This paper addresses hardware designers of Information and Communication Technology equipment, i.e. the users of digitally controlled Board Mounted Power Supplies (BMPS). The intention of this paper is to explain how the digital power technology can be used in both existing and new designs.
1. INTRODUCTION

Digital Power Technology covers both digital implementations of the dc-dc control IC as well as a possibility of controlling the dc-dc converter parameters with a digital interface.

A digital IC controls cycle-by-cycle the switching process of dc-dc converters. Instead of using the analog feedback signal, the digital controller uses digitalized measurements of the input and output electrical parameters and takes a proper switching decision.

When a digital interface is added to a digitally controlled BMPS, the power converter becomes flexible and new features are available. Protection functions can be re-defined depending on the application requirements. Input and output parameters can be modified either before the first power up or “online” (during operation).

Electrical parameters and temperature can be monitored. The possibility of controlling BMPS “online” can dramatically improve efficiency of BMPS on board and system level.

2. VENDOR CONFIGURED BMPS

Digitally controlled dc-dc modules can be completely programmed by the vendor. Both standard and customized configuration information can be put into the control IC memory. The modules may have a standard pinning and work in a stand alone mode. In this case, there is no need for any additional communication interface. The vendor configured digital power modules can be used as replacement of analog BMPS.

Contrary to the analog BMPS, the digitally controlled modules are much more flexible. It is dramatically easier to design and produce customized variants. For instance, a user can order a pre-programmed variant of a Point of Load module with 1.35 V/14 A output, 11 ms start-up time, 7 ms ramp-up time and the load transient response optimized for 1000 μF external ceramic capacitors.

Using vendor configured stand alone modules is the simplest way to take advantage of the digital power technology. No prior knowledge of the digital power is needed at the user site. The drawback of this design approach is that only the vendor can reconfigure the digital module when the user requirements are changed.
3. USING EVALUATION TOOLS

To speed up the development of the customized BMPS, it is required that the users can update the BMPS configuration themselves. The easiest way to do it is using preconfigured digital modules and dedicated design tools.

A typical design tool contains an evaluation board with sockets for one or more digital modules and Graphical User Interface (GUI) personal computer software. Each module on the evaluation board is equipped with an additional digital interface connector. This connector contains pins for serial communication bus as well as address pins. The address pins are necessary when several modules are evaluated at the same time.

The PMBus[1] is often used for internal (within evaluation board) communication and the USB is used for the communication between the evaluation board and the personal computer. The evaluation boards usually contain a PMBus / USB adapter.

Thanks to the GUI, the user does not need to know the PMBus commands. The GUI presents directly the BMPS electrical parameters on the PC display. The designer can change the parameters by typing new values and save them in the module's IC flash memory.

Typical parameters which may be changed by the user are: under and over voltage protection levels, output current limits, start and ramp up times and over temperature protection thresholds. The user can also define the behavior of the BMPS when a protection condition occurs. The user can chose a number of events before the protection is activated as well as the protection mode (e.g. latching or automatic restart).

Setting the protection parameters is particularly important since there is a significant difference between digital and analog BMPS as far as the sensing of the input/output voltage and current is concerned. In digital BMPS, the voltage level is measured with a very fast A/D converter. The results correspond to an instant value in the sampling moment. The voltage sensing in analog BMPS is rather slow, an average value over tens of microseconds is measured. High frequency noise is often present in the monitored voltages. To avoid activation of the protection functions in case of low energy spikes, necessary margins should be added to the protection threshold values.

Figure 1 - 3E Evaluation Kit
4. CONFIGURING BMPS ON APPLICATION BOARDS

For more complex applications (particularly when several modules are used and they require a sophisticated sequencing or when the board power consumption must be minimized) it is not convenient to use a design evaluation board. Instead, it is recommended to add a dedicated serial communication bus (e.g. PMBus) to the application board. Each digital power converter connected to the bus should have a unique address. General design recommendation regarding signal integrity should be applied when routing the PMBus data and clock traces. It is also important to apply proper line terminations. An external PMBus to USB adapter can be used to connect the board under development to a PC. The same GUI as provided with the evaluation board can be used for the BMPS development on the application board.

Once the power design is optimized it is not necessary to copy the PMBus signals and the addressing connections from the prototype to the final version of the application board. The devices once programmed can work in a stand alone mode. However, it is recommended to keep the PMBus lines and the module address configuration for future improvements. Besides, it is likely that new versions (e.g. with lower core voltage) of the application board key components like processors and DSP will arrive on the market. In this case re-configuration of the BMPS will be easier.

5. CONFIGURING FROM A HOST PROCESSOR

When application requires that the BMPS can be reconfigured “online”, the digital power communication bus (e.g. PMBus) must be controlled from a host processor. This design approach is necessary when “online” Energy Management will be implemented. Complex application boards often have board management processors which can be partially used as a host processor for digital power management. It is not recommended to implement the PMBus interface using standard I/O ports and software blocks since it would be a complex task and would require processor resources. Dedicated ICs or commercially available FPGA reference designs should be used instead.

Using host processors gives the designer a great possibility to optimize the BMPS on prototype boards. Parameters as switching frequency, intermediate bus voltage and dynamics of the control loop can be optimized for a specific application. Also, “real-time” monitoring of the BMPS parameters will be possible. It will enable energy management on board and system level.

The advantage of a host configuring is that the high volume manufacturing will not require additional efforts for power configuration. The BMPS can be configured during a Boundary-Scan test of the application board (In-System Programming). The drawback of configuring the BMPS from a host processor is relatively complex software which could be time consuming. A close co-operation between software and power engineers is necessary.

Figure 2 - Benefits of digital Point-of-Load design.

Figure 3 - Intermediate Bus Converter built with digital control & management capability.
6. CONCLUSIONS

Digital power technology makes Board Mounted Power Supplies flexible and more efficient. New features like parameter monitoring and Energy Management become available. On the other hand, the power design becomes more complex, at least, initially.

Digital power knowledge must be transferred from vendors to users. New software tools must be developed. Besides, it is necessary that the board power designers closely cooperate with system and software designers.

The end user of the ICT equipment will definitely benefit when digital power technology is fully implemented.

7. GLOSSARY

DSP       Digital Signal Processor
FPGA      Field Programmable Gate Array
GUI       Graphical User Interface
IC        Integrated Circuit
I2C       Inter-Integrated Circuit
          (multi-master serial computer bus)
ICT       Information Communication Technology
PMBus™    Power Management Bus
SMBus     System Management Bus
USB       Universal Serial Bus

8. REFERENCES

[3] Manufacturing Test and In-System Programming,

All referenced papers and data sheets can be found at Flex Power Modules’ web site:
http://www.Flex.com/power/modules

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