Telecommunication power supply system

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Ever-higher levels of integration offered by new semiconductor technology are enabling today"s telecom systems to incorporate more and more functions in increasingly smaller dimensions. Smaller-geometry processes ensure less power consumption, lower working voltages, and fewer square mils of silicon per function. New PC boards often include ICs operating at 5V, 3.3V, 2.5V, O.8V, and so on.

Power requirements for ICs of this new generation are more stringent in terms of load, line, and static voltage regulation. In some cases (those governed by the Intel VRM 8.2 specification, for instance), the output voltage is programmed by means of a digital bus for levels between 1.8V and 3.5V with load currents of 30A or more. Power-supply technology in general has not kept up with this trend, although semiconductor technology allows a higher integration, complete automatic board assembly, and a smaller pitch between the boards.

Except in rare cases, power supplies cannot be assembled automatically. Most have big heatsinks for thermal management that compel a manual assembly. For the majority of telecom systems, conventional cooling techniques have forced a growth in the heatsink dimensions. The heatsink surface that is required relates directly to the power-supply efficiency (Figure 1). Thus, the new power-supply voltages (3V and lower) have a direct influence on heatsink dimensions. Consider a forward converter, as illustrated in Figure 1, operating at 100W:

Moving the supply voltage from 5V down to 3V increases the power dissipation from 20.5W to 42.9W, producing another 22.4W of power dissipation that must be accounted for in the thermal design. The first problem of power dissipation is the rise in internal temperature, which lowers the MTBF of all components. Thus, shrinking the dimensions and costs of IC fabrication has an opposite effect on the associated power supply, unless we considera completely new architecture for power management.

First, multiply the interface requirement by 10 to accommodate a maximum of 10 boards in a system. The total power needed is then 230W, apportioned to five fixed regulated output voltages plus a variable one programmed by means of a 5-bit bus. The maximum tolerance on this variable output is 1%, including line and load regulation. The three power-distribution architectures under consideration are a centralized supply, a distributed and isolated supply, and a centralized single output with auxiliary non-isolated distributed outputs.

This unit generates all required voltages as secondary outputs isolated from the battery voltage. At the output-power level required for this example (230W), the typical configuration can be forward or half-bridge, with the control loop closed (for example) on the main output of 3.3V. The other outputs must be post-regulated to comply with tight tolerance requirements. These post-regulators can be linear or switching types, each independent of the others and driven by a multiple secondary transformer with coupled output inductors (Figure 3).

This approach has several drawbacks: Custom-designed magnetic components are difficult to produce, parasitic elements can have a dramatic effect on performance, and the system"s efficiency is low. Note that a lower output voltage causes lower efficiency, because the loss represented by rectifier diodes and linear regulators (even LDO types) becomes a greater percentage of the output.

Consider a simplified analysis of a 1.5V output (Figure 4). Assuming the duty cycle for current is 50% and the rectifier-diode currents are equal to IOUT, the inductor losses relate only to resistance and not to magnetic effects due to the core material, switching frequency, and so forth. For similar reasons, we neglect losses due to ESR in the capacitor:

Thus, for every watt delivered to the load, the circuit loses 0.7W as thermal energy, which is not an attractive use of energy. More interesting is a system based on switching post-regulators (Figure 5).

The main 5V output in Figure 5 is regulated with optocoupler feedback, and all other outputs are regulated by ICs such as the synchronous step-down types (MAX1630, MAX1637, MAX1652, and MAX1638) or the MAX774 inverting type for negative output voltage. Using standard "off-the-shelf" magnetic components from various suppliers, the 1.5V output generated by a synchronous step-down regulator achieves 87% efficiency, versus 58% in the linear-regulator approach.

The step-down-regulator IC, shown in Figure 6, includes synchronous rectification and is a member of the largest family of such devices available. It features step-down regulation with over- and undervoltage protection, current protection, and auxiliary-voltage capability.

Another possibility is the generation of a negative voltage from a positive one, using an inverting DC-DC controller, as shown in Figure 7. This IC and a few external components (inductor, power MOSFET, and output capacitor) provide the simplest and easiest way to produce the -5V @ 2A required for this system. An evaluation kit from Analog, incorporating all the parts just mentioned, simplifies the board layout and accelerates the design process.