Live Digital Solutions for Efficient Power Supply Designs (Part I)

With the continued rapid development of various electronic products, high-efficiency power supply design requirements are continually evolving. The high-efficiency conversion circuits defined in textbooks can no longer meet the actual needs of the market, because achieving high efficiency under rated operating conditions is just one of the requirements. A truly competitive power supply design must maintain high efficiency across the full load and operating voltage range, including light load and standby operation.

In this regard, mainstream energy efficiency regulatory agencies — such as the European Commission, ErP/EuP Ready, 80 Plus, and Energy Star — have created standards regarding product power consumption and efficiency (see Figure 1).

Figure 1: Energy Efficiency Regulatory Agencies

Most of these standards provide average efficiency requirements spanning 10% to 100% of rated load current, as well as the maximum power consumption allowed in a no-load or standby state. In fact, different market segments often have specific requirements based on their end applications.

Some examples of this include:

- Because desktop computers typically operate for a long period of time under light loads, they have specific efficiency requirements for load conditions below 10% of the full load. Specific brands and models will have different requirements.
- For TV power supplies, the most significant concern is about efficiency in standby mode. Taking into account some basic display and remote control functions, the requirement is usually below 300mW.
- The power adapter can be completely disconnected from the load, so minimizing the no-load loss is a high priority. The no-load loss of some mobile phone adapters can even achieve less than 10mW.

What's more, in product-level power supply design, efficiency is only one of many performance considerations and tradeoffs a designer has to make. Any attempt to improve efficiency must also take into account the effect on other performance considerations such as ripple, transient performance, noise, and EMI. In the actual product design process, this can require a lot of optimization to meet the specific requirements of the varying projects in different markets.

Faced with such complex and diverse requirements, designing power solutions generally becomes more difficult with each generation of products. Many traditional analog power solutions do not have the flexibility and programmability to meet current standards. Making full use of digital multi-mode solutions has become the key to achieving high-efficiency power supply design.

As MPS's second-generation digital PFC + LLC integrated controller, the HR121x family of products provide a variety of control modes as well as superior design flexibility, enough to meet the efficiency and performance needs of various market applications and power levels (see Figure 2).

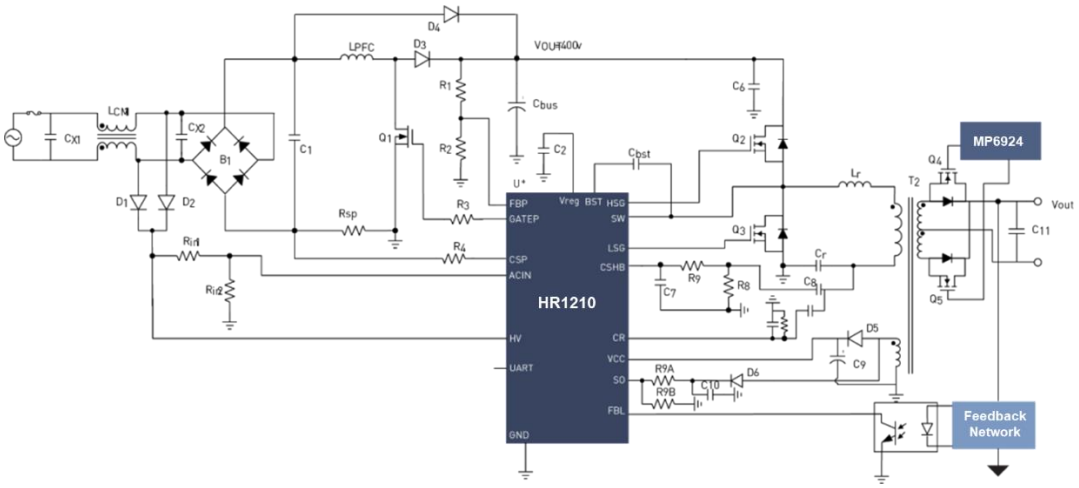

Figure 2: Typical Application Circuit for the HR1210 in the HR121x Series

The HR121x series products integrate a high-voltage current source, a safety-certified X capacitor discharge circuit, and a high-voltage PFC + LLC drive circuit, and is thus a very simple circuit with few external components compared to competing solutions.

Moreover, the HR121x series products also inherit the advantages of traditional analog chips in terms of corresponding speed, real-time peak current protection, capacitive protection, automatic dead zone adjustment, and other functions within the switching cycle through the digital-analog hybrid chip design.

The HR121x digital control core combined with the re-editable memory gives the entire solution great flexibility. The coordination between the PFC and LLC two-stage circuits, the switching between different control modes, the switching frequency of key operating points, and the threshold time and recovery method of the protection functions can all be easily controlled through the UART communication port configuration. This enables the power supply designs based on HR121x series products to flexibly adapt to the performance requirements of different applications at every load condition (see Figure 3).

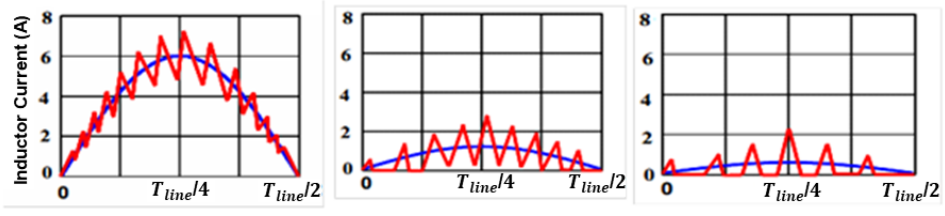

Figure 3: PFC Control Mode for HR121x Series Products

The PFC control part of HR121x series products enable mixed CCM and DCM operation:

- HR121x series products can fully work in CCM under heavy load conditions to minimize peak current.
- With a medium load or high input voltage, CCM and DCM hybrid mode can be used in the same power frequency cycle to find the best balance of switching loss and peak current.
- Under light-load conditions, HR121x series products can operate in the low-frequency DCM or the programmable burst mode to further reduce the switching loss.

By adjusting the switching points of different modes through the internal digital registers of HR121x series products, each portion of the efficiency curve can be optimized for different input voltages and load conditions.

The LLC control aspect of the HR121x family of products adopts advanced current mode, which has better stability and response speed than traditional voltage mode. In addition, HR121x parts are divided into three different working modes according to the load conditions (see Figure 4).

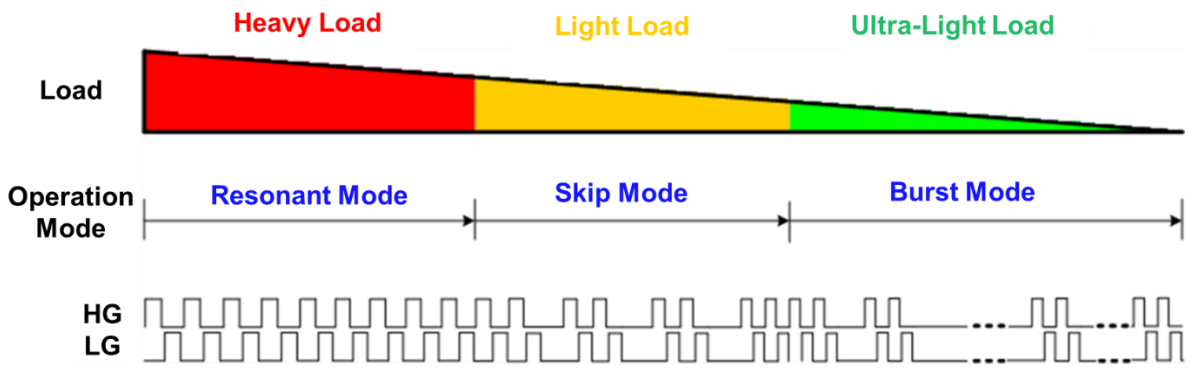

Figure 4: LLC Control Mode in the HR121x

- Under heavy-load conditions, continuous resonance mode is used to ensure zero voltage turn-on and minimized RMS current.
- If the device enters skip mode under relatively light load conditions, it reduces the equivalent switching frequency by inserting a dead time, and avoids switching into the audible frequency range.
- The frequency-configurable burst mode can be entered under extremely light loads, so that while further reducing the switching loss, the effect of audible noise can also be adjusted through frequency control.

Similarly, the switching point and working status of each mode can also be adjusted digitally to achieve the best balance between efficiency and audible noise.

The HR121x product family provides an excellent solution to meet today's efficiency requirements for many applications, while providing best-in-class performance and integration. With its digital core, it also provides the designer with the flexibility to further optimize their design to meet all the challenges of today's power efficiency standards and emerging requirements for the next generation of devices.