate temperature and humidity and are located in office buildings in metropolitan areas. Under these conditions electrical disturbances are considerably less likely as compared to the industrial environment, thus making PWM technology successful in the EDP environment. In regards to maintenance, EDP users are accustomed to the normal procedure for maintaining sensitive equipment. This usually involves entering into expensive maintenance contracts for the services of factory technicians in order to prevent lengthy periods of downtime.

In contrast, Ferroresonant Inverters do not use linear magnetic. A line frequency square wave developed by the switching bridge is filtered into a sinusoidal wave shape by means of the nonlinear actions of a saturated-resonating secondary winding. The peak current demanded by those switching-mode power supplies (non-linear) is supplied by the storage energy in the saturated secondary winding. The load current is not coupled to the switching bridge. The secondary winding also contains harmonic traps tuned for the 3rd and 5th harmonic. Thus, Ferroresonant Inverters

are uniquely compatible with switching-mode power supplies and do not have to be oversized to provide proper operation.

For industrial applications where high reliability and ease of maintenance by plant personnel is of utmost importance, the more rugged Ferroresonant approach is generally favored. The following list itemizes advantages and disadvantages of both technologies.

Pwm Advantage

1 Perceived as lower cost UPS (First cost investment).

2. Small physical size.

3. Low audible noise.

4. Higher efficiency.

5. Better transient recovery from a 0 - 100% step load change (although this is not a "realworld" occurrence; the maximum step load likely to occur during normal operation is 30% to 50% at which point the ferro is comparable. 0 - 100% step load transient response data is generally sales propaganda and normally only occurs at the factory during testing. Most loads will tolerate a short duration transient (8 ms) to 25% without danger of failure).

6. Maintenance free batteries do not require ventilation.

7. Large number of fixed alarm selection.

Pwm Disadvantages

1. More components (lower reliability per MILSTD 217, thus increasing long-term cost).

2. Complex circuitry (frequently requires factory technician for maintenance).

3. Difficult to repair.

4. Environmentally sensitive (electrical and atmospherically).

5. DC battery voltages are not compatible with station batteries in many cases.

6. Input transformer is often not used (rectifies "off the line" resulting in no isolation.

7. Monitoring and alarm functions are displayed one at the time.

B. Limited faults clearing capability if bypass is not available. (Typically 200-300% vs. 500%; especially important when feeding branch distribution panels.)

9. Packaging similar to computer equipment, not suitable for industrial environment.

10. Most spares not commercially available.

11. Manufacturers reluctant to release documentation for fear of it failing into the hands of a competitor and because manufacturer wants to perform the maintenance.

12. Limited reliability if environmental and maintenance conditions are not met.

13. Multiple circuit boards.
14. Normally use sealed maintenance free batteries, which provide limited life and are not environmentally tolerant.
15. Short design life (obsolete design life).

Ferroresonant Advantages

1. Simple proven design.
2. Few components.
3. Easy to maintain (can be done by plant electrician).
4. Rugged construction.
5. Complete monitoring and alarm functions.
6. Excellent fault clearing capability without bypass (500%).
7. Many spare parts commercially available.
8. Environmentally tolerant.
9. 125 and 250 VDC standard battery voltages.
10. Reliable under all operating situations.
11. Compatible with high crest factor non-linear loads.
12. Design life of more than 20 years.

Ferroresonant Disadvantages

1. Footprint physically larger than PWM.
2. Higher acoustical noise.
3. Less efficient than a PWM.
4. Higher initial expense (first cost), but long-term cost savings related to more up time and less maintenance expenses.