

Power Management Consortium (PMC)

In 1997, at the request of Intel, CPES established a voltage regulator module (VRM) mini-consortium to address the issue of power management for future generations of microprocessors, targeting sub-1 volt and 100-200 amps current. As a result of this focused research, the CPES team developed a multi-phased VRM. Instead of paralleling power semiconductor devices to meet the current demand and efficiency requirements, the research team proposed to parallel a number of mini-converters. By paralleling the mini-converters and phase-shifting the clock signal, the team was able to both cancel the significant part of the output current ripple and increase the ripple frequency by N times, where N is the number of channels paralleled. This resulted in significant demonstrated improvement, specifically:

- 4 times improvement in transient response.
- 10 times reduction in output filter inductors.
- 6 times reduction in output capacitors.
- 6 times improvement in power density.

The new generation of Intel's microprocessor is operating at a much lower voltage and higher current, with a fast dynamic response in order to implement the sleep/power mode of operation. This mode of operation is necessary to conserve energy, and to extend the operation time for battery-operated equipment. The challenge for the VRM in this case is to provide a precisely regulated output with fast dynamic response in order to transfer energy as quickly as possible to the microprocessor. Today, every Intel processor is powered by such multiphase VRMs developed by CPES.

The Power Management Consortium (PMC) is an outgrowth of the early VRM mini-consortium initiated in 1997. The goal is to extend its research scope with a focus on developing precompetitive technologies in the areas of power management for distributed power system architectures, EMI/EMC, power quality, ac-dc converters, dc-dc converters, POL converters in applications including microprocessors, smartphones, tablets, notebooks, servers, data centers, networking products, telecom equipment, solid state lighting, battery chargers, transportation, renewable energy, and other industrial and consumer electronic applications.

The PMC mini-consortium has accumulated a wealth of knowledge and made significant contributions to the power management industry. Since its inception, the program has been supported by more than 50 major semiconductor and power supply companies. PMC currently has 19 members. In the past year, Innoscience (Zhuhai) Technology and NexGen Power Systems have joined PMC.

The PMC places a significant emphasis on developing high efficiency, high-power density switch-mode power supplies based on recent developments in wide bandgap (WBG) power devices such

as gallium nitride (GaN) devices and silicon carbide (SiC) devices. This emphasis is highly leveraged with the recent DOE award of "PowerAmerica." CPES is a partner in this multi-industry, multi-university collaborative program. The role of CPES is to work with the wide bandgap (WBG) manufacturing industry to explore potential applications and impacts of GaN and SiC devices on power conversion technologies.

Below are some highlights of our WBG-based research:

- High-frequency adapter with 40 W/in³ power density and above 94% efficiency.
- High-frequency 1 kW single phase PFC with 700 W/in³ power density and 99% efficiency.
- High-frequency 1 kW 400 V/12 V unregulated LLC converter with 900 W/in³ power density and 98% efficiency.
- High-frequency 3 kW 400 V/48 V isolated dc-dc converter with above 98% efficiency and 300 W/in³ power density.
- 48 V/12 V bus converter for telecom and server application with above 98% efficiency and 1600 W/in³ power density.
- High-frequency 48 V/1 V voltage regulator for server application with above 94% efficiency and 800 W/in³ power density.
- High-frequency 6.6 kW bidirectional on-board charger for plug-in electric vehicles with above 96% efficiency and 50 W/in³ power density.
- 11 kW battery charger with above 96% efficiency and 60 W/in³ power density.
- 25 kW inverter/rectifier module with 99% efficiency and 170 W/in³ power density.

WORK SCOPE

- **High-performance VRM/POL converters.**
- **High-efficiency power architectures for laptops, desktops, and servers.**
- **High-frequency magnetics characterization and design.**
- **High-efficiency and high-power density power supplies with wide bandgap-power devices.**
- **Digital control.**
- **Power management for PV systems.**
- **Power management for battery systems.**
- **Power management for automotive applications.**
- **Solid-state lighting.**
- **EMI.**



PARTICIPANTS *January 2019 – January 2020*

PMC MEMBERS

3M Company
 Analog Devices
 CRRG Zhuzhou Institute Co. Ltd.
 Delta Electronics
 East China Research Institute of
 Microelectronics (ECRIM)
 Efficient Power Conversion
 FSP-Powerland Technology Inc.
 Huawei / Futurewei Technologies Co. Ltd.
 Infineon
 Innoscience (Zhuhai) Technology
 Intel
 Inventronics (Hangzhou) Inc.
 Jiangsu Wanbang Dehe New Energy Co. Ltd.
 Lite-On Technology Corporation
 Lockheed Martin Corporation
 Murata Manufacturing Co. Ltd.
 Navitas Semiconductor
 NexGen Power Systems
 NXP Semiconductors
 ON Semiconductor
 Panasonic Corporation
 Silergy Corporation
 Texas Instruments
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