

Transformer Isolation: Myth and Facts

Nasser Kutkut, Ph.D. - PowerDesigners, LLC - Madison, WI

Transformer isolation is a required in most, if not all, power equipment connected to the AC line including battery chargers. Isolation transformers provide the required safety isolation from input to output as well as step down the input AC line to a level compatible with the battery voltage to be charged.

Conventional chargers utilize 60Hz, step down isolation transformers to step down the incoming AC line as well as provide the required safety isolation. However, these transformers are quite bulky and contribute to most of the efficiency loss in the charger.

IGBT Based Chargers

New classes of IGBT chargers also utilize 60Hz isolation transformers to provide the required safety isolation and step down function (Fig. 1). Although the performance of an IGBT charger is better than that of an SCR or a ferroresonant charger, the benefits of high frequency operation are masked by the use of the 60Hz transformer. The size and weight of the input 60Hz transformer make these chargers quite bulky and contribute to most of the efficiency loss of the charger.

An IGBT charger with a 60Hz transformer isolation is nothing more than an SCR charger with the SCRs replaced with diodes and a single IGBT and diode added to provide output voltage and current regulation. The added benefits of an IGBT charger will be reduced output AC ripple effect and improved power factor. Note, however, that the **maximum theoretical power factor is limited to 0.95**. In practice, the **maximum attainable power factor is approximately 0.93** and degrades rapidly as the charging power reduces.

60 Hz Isolation Transformer MYTHS:

- Many claim that battery chargers with 60Hz isolation transformers are more reliable suggesting that they provide protection against surges, lightening, severe load transients, and AC line fluctuations, and many others.
- Others claim that high frequency chargers utilizing high frequency transformers have the power semiconductors (MOSFETs / IGBTs) exposed to the AC line and thus are more susceptible to AC line disturbances and fluctuations.

60 Hz Isolation Transformer FACTS:

- 1- 60Hz isolation transformers provide **no protection against AC line fluctuations** (sags and surges). Electrostatic shields provide limited protection against common mode fast transients.
- 2- Protection devices, such as **surge protectors and line arrestors** are needed in all equipment and are actually used in all 60Hz transformer isolated battery chargers to provide the required protection.
- 3- The bulk of the power supply industry utilizes high frequency isolation to take advantage of the compact size and efficiency improvements. The high reliability of these supplies and their corresponding power devices is the main driver behind their widespread use.
- 4- Almost all motor drives used in industrial plants around the world **DO NOT USE ISOLATION TRANSFORMERS** and utilize high frequency IGBTs directly connected to rectified AC line. DC isolation chokes provide mitigation of AC line fluctuations while surge protection devices and advanced controls are used to mitigate AC line surges. The widespread of these motor drives proves their real world reliability and suitability for even the severest of applications.
- 5- Surge protection devices and line arrestors provide the best protection against all AC line transients as well as lightening. All high frequency power supplies and motor drives utilize these devices to provide protection against AC line transients.
- 6- High frequency chargers with advanced controls provide additional mitigation of AC line transients as well as ride through capabilities.

PowerDesigners' High Frequency Chargers

PowerDesigners' PowerCharge line of fast and high frequency battery chargers incorporate state of the art power electronics technologies and controls. Unlike SCR or IGBT chargers, the PowerCharge chargers eliminate the need for an input 60Hz transformer and utilize instead a high frequency transformer (Fig. 2). This yield very high efficiencies and very compact

design. **The size and weight of the high frequency is almost 1000 times smaller and lighter.**

A high frequency isolation transformer achieves the same benefits of 60Hz isolation transformer as it isolates the output from the input line as well as steps down the incoming ac voltage. Yet, their size and weight is greatly reduced. There are no performance impacts when utilizing high frequency isolation.

The PowerDesigners high frequency chargers incorporate a **four-stage protection** system that greatly suppresses and mitigates AC line transients and surges at every stage. The four-stage protection system include:

- 1- Input electromagnetic interference (EMI) filter which reduces AC noise and surges from getting into the charger as well as preventing noise from being injected into the line (double protection).
- 2- Transient voltage suppressors (TVSs or MOVs) that protect against line surges due to load switching of other loads connected to the line.
- 3- A DC side choke that provides even higher mitigation of AC line fluctuations and dips.
- 4- A DC capacitor bank that provides energy storage to ride through extended AC line sags while preventing AC line surges from getting to the MOSFETs/IGBTs.

Above that, PowerDesigners high frequency chargers offer:

- A compact high frequency isolation transformer that provides safety isolation of 4kV (4000V) and the required step down function.
- Advanced and fast controls that can respond instantaneously to line and load transients.

Conclusion

In summary, high frequency battery chargers with high frequency isolation transformers provide similar or even higher protection compared with 60Hz transformer based designs. The elimination of the 60Hz transformer greatly reduces the charger size while greatly improving the charger efficiency. A four-stage protection system greatly suppresses AC line transients and surges at every step of the way.

References:

- [1] Can shielded isolation transformers provide power conditioning?
http://enews.primediabusiness.com/enews/powerquality/power_quality_news_beat/current
- [2] Overview of Power Conditioning Technologies
<http://www.leviton.com/pdfs/spd/pqtech104.pdf>

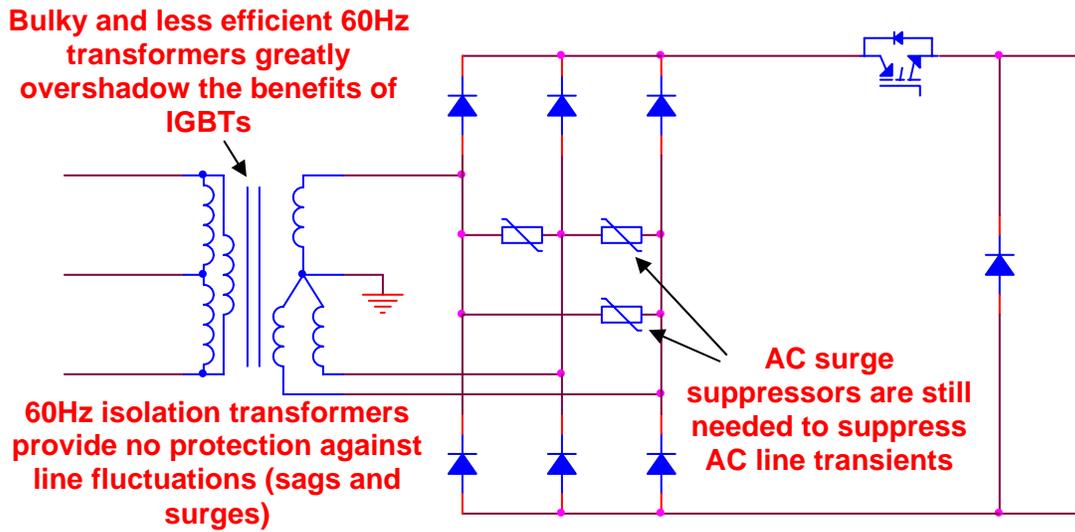


Fig. 1: IGBT based battery charger with 60Hz isolation

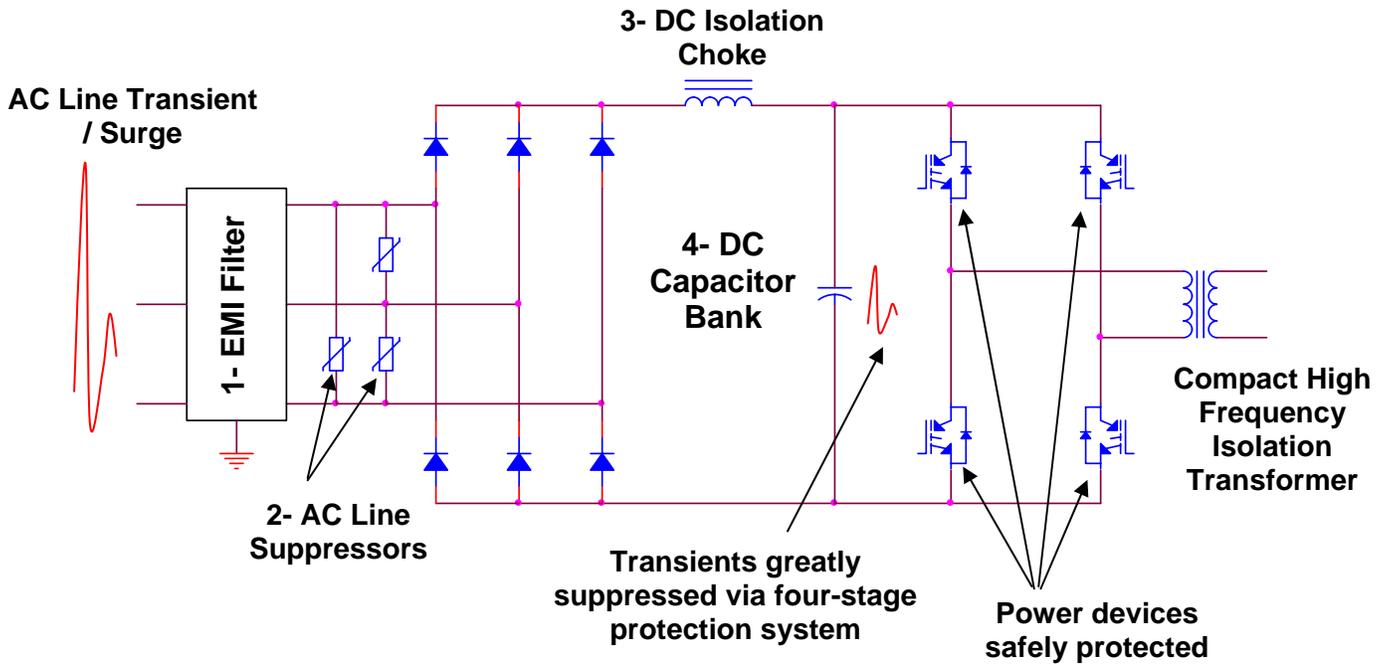


Fig. 2: PowerDesigners High Frequency Battery Charger with Four-Stage Protection System