Power design challenges for flat-panel DTVs

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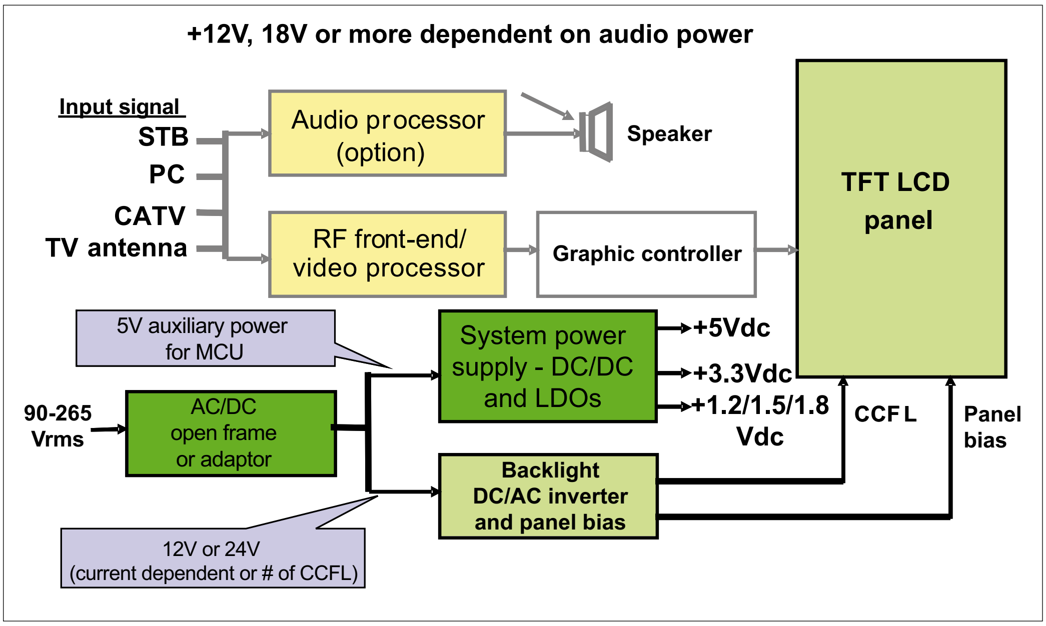
The growth trajectory of flat-panel DTVs puts them on a pace to gain more than 50 per cent of the worldwide TV market in the next year. Power design challenges for DTVs such as plasma and LCD differ significantly from CRT TV applications. The primary challenge is in fitting the power supply into the thin-panel format. Along with this come the tasks of managing heat and EMI in close proximity to the video circuits. The power levels required in these displays are higher compared to CRT requirements, and the required voltages are different, thus complicating the problem further. By one estimate, power supply constitutes 12 per cent of the BOM cost of LCD TV if the display cost is excluded. Physically, it also occupies a significant part of the real estate behind the screen.

The figure provides the architectural overview of an LCD TV system with the power system blocks highlighted. The front-end is an AC/DC converter that takes universal AC input (90-265Vrms) and converts it to isolated DC voltages after applying power factor correction (PFC) upfront. For smaller screen sizes, if the power input is below 75W, PFC may not be required. One of the primary voltages (24V typical) generated by the AC/DC converter primarily feeds the backlight inverter, and its current/power requirement depends on the number of CCFL lamps used in the display (larger screen sizes require more power). Backlighting can consume more than 80 per cent of the total power in a large LCD TV. The second key voltage out of the AC/DC converter is the 12V output used for the audio sub-system and downstream system power after a DC/DC conversion stage for low-voltage signal processing and processor power. Small TVs may use 12V for backlighting and powering the audio amplifiers. There is an additional requirement for a 5V standby power with up to 2A current capability.

All other voltages required in the system are derived by additional processing using LDO or DC/DC converters. The physical location and choice for this processing depends on current requirements and physical constraints.



Power-processing blocks are highlighted in this typical LCD TV block diagram.]

Platforms for screen sizes

While individual design requirements vary depending on factors such as panel size, panel manufacturer, audio requirements and chipset used, the imperative for TV manufacturers and their power-supply ODMs is to come up with standard platforms that can be quickly adapted for differing requirements. These standard platforms may cover a given range of panel sizes (e.g. one platform for up to 26inches, another for 26inches to 32inches and so on). Platform choice is primarily dictated by the cost factor. Since the smaller screen size designs (<26inches, <150W) are lower-power and most cost-sensitive, they are dominated by simple flyback designs. If PFC is required, Critical Conduction Mode (CrM) circuits are used to minimise the cost. However, the need for low EMI and high efficiency has required use of valley-switching (or QR) flyback topology. Minimising heat generation inside the TV is important since LCD TVs are passively cooled, and the significant differences in temperature between the top and bottom of the set may impact the consistency of the CCFL lamp light output. It has been demonstrated that using the appropriate IC solutions from ON Semiconductor and other vendors, the cost impact of changing from traditional fixed frequency flyback to valley-switching is negligible. Low-end designs incorporate single 12V output power supply and create the 5V using post-processor. Standby management is tricky in this approach, as it requires additional load switch.

The next platform level is used for 26inch to 37inch TVs with power levels between 150W and 250W. For these systems, it's a must to have a separate standby converter within the power-supply board, as meeting a standby requirement of <1W input power for 0.5W load becomes difficult otherwise. In addition, the transition to 24V output for backlight inverter occurs. The other signal processing circuits and audio still require 12V bus, so multiple output converters are typically used. While the traditional and lower-end platforms still use flyback topology for the main and standby converters, there is an increasing trend to using the soft-switching topology of LLC half-bridge converters for higher efficiency and lower EMI.

For the higher screen sizes (>37inches), where the power level is >250W, the use of LLC half-bridge converter for main power is more common. Moreover, the PFC function is typically implemented using continuous conduction mode (CCM) circuits. The power level and complexity of requirements increase, so the auxiliary power is handled through a flyback converter. The second rail on the main power goes up to 14V to support increased audio power requirements.

PFC overview

Although the driver for PFC implementation is primarily IEC61000-3-2 (European standard for harmonic reduction),

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the side benefits of active PFC front-end have made it almost a universal choice for majority of flat-panel TVs. This is in stark contrast to CRT TVs, where PFC solutions, if any, were predominantly passive and bulky. Design challenges for the PFC front-end have been eased by recent introduction of simplified CCM controllers such as NCP1653 and supporting collateral. The common choice for the low-end solutions is CrM topology supported by controllers such as the NCP1606. However, a recently introduced variant, the frequency-clamped CrM approach (e.g. NCP1605) is gaining acceptance due to improved standby management and lower EMI.

Other considerations

While selecting the PFC topology for the flat display application, it is important to consider issues such as sequencing of power stages, hold-up time, output voltage range, operation in standby and light load.

The choice of appropriate topology for the main power stage is dependent on factors such as power level, designer familiarity and output requirements. While the flyback approach is very popular, the LLC half-bridge converter needs special mention.

This topology provides significant reduction in power losses by eliminating the turn-on switching losses. In addition, the topology is relatively simple in that it does not require output inductors, unlike other resonant approaches. The resonant tank can also be simplified by integrating the resonant inductor into the main transformer. It also limits the switch voltage stress to maximum of input voltage. These benefits make it a very convenient choice for high-power LCD and plasma TV power-supply design. The presence of a stable PFC voltage rail simplifies the design process, as the switching frequency does not vary significantly. However, designing the power supply using this topology requires special considerations and trade-offs. These include choice of resonant tank, input and output capacitors and transformer design. These are covered in related ON Semiconductor publications for NCP1396. It has been demonstrated that using the LLC half-bridge topology can help achieve more than 90 per cent efficiency.

Emerging architecture

As growth in LCD TVs picks up pace, the pressure to build more cost-effective and energy-efficient power supplies also increases. There are two major initiatives being pursued for this.

The first is the recognition that the input voltage range diversity of markets offers an opportunity to customise the power supply for a given market. For example, designing a power supply for the North American market alone would limit the input voltage range to 90-132Vrms and eliminate the PFC regulatory requirement. This can result in significant reduction of cost and optimisation of the power supply. Similarly, designing for European mains with PFC can also allow a targeted, optimised design.

The second significant architectural trend is to integrate the backlight inverter into the power supply in what is known as an LCD integrated power supply (LIPS). This approach eliminates the need for a 24V rail for the backlight inverter and powers the inverter directly from the PFC output voltage (390V). This results in reducing the overall system power, reduction of heat in the chassis, and cost reduction.

However, since it involves merging two different sections of the TV that may be sourced from different vendors (one from a panel supplier and the other from a power supply ODM), this trend has challenges in terms of supply chain management, as the power supply must now be optimised to a specific panel manufacturer and lamp configuration.

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