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Modular Solutions for Your Power System

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The longstanding worldwide trend in telecommunication has been away from fixed (wireline) service and towards wireless communication (see Figure 1). Meanwhile, as part of the convergence of tele- and data-communication, network traffic has been increasing by an order of magnitude roughly every four to five years. Forecasts predict the historical trend to continue at least through the end of the current projection window with, at most, only slight deceleration (see Figure 2).

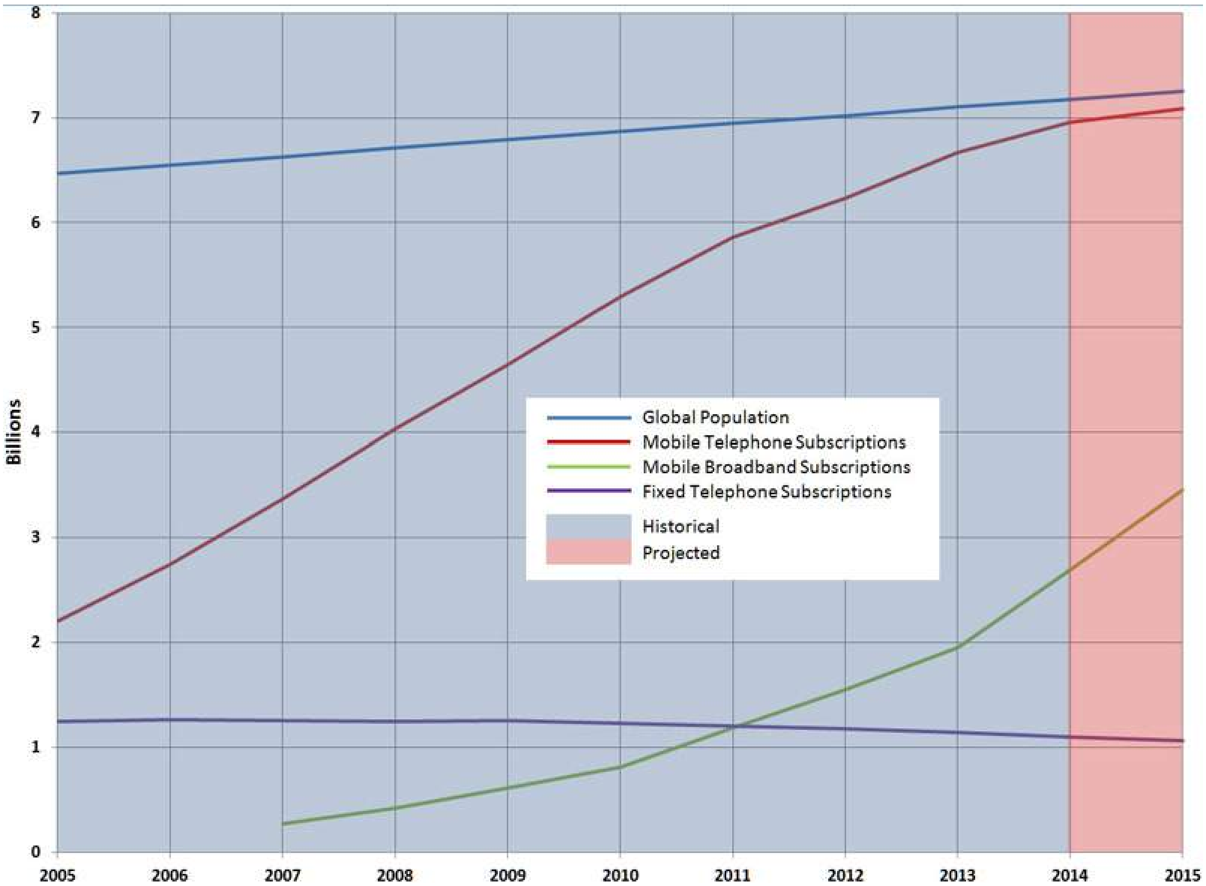

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Figure 1: Trends in fixed-telephone, mobile-telephone, and mobile-broadband subscriptions show rapid growth in wireless adoption as wireline use continues to decline. The global-population trend line represents the ideal-case TAM (total available market) not counting cellular-connected IoT devices, which have yet to emerge as a significant factor in this market. (Data Sources: IUT and World Bank; Graph courtesy JAS Technical Media)

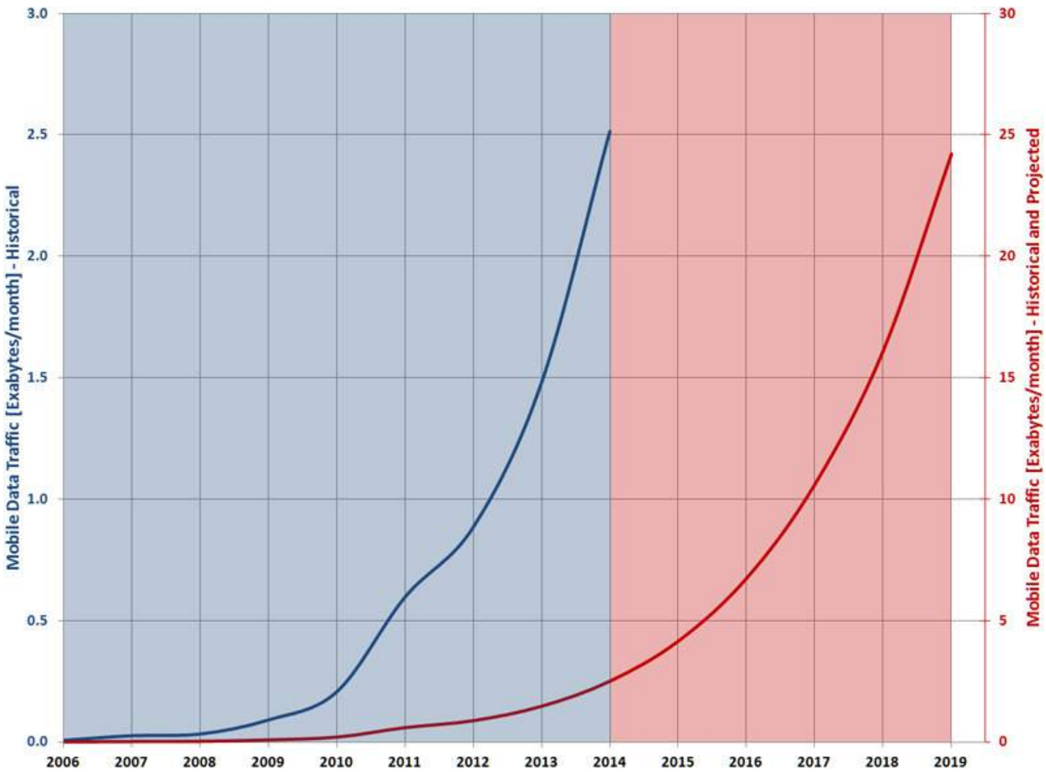

Figure 2: Two trends acting synergistically are largely responsible for continued exponential escalation of network data traffic: Growth in mobile broadband subscriptions and the increase of video content as a fraction of total traffic. (Data source: Cisco; Graph courtesy JAS Technical Media)

Mobile data is the fastest growing traffic segment, on track for a CAGR (compound annual growth rate) of 57% from 2014 through 2019. This compares to 23% for fixed Internet, and 24% for consumer data traffic overall [1]. As a result mobile-sector growth is forcing a significant increase in RAN (radio-access network) capacity.

Data traffic density has never distributed evenly geographically. For example, an October 2012 whitepaper from the wireless-industry association 4G Americas reported that 20% of macro cells carried 80% of mobile traffic [2]. Current use trends exacerbate density in high-traffic areas as mobile broadband subscriptions dominate market growth, data streams increasingly carry video content, and users more and more expect ubiquitous broadband access.

Working within the lines

Service providers must operate within constrained RF-spectrum allocations. Industry studies show that small cells operating in high-traffic geographies significantly increase network capacity, effectively recycling spectrum by decreasing spatial granularity for individual cell deployments.

Macro cells, with ranges to 30 km, remain the core of wireless networks. Although the market applies the nomenclature loosely, small cells include micro cells with ranges to about 2 km, and pico and metro cells that operate to radii of about 200 m. Femto cells are truly short-range nodes with typical ranges on the order of 10 m.

HET-NETs are heterogeneous networks formed of macro cells, small cells, and—optionally—WiFi access points. HET-NETs can improve network capacity by more than a factor of ten with significantly smaller investment and greater spectrum-use efficiency than homogeneous networks relying on macro cells alone.

With all carriers competing with essentially similar suites of services, differentiating customer experience often comes down to coverage area, access reliability, and wireless link speed. As carriers fill in their nominal 3G coverage maps with 4G/LTE service, all three of these differentiating characteristics benefit from HET-NETs that supplement the macro-cell network core with strategically located small cells.

Cost is a critical factor in this competitive, fast-growing market. As the industry embraces HET-NETs, analysts at ARCchart forecast the industry will ship 1.4 million macro cells, 5 million small cells, and 11.5 million Wi-Fi access points annually by 2017 [3].

Small cells first deployed to mitigate the urban canyon effect where large buildings cast RF shadows over nearby areas, creating wireless-network dead zones. The presence of large structures also increases multipath interference, so even locales serviceable by a given macro cell may provide poorer communication-channel performance than a local, low-power small cell located at a lower elevation.

Today, small cells are much more than geo-specific RF bandaids; they are central to carriers' service strategies, combining improved network capacity, geographic coverage, spectrum efficiency, and build-out cost savings. Growing dependence on small cells—particularly in large public gathering areas such as transportation hubs, sports and entertainment arenas, dense commercial districts, and shopping malls—increases the need for unobtrusive inexpensive systems. Small cells also allow mobile terminal equipment to communicate at lower RF-power levels, which improves user experience by extending per-charge operating time.

Demands on small-cell power subsystems

Few applications drive near-equal amounts of data through downstream and backhaul channels and none of those represent but a tiny fraction of the total network load. The vast majority of traffic is downstream. As a result, cell transceivers spend most of their time transmitting, which is the operating mode most demanding on the power subsystem.

Cellular nodes transmit in bursts. Although the transmitted signal may be an encoding of digital data, the encoded signal is analog in nature: Rapid perturbations in amplitude within the signal envelope's bandwidth, for example, can manifest as signal-distortion and degrade the quality of the transmission channel. Such degradation can result in lost data—effectively reducing throughput and, in severe cases, result in data rates insufficient to support certain applications such as streaming video.

Burst-mode transmission systems, therefore, demand high waveform fidelity while drawing high transient currents from the power subsystem. During rapid current-waveform transitions, the power subsystem must limit the output-voltage perturbation to as small a value as possible. Residual output-voltage disturbances can appear as a variation in the RF signal output with little attenuation.

Beyond exhibiting a low dynamic output impedance to support high transient currents, a small-cell power subsystem must also provide high power density. As the RF section and baseband signal- and data-processing components benefit from ongoing trends in device design and semiconductor-process miniaturization, market pressure mounts for power components to keep apace.

Power components must also exhibit excellent thermal characteristics: High temperature is the enemy of reliability, and small-cell designs must tolerate exterior and unregulated-interior operating environments without forced-air cooling. Lastly, a small-cell power subsystem must be resilient in the presence of power-line transients, present a high power-factor load to its AC power source, and minimize conducted and radiated EMI

Considerations for design

Historically, small-cell designs have depended on silver-box style AC-DC power supplies. However, this approach results in rigid designs often with form factors and feature sets that do not allow system designers to improve system density by exploiting advances in power-management topologies, devices, or packaging technologies. Additionally, typical silver-box supplies do not offer thermal interfaces optimized for conductive cooling.

By contrast, flexible modular power-subsystem designs allow small-cell manufacturers to improve space allocations in ways that improve both electrical and thermal performance. Modular power subsystem designs can also take advantage of evolving technologies, low-risk design methodologies, and advanced design-support tools while maintaining stable, reliable product platforms. Fortunately, the requirements of power-subsystem designs for current and emerging small-cell applications align well with some of the latest advances in power-conversion component technologies.

For example, new AC-DC power front-end components have only recently become available in VIA (Vicor Integrated Adapter) packaging. A PFM power front-end module in a 124.8 x 35.5 x 9.4 mm VIA package presents a 25% lower profile and occupies 54% less volume than AC-DC converters with power-factor correction (PFC) in traditional full brick packages. Available in either board or chassis-mount configurations, a PFM can tuck into what might otherwise be waste space along a chassis side or back edge. With the VIA thermally adept housing, arrangements like this can use the system chassis as part of the thermal design.

At its core, the PFM provides isolation, voltage transformation, and regulation. But the power front-end module also integrates key ancillary functions such as EMI filtering, transient protection, and PFC with only a single converter stage. The addition of an AIM provides rectification and drop-in Class-B conducted EMI compliance.

The PFM is compatible with the Power Component Design Methodology—a complete set of components and design tools that allow rapid, low-risk design of flexible, modular power subsystems. The power front-end module extends the Power Component Design Methodology from plug to point of load (POL).

For example, most small-cell deployments take power from the local mains. The PFM operates from universal AC inputs (85 to 264 VRMS), so a single power-subsystem design can apply worldwide. For installations with access to either unregulated 48 VDC or emerging HVDC (380 VNOM), low-voltage and high-voltage BCM modules available in the same VIA form factor can replace a PFM to further extend the applicability of a single small-cell power design (figure 3).

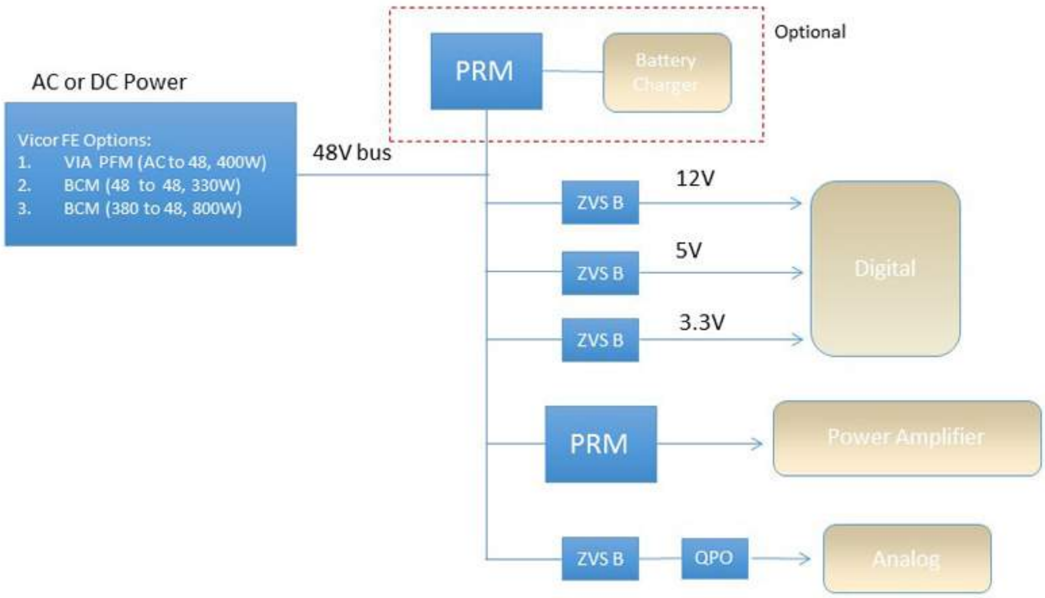

Figure 3: A complete modular small-cell power-subsystem design features an interchangeable front end and is early customizable to support functional options such as single- and dual-band WiFi, various backhaul channels, and PA technologies.

Another example of the benefits of modular designs using the Power Component Design Methodology arises when designers add either single- or dual-band WiFi to a small-cell design. In high-data traffic areas with stationary or slowly moving users, WiFi adds data-carrying capacity while reducing the load on the cellular-network. Sample venues include airport and train terminals, entertainment centers, and conference facilities.

In such cases, designers can locate ZVS buck regulators on the WiFi card to connect to the PFM's 48 or 24 volt bus. The entire WiFi function snaps in as needed, complete with the exact power components necessary to support the function. Small cell manufacturers can also make such functionality available as a field upgrade, needing only the appropriate connectors on a base-model small-cell's main circuit board.

Similarly, as power-amplifier (PA) technologies evolve, supply-voltage requirements change. The trend in power amplifier design has been toward increasing power efficiency so, while the PA's POL voltage may need to change to accommodate new devices, the overall power-delivery capacity should either remain steady or decrease. A modular approach to power subsystem design minimizes the design effort, cycle time, and risk associated with phasing in new power amplifier electronics and allows recycling of much of the mechanical and thermal design as well.

A final example, small-cell operators can choose from a variety of backhaul technologies including RF, fiber-optic, and Ethernet. Here again, modularity in the power-subsystem design allows small-cell designers to build in maximum flexibility to a basic design, allowing customers to choose the back-haul method that best suits a particular installation and manufacturers to respond without sacrificing manufacturing economies of scale or power efficiency.

References:

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