Rev A

From Digital Confusion to Digital Conversion

Presented at Digital Power Forum 2007

Technical Paper

It is now several years since commercial products with ‘added digital performance’ aiming to revolutionize the on-board power industry have been around in the marketplace. The debate around how such products will change the face of the world has never been so intense, resulting in a certain kind of confusion.

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About this paper

Part of the material contained in this paper was presented on September 10, 2007 at Digital Power Forum 2007 - Plenary Session.
This focused three-day international conference served an audience of decision makers who are interested in learning about and contributing to the latest practical advancements related to the use of digital power control techniques in electronic systems and in power converters, and digital energy management and power management in enterprise-level installations and related digital equipment.

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1. Introduction

Energized by the marketing buzz surrounding 'the new power revolution', many articles and column inches have often forcibly expressed the details and benefits of implementing such technology into an industry that has for some time been considered as commodity, and slow moving in terms of innovation when compared to others.

Thus fuelled by the force of marketing led arguments about the inevitable replacement of analogue by digital, digital aficionados predict that as it has been for other market segments, the power industry will not be able to avoid the inevitable digital revolution, comparing it to other industries such as the music industry and the death of vinyl, replaced by the CD [1].

Looking at the other side of the argument, analogue aficionados claim that digital power is nothing new, and that adding digital functionalities to a power supply is as old as the launch by Philips of the world famous Inter-IC Bus (I2C) introduced in early eighties [2], and that nothing will drastically change just because digital marketing is in the air.

2. Halfway

Analogue supporters highlight the lack of market success of products released throughout the years - especially some recent ones that were backed by high power marketing - questioning how such products have contributed to the predicted power revolution.

In fact, for some time the VRM (voltage regulator module) industry has used five bit bus technology (VID or voltage identification) to control the output voltage of the VRM, new generations of VRM and VRD (voltage regulator down) include SMBus for power management, and most of the Telecom and Datacom applications already include digital power management.

So, does the evidence really suggest that nothing is changing, when simultaneously the number of control circuits devoted to add digital performances to power conversion and to optimize power management as never been so high?

It's a paradox that at a time when the semiconductor industry is investing so much money in developing this area, and as major processor manufacturers invest in start-ups and established companies to develop the next generation of digital power management control ICs (e.g. June 2006, Intel Capital invest in FyreStorm) aiming to optimize performance/watt, that end products such as board-mounted ones are so slow at gaining market adoption.

However, strengthened by the number of product releases, press announcements, and motivated by different interests, digital supporters are promoting 'full digital power is the only way to go', and that end-users will very soon have no other choice than to adopt existing products and technologies.

In fact, both arguments are right and wrong; the truth lies in between.

3. Evolution not revolution

Taking into consideration the arguments from both camps, the power industry generally behaves similar to others, following the same rules in terms of technical evolution, technology transition, and marketing.

However, instead of comparing drastic evolution and technology revolution such as that experienced in the vinyl versus CD debate, it would be more relevant to compare the power industry to the car industry.

As it is for the motorcar, the power industry is composed of several elements that have always worked in a certain way and would continue to work that way, unchanged, without major evolution, whilst other industries will evolve and develop bringing significant benefits.

Compared to the car of 1900, today's car still has wheels, an engine, and seats, though automobile manufacturers have gradually introduced new technologies that have improved comfort, performance and safety while reducing energy consumption - and many more improvements are in progress.

The introduction of fuel injection and electronic control in commercial cars is comparable to the introduction of synchronous rectification and the implementation of digital power management in the power industry. Furthermore, electronic intelligence such as navigation systems and performance optimizations gained by adding computerized controls in cars are akin to what has been called the digital revolution in the electronics power industry.

While the wheels have continued to turn, step-by-step the car industry has implemented new technologies, moving from pure analogue control to digital. Adopting this comparison makes it easier to understand that any confusion resulting from information from different sources in the power industry may not be relevant. After filtering out this noise we get nearer to the truth about the evolution of power conversion.

4. Driving factors

In the car industry, the level of evolution and the amount of improvements have been driven by competition and demand from customers. However the most significant improvements, the ones that drove the move from analogue to digital control occurred when fuel prices reached a peak.

Computerized ignition and the optimization of fuel injection to suit driver profiles and traffic conditions took place during an energy crisis, and new technologies to further improve performance per liter of fuel are very similar to what we see in other industries such as microprocessors finding ways to escape the 'suicide curve' by developing Dual-Core technologies

bringing in more performance per watt whilst reducing overall power consumption [3].

Less visible for decades, the power industry is now facing similar challenges, and from site management down to on-board power solutions, every watt saved contributes to reduce the total cost of ownership and global energy consumption.

As it was in the car industry, analogue control reached performance standards that will be difficult to improve upon without changing ways of working, ways of designing products, and by introducing new technologies.

Also, pressure from end-customers to reduce the time-to-market while simultaneously decreasing cost and increasing performance per watt has placed new demands on power supply manufacturers, who must now consider more than pure power conversion by integrating power management and energy saving into the complex equation.

Taking all these aspects into consideration, it is clear that the power industry is now ready to take a serious step forward in digital power - while the wheels are still turning.

Driven by the explosion of portable equipment such as mobile phones, game terminals, MP3-players, and also the increased level of functionalities such as video and online multi-services, the mobile industry has a very high requirement on performance optimization and particularly, the amount of usable power one can eke out of the battery. After all, who would buy a portable equipment that functionally does virtually anything, but offers a battery time as short as a spark?!

As an example of the complexity attained by mobile equipments, combining all modes and functions, the latest mobile phones require no less than 18 voltages, often adjusted to be within a couple of millivolts. Taking into consideration that all those voltages are derived from a single voltage battery, that gives some idea of how complex energy management can be, and evidence if it were needed that only digital control can do the job.

Recent announcements that mobile player manufacturers have signed partnerships and licensing agreements with semiconductor and IP developers to implement the most advanced digital power management into the next generation of portable equipment are evidence that; digital conversion has become a true reality (eg. June 2006, Samsung and National Semiconductor).

Over the last two years, semiconductor manufacturers have taken serious steps to integrate digital functions into the latest generation of control ICs [4] (figure 1), step-by-step adding all the necessary elements to simplify the development of efficient power solutions, and already tangible benefits are evident in

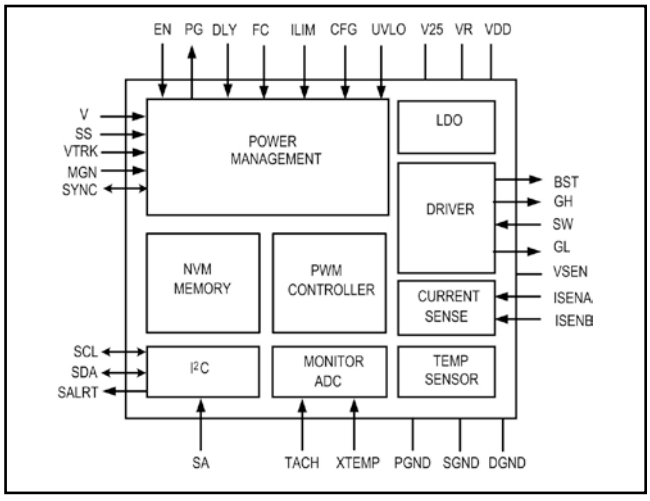

Figure 1 - Integrated PWM with digital control and interface

other segments as well as mobile.
Simultaneously, in the consumer industry, areas such as plasma/flat screen have started to implement digital techniques to gradually replace analogue PWM with digital PWM and ultimately to use a digital DC controller (figures 2, 3, and 4).

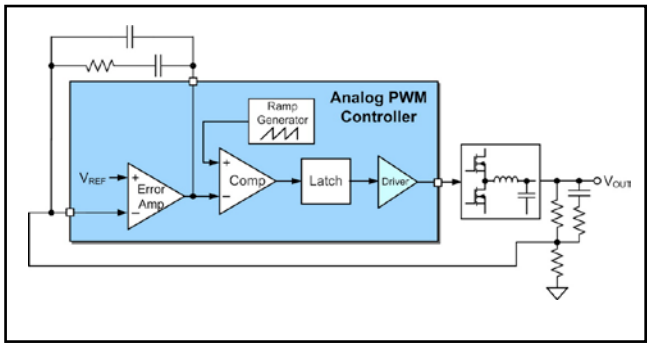

Figure 2 - Conventional analogue PWM controller block diagram

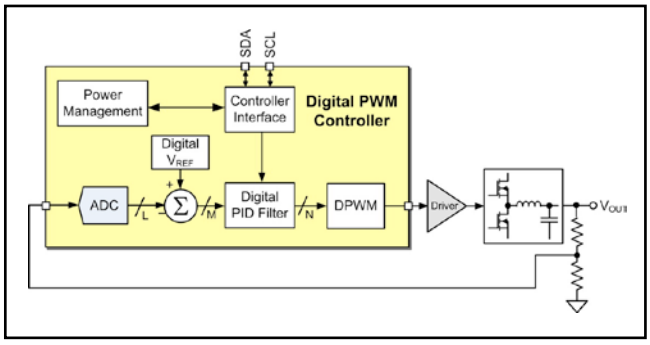

Figure 3 - Digital PWM controller block diagram

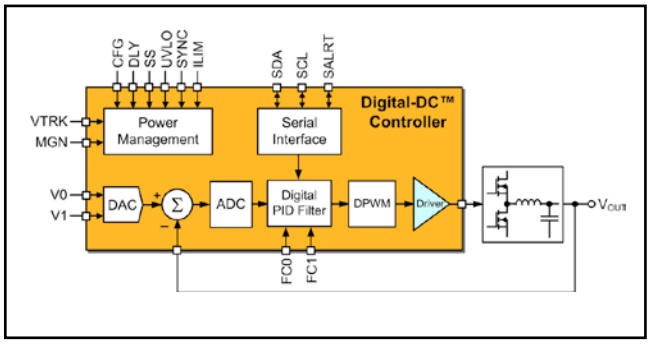

Figure 4 - Fully digital controller

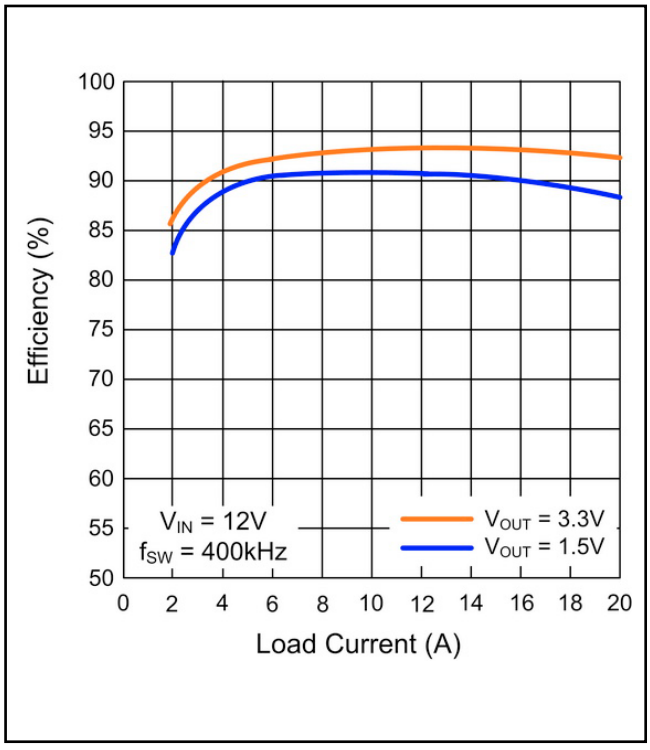

Figure 5 - Efficiency of POL device

The immediate benefit of this transition has been the reduction of power consumption achieved by supplying time controlled, extremely accurate voltages to control specific functions, facilitating compliance with the forthcoming European Directive 2005/32/EC, that encourages manufacturers to produce products that are designed to minimize their overall environmental impact.

Implementing optimized power management and higher efficiency converters and regulators at all points on the curve is the only way to meet future requirements. As well, the results of optimizing such parameters will improve thermal performance, reducing un-necessary power burn, increasing equipment life time, and avoiding noisy cooling equipment resulting from previous forced air circulation, etc.

A further benefit of digital DC controllers is the ability to adjust switching parameters to match load requirement, and that loads as low as 10% of the maximum allowed by the constructor can be accommodated (figure 5).

Knowing that most DC/DC converters and regulators are operated in the range of 40 to 70% of the maximum specified by manufacturers, efficiency improvements at lower load levels have a direct impact on the total cost of ownership.

Other sectors such as aeronautical and transportation already reap the benefits from the new generation of digital DC controllers that include integrated interfaces such as SMBus [5] or PMBus [6], simplifying the designer's job when considering power management at board and systems level (figure 6 & 7).

Figure 6 shows a conventional power architecture using external power and function monitoring, whereas figure 7 highlights the benefits of a fully integrated, digitally controlled power architecture that is obviously much simpler for a designer to implement.
In fact, exploring different segments, we see that digital confusion has already efficiently moved on to digital conversion - again while the wheels have kept turning.

5. Success while moving

In the introduction, I mentioned the analogue aficionados' comments about the number of products released over the years aimed at addressing digital power solutions, and them not being seen as being revolutionary because of slow market adoption.

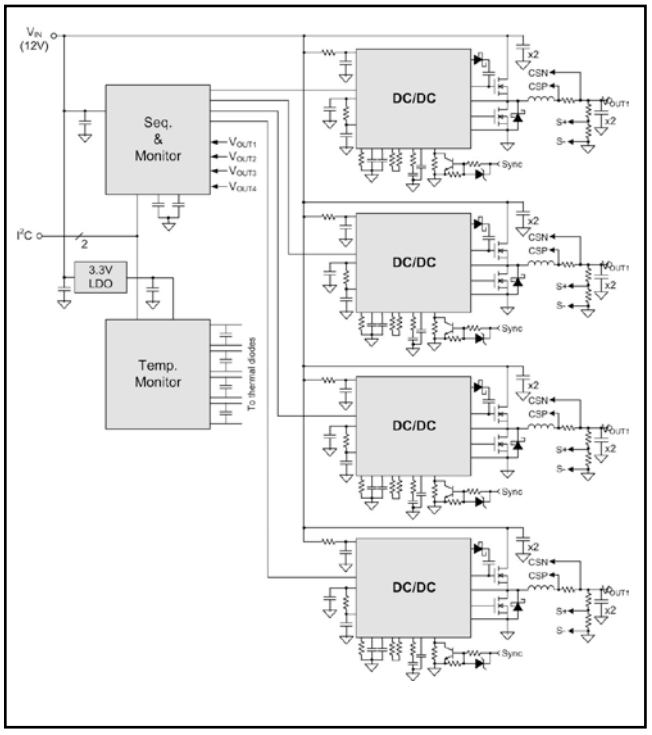

Figure 6 - Conventional power architecture using external power and function monitoring

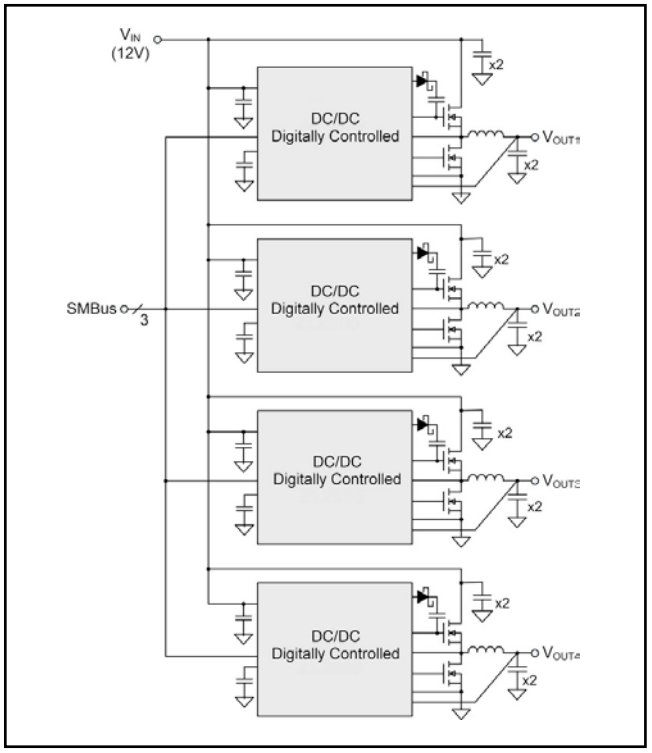

Figure 7 - Power architecture with fully integrated power and function monitoring

Is that really the case, or part of the digital confusion?!

As for all industries - including car - the power industry follows the rules of a marketplace driven by demand, and new products addressing developing segments are always a challenge.

Mentioned earlier, the transition from vinyl to recordable CD has always been highlighted as a reference, but that is without considering other products and standards, where despite technical benefits and leading edge technology haven't encountered expected market recognition.

As the data-storage industry presently battles with the standardization of the next generation of high density DVD format (Blue-Ray versus HD-DVD), we should remember that a few years ago Betamax lost the battle against VHS - despite Betamax's better performance.

As it was for the adoption of a video standard, even at it's relatively modest level, digital power conversion is following the same rules and the principle of 'R.G. Cooper's Law' [7]; "for every four products that enter development, only one becomes a commercial success."

As we've seen, digital power management and conversion is already a reality for a number of segments where standardization is considered at a different level. World leading companies in consumers' high-end equipments are following a business model based on strong partnerships between power supply vendors and equipment manufacturers, in the best mutual interests of the parties involved.

The Telecom and Datacom industries have placed strong demands on on-board power supply manufacturers, demanding strong interoperability between products.

The result of these demands in an industry where time and resources are as important as technology, are the alliances POLA, DOSA and PMBus.

These are aiming to support the power industry with appropriate specifications, footprints, and a communication bus protocol that will result in full interoperability.

6. Conclusions

Driven by growing concerns about energy preservation and reduction of CO_2 released during the operation by the Information Communication Technology (ICT) industry, power supply manufacturers have seriously taken the measure of the situation and initiated number of projects contributing to reduce environmental impacts.

The development of efficient power conversion systems associated to active energy management made possible by digital technologies are the most evident way to go, which will contribute to the rapid development of commercial “digital power solutions.”

Despite some to believe that one technology will prevail on another, it will not be a war between analogue and digital, but more a cohabitation between both and a smooth transition at time equipment manufacturers consider new systems or major updates.

We should remember that volume applications such as radio base stations or datacenters have longer life cycle than most of the consumer’s products and that requirement on inter-operability and make such product longer to design as well.

Whatsoever, and to conclude, as it has been for other industries (remember why Bluetooth and WiFi turned into success), the migration to digital power will require the power industry to consider new ways of working and efforts to standardize the basic principle.

That is the only way to go to guarantee market adoption by designers and end-users of digital power technology, and nothing will happen by magic.

We should all remember that; whatever good products will be, they will not escape ‘R. G. Cooper’s Law’ strengthening the demand on all players to work together - while the wheels are turning.

7. Glossary

CD	Compact Disc
DOSA	Distributed-power Open Standards Alliance
DVD	Digital Versatile Disc
IC	Integrated Circuit
I²C	Inter-Integrated Circuit (multi-master serial computer bus)
ICT	Information Communication Technology
PMBus™	Power Management Bus
POLA	Point Of Load Alliance
PWM	Pulse Width Modulation
SMBus	System Management Bus
VID	Voltage Identification
VRD	Voltage Regulator Down
VRM	Voltage Regulator Module

8. References

[1] Philips celebrates 25th anniversary of the compact disc
http://origin.newscenter.philips.com/about/news/press/20070816_25th_anniversary_cd.page

[2] Philips / DesignCon 2003 TecForum I2C Bus Overview / Jean-Marc Irazabal / Steve Blozis

[3] APEC 2006 – INTEL – Ed Stanford - Power Delivery Challenges in Computer Platforms

[4] Zilker Labs / June 2006 / Digital Power presentation
http://www.zilkerlabs.com

[5] SMBus: http://smbus.org

[6] PMBus: http://pmbus.org

[7] R.G. Cooper, Winning at New products (Reading, MA, Perseus Books, 1993), page 9