APFC Startup

This document provides design information to show how to power a RediSem IC off a typical LC / LLC / LCC DC-DC converter and how it should be connected to a typical PFC converter. The startup and shutdown sequence of the two controllers can be difficult to manage and this guide provides an explanation of how to do it. RediSem supplies both complete LED or SMPS designs with a PFC stage and LLC stage combined, but also provides converters that are intended to be connected to a separate PFC stage. In the case where RediSem supplied a DC-DC reference design only, this guide gives some advice of how to couple it to a PFC stage.

Overview

PFC stage starts first, which then starts up the LLC stage. This allows the HT bus to settle before load is applied. RediSem CC APFC IC's have a soft-start, so that load is applied to the HT bus slowly, giving opportunity for the slow control loop in the PFC bus to respond. Once the RediSem control IC has been powered up, the power to keep it operating is supplied by the LLC converter.

Powering a RediSem APFC converter

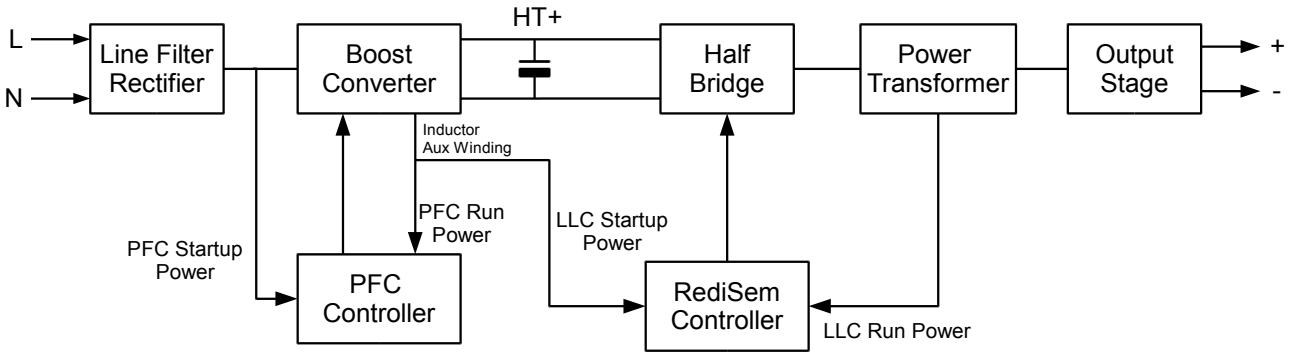

Figure 1: APFC Powering Configuration

Using Figure 1 the power-up sequence is:

- The PFC controller is started up via a resistor chain off the rectified AC waveform
- Once the PFC converter starts, it provides its own power to run via the aux winding in the PFC boost inductor
- When the HT bus rises to almost full voltage, the PFC inductor aux winding also provides power to the RediSem controller to start it up
- When the output voltage rises, the main LLC converter power transformer powers the RediSem controller

When the converter powers down, the sequence is:

- AC mains is lost, so the PFC stage turns off
- The LLC continues to deliver power to the load until the HT bus is run down
- The RediSem controller senses that there is a problem and latches off
- The RediSem controller can no-longer restart because the PFC boost inductor aux winding can no-longer deliver power
- To prevent the RediSem IC from restarting, the resistors connected to the VFB pin should be enough to pull Vdd down to remove the Vdd capacitor charge

A more detailed schematic with the important connections is shown in Figure 2 below:

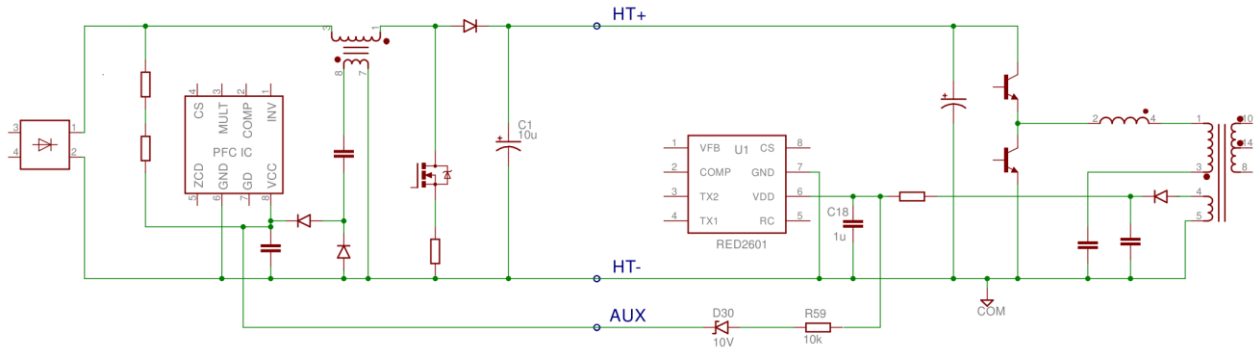

Figure 2: Schematic of the power connections

Note that the Aux connection should be around 20V for the DC-DC section to start up correctly.

DC –DC only connections

RediSem often only supplies the DC-DC converter part of the complete system, which means that you must provide a PFC stage. To start with, just connect the PFC output HT voltage directly to the RediSem LLC DC-DC converter. To complete the design so that it functions completely correctly, an Aux power should also be connected. This is explained later.

HT connections only – no Aux connection

The DC-DC converter will be supplied so that it is able to start up by itself, without the Aux connection, so only 2 wires are required to start up the system. This can be seen in figure 3.

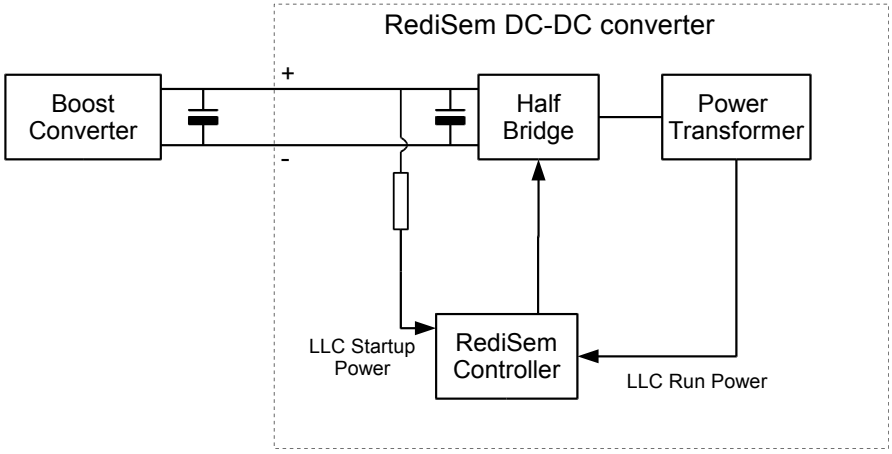

Figure 3: Connection without Aux

Starting and running the DC-DC converter in this configuration needs some caution:

- Supply the correct DC voltage. If in doubt, please check with RediSem, but typically in the range of 390 to 460VDC, depending on the AC input range.
- Make sure that the APFC converter has enough HT capacitance. The total capacitance should be around 0.33uF / W
- Make sure that the transient response of the PFC stage is quick enough so that it does not fall too low when the DC-DC turns on, otherwise the DC-DC might turn off
- When the mains is turned off, the DC-DC may try to re-start because it is powered off the HT bus which remains high. This problem will disappear when the Aux connection is used correctly.

HT & Aux connected

The DC-DC converter can be modified to disconnect the self-starting pullup resistor so that the PFC and DC-DC stages operate as a complete unit. This is shown in figure 4 below:

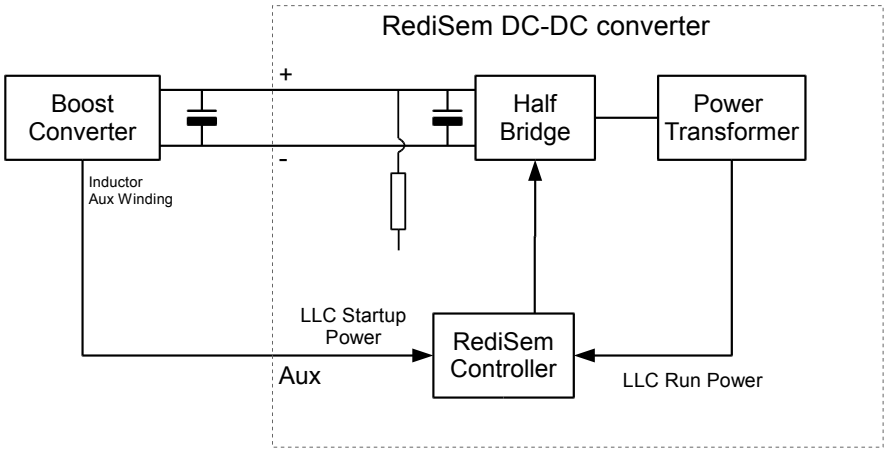

Figure 4: Complete system with Aux connected

When connecting the two converters together, make sure that:

- Check that the Aux voltage is in the region of 18-20V when the APFC converter is operating. This will give the RediSem controller enough voltage to start up
- Disconnect the resistors that act as pullup to turn the RediSem controller on
  - Connect the bottom of the pullup resistors to GND instead so that the half-bridge is balanced before it is turned on. From figure 5 below, disconnect startup resistor R27 and add R28
  - R28 helps balance the half-bridge before startup so that the first few cycles are balanced
- Apply a short circuit to the output. If the DC-DC converter operates continually, then increase the value of the Zener (D30)

A more detailed schematic of the converter connections is shown below.

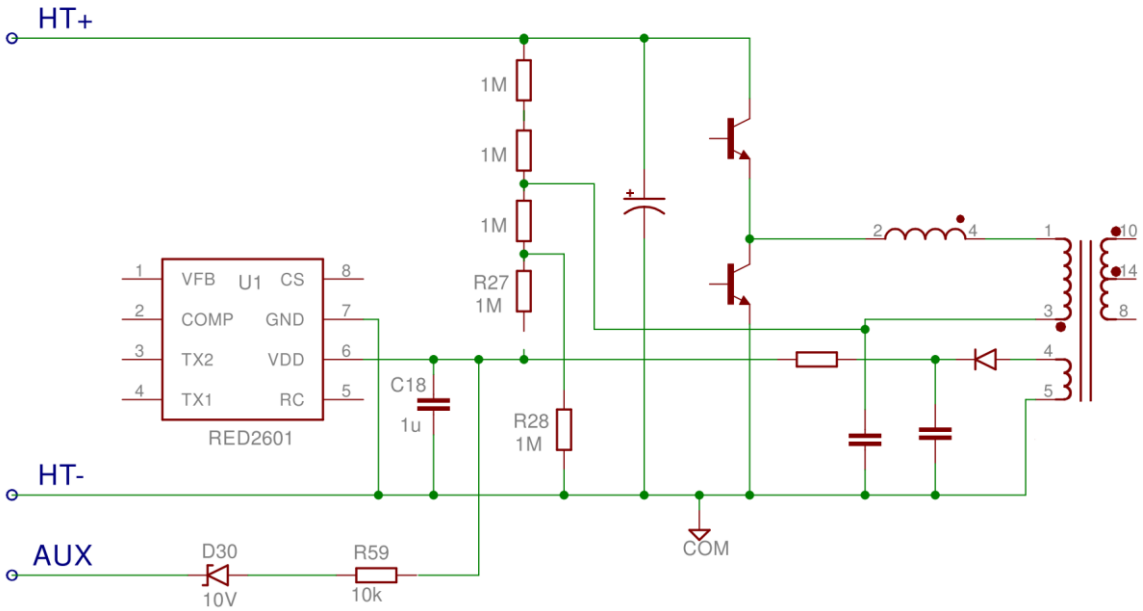

Figure 5: Schematic detail

About RediSem

RediSem designs and supplies semiconductor ICs for energy efficient power management applications. RediSem uniquely combines extensive experience in power electronics with in-depth knowledge of IC design and manufacturing and works with the world's top suppliers and customers. RediSem's unique patented IC and converter technologies deliver maximum efficiency and performance, while reducing overall bill of materials cost through the use of bipolar transistors.

RediSem's range of LED control ICs can be used with RediSem's patented single stage LED control solution to provide very high efficiencies with low EMI – all with a single IC. When combined, these features deliver a low cost, high performance LED driver solution.

RediSem's fluorescent driver controller ICs achieve the advanced performance of MOSFET drivers by using bipolar transistors at a fraction of the BOM cost. RediSem's range of SMPS (Switched Mode Power Supply) control ICs enables low-cost LLC converters with bipolar transistors that deliver very high efficiencies already meeting DoE Level VI regulations, have low standby power and have much lower EMI compared to flyback converters.

All RediSem ICs are supported by comprehensive turn-key application designs enabling rapid time to market. For further information please use our contact details below

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