TECH BRIEF

High Frequency / High Ripple Resonant Chargers: Good or Bad?

By: Nasser Kutkut, PhD, DBA
Advanced Charging Technologies Inc.

Introduction

Battery charging is a complex electrochemical process, in which the discharged electric energy is replenished from the electric power grid. This is accomplished using a battery charger, which is an electrical/electronic device that converts the incoming AC line voltage into a regulated DC voltage to meet the charging needs of the respective battery (Fig. 1).

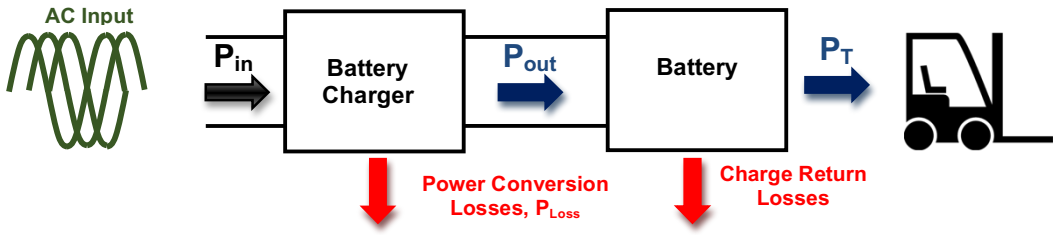

Fig. 1: Battery charger block diagram

While various battery charging technologies can be employed, new high frequency battery chargers are making headways into the industrial battery charger market due to their higher efficiencies and smaller sizes and weights as compared to ferroresonant and SCR type chargers.

A typical high frequency battery charger incorporates a front-end AC-DC rectifier to generate an unregulated DC input voltage, a high frequency (HF) power converter that converts input DC input into a high frequency AC voltage, a high frequency isolation transformer to provide output isolation, as well as voltage step-down function, and an output rectifier and filtering stage to generate a smooth, very low ripple output DC voltage (Fig. 2).

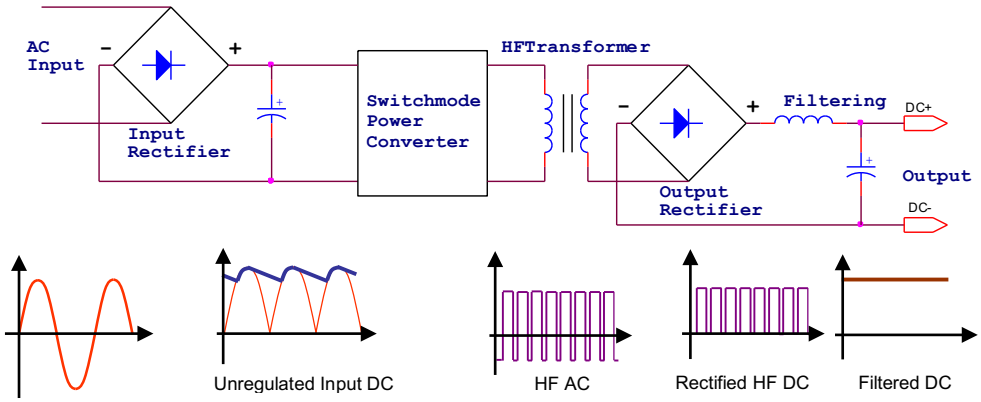

Fig. 2: Typical isolated high frequency battery charger

Unlike ferro resonant and SCR type chargers, the output voltage and current of the high frequency charger of Fig. 2 is almost a pure DC with negligible AC ripple, thus matching the characteristics and needs of industrial batteries. Ferro and SCR chargers exhibit high AC output voltage and current ripple resulting in additional heating of the battery.

High Frequency / High Ripple Resonant Chargers

One abnormal example of high frequency chargers available on the market is the high frequency, high ripple, resonant chargers used by Hawker and Enerysy in their LifePlus, PowerTech, and Enforcer charger series. These chargers utilize a high frequency resonant power conversion stage, where a resonant circuit is used to generate high frequency resonant voltage and/or current waveforms (Fig. 3).

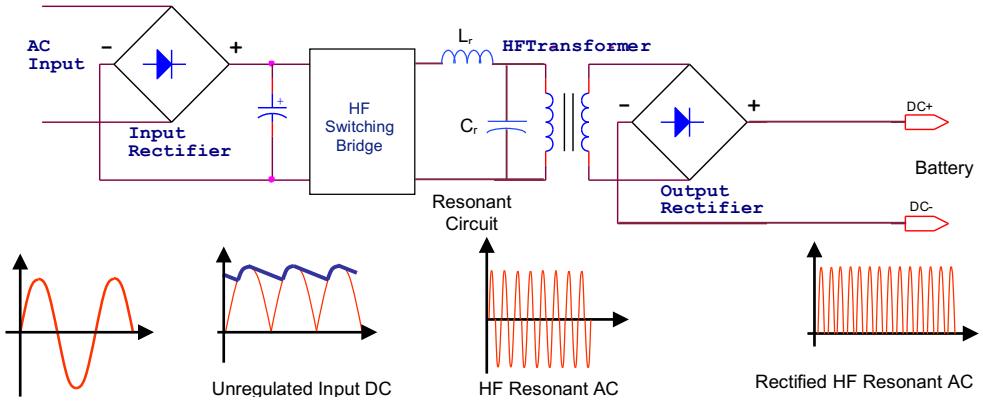

Fig. 3: High frequency, high AC ripple resonant battery charger

Unlike resonant type power converters, where an output filter stage is used to filter out the high frequency resonant voltage or current waveforms to yield a clean DC output voltage, these chargers apply the resonant voltage directly to the battery (i.e. use the battery as a filter). As a result, the output of the charger is a rectified high frequency AC resonant voltage as shown in Fig. 3.

Figure 4 shows the actual voltage and current waveforms of an Enforcer high frequency, high AC ripple resonant charger charging a 36V, 1000 Ahr battery. The captured waveforms show the charger output voltage and output current during the bulk charging phase. The average output current displayed was 117A while the average output voltage displayed was 43.56V (2.42 VPC). However, a closer look at the output voltage shows a very high output AC voltage ripple and AC current ripple. In fact, while the average output voltage displayed by the charger was 43.56V, the peak output voltage of the charger was 65.2V (3.6VPC). In addition, the output current also had a high AC ripple components of more than 20A (20%). These ripple values are quite high and untypical of most high frequency chargers.

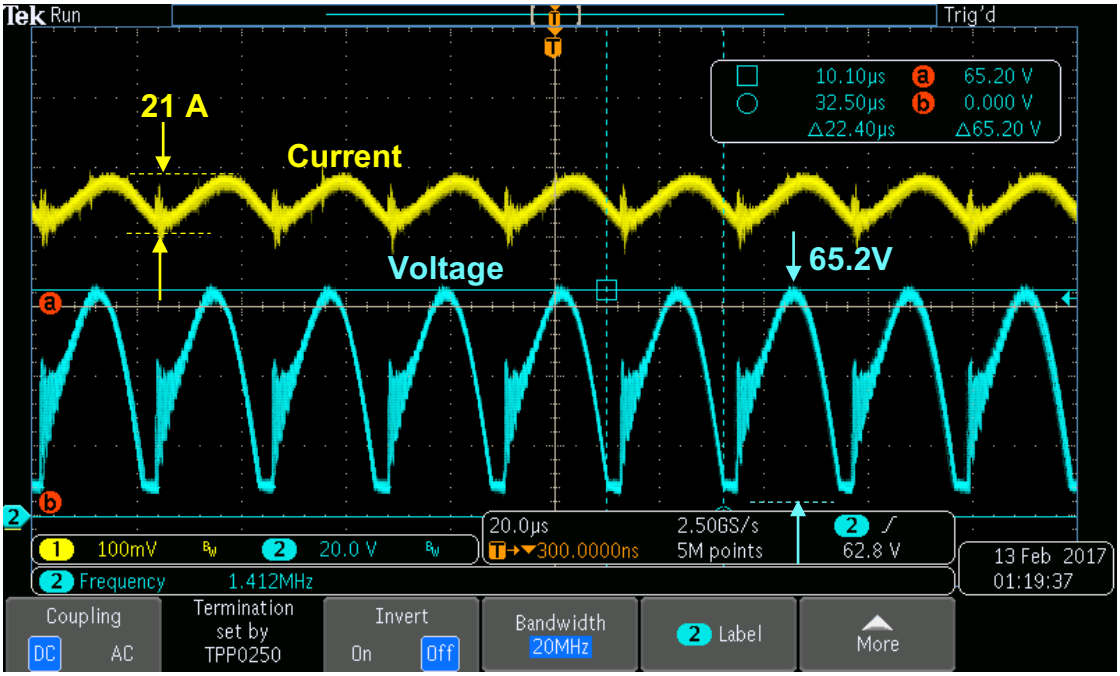

Fig. 4: High frequency output voltage of the LifePlus, PowerTech, and Enforcer chargers

There are a number of issues with high frequency / high ripple resonant chargers of this type, including:

- The charger output voltage shows extreme peak voltages in excess of 3.6 VPC. As shown in Fig. 4, the peak charging voltage was 65.2V for a 36V battery during the bulk charging phase (3.6VPC). This high peak voltage causes extra stress to the battery and may interfere with many battery monitoring devices and water level sensing devices, leading to faulty readings.
- The resonant nature of the charger voltage results in a high AC ripple charging current. For the 36V battery waveforms shown in Fig. 4, the charging current has a DC value of 117A with a high frequency AC ripple of more than ~21A (almost 20%). In fact, the current ripple at the start of charge was quite higher (almost 50A or 45%). This high frequency AC current ripple will reduce the charging process efficiency and may also result in further interference with battery monitoring devices employing power line communication devices.
- The high AC ripple resonant voltage and current waveforms may cause interference with other sensitive electronic devices since the DC cables will act as antennas transmitting and spewing the high frequency resonant AC ripple across the charging area.

In conclusion, high frequency and high ripple resonant chargers exhibit many undesirable characteristics that can either cause additional battery heating, reduce charging process effectiveness, and/or interfere with other monitoring devices and sensitive equipment due to the spewing of the high frequency noise via the DC charging cables.