

## ***Voltage Regulator ICs Take Monolithic Integration To Another Level***

The Milpitas-based startup, [Empower Semiconductor](#), has introduced its first product, a family of power management ICs described as Integrated Voltage Regulators (IVRs). According to the company, the EP70xx will provide significant energy savings in data centers with the single biggest point-of-load power performance disruption in over a decade.

The EP70xx achieves the total integration of a triple-output dc-dc power supply with no external components in a single 5-mm x 5-mm package, attaining up to 10x higher current density, 3x tighter accuracy during transients, and 1000x faster dynamic voltage scaling than leading competitors, says Empower (see Figs. 1 and 2.) The last capability enables fast and lossless processor state changes that can save 30% or more of processor power, according to the vendor.

"Customers are excited about the game-changing nature of our technology and the impact it is having on their systems and digital ICs", says Tim Phillips, chief executive officer and founder of Empower Semiconductor. "The combination of density, speed and efficiency is allowing designers to utilize our products in groundbreaking ways, enabling breakthrough levels of system performance."

The company adds that its patented digitally configurable hardware platform has simplified the adoption of dc-dc converters for designers. With a single footprint, no external components, extensive programmability, a wide range of current and output configurations, power designers can proliferate the EP70xx across nearly all designs and platforms. By having multiple entire power supplies in a single IC package, the usual concerns of component variation and sourcing, synchronization and stability are all either eliminated or reduced significantly.

"Empower Semiconductor had a vision to not only offer breakthrough performance and density, but to make the design process simple with high confidence. We made it simple to place the EP70xx on the PCB with no discrete components, select your settings using the provided GUI, and load the device via the I3C/I2C port. Just like that you have three outputs regulating at high currents with wide bandwidth and high efficiency", says Trey Roessig, chief technology officer & SVP of engineering of Empower Semiconductor. "No input filter design, no output filter design, no feedback resistors, no loop compensation design, no component changes."

With this product introduction, Empower is highlighting the performance capabilities of its new technology and first products, but not revealing much about the underlying technology and how it achieves its performance. According to Phillips, the IVRs switch at a very high frequency—"way above 10 MHz," but still achieve a peak efficiency of 91% with a nearly flat efficiency curve up through 10 A of output current.

When asked about the topology used within the IVRs, the company won't comment on whether it's switched-capacitor or inductor based. However, Phillips notes that no magnetic core inductors are used. He also notes that some of the devices co-package capacitors, while others rely on capacitors that are integrated within the die.

Some high-level specifications are being published now (see the table and features discussed below), including those provided in product briefs. But product data sheets are only available under NDA.

The EP70xx family comes to market with eight initial products: four triples, two duals and two singles. Outputs are available from 1 A to 10 A in a 5-mm x 5-mm or 4-mm x 4-mm package with a 0.75-mm profile, which is said to be 3x to 5x thinner than traditional integrated power modules and inductors (see the table and Fig. 3). The products are also available in bumped die form for co-packaging with digital ICs, enabling full power management integration into the SoC.

Other features of the EP70xx family include:

- A current density of 0.4 A/mm<sup>2</sup>
- A programmable output voltage of 0.40 V to 1.31 V
- Output voltage set point accuracy of  $\pm 1.0\%$  over power, voltage and temperature
- Ultrafast transient response with no output caps

- Programmable fast DVS—up to 12 mV/ns
- Programmable auto-phase shedding
- Extensive fault protection, programming and warning: OVLO, UVLO, OVP, OCP and short circuit
- Accurate current ( $\pm 10\%$ ), voltage ( $\pm 2\%$ ), and temperature ( $\pm 4^\circ\text{C}$ ) reporting
- Adjustable fast soft start with low inrush current

Product samples, demo boards, and reference designs of the EP70xx family with input voltages varying from 2.5 V to 16 V are available immediately to qualified customers. Production volumes are planned for Q4 2020. For more information, see the [website](#).

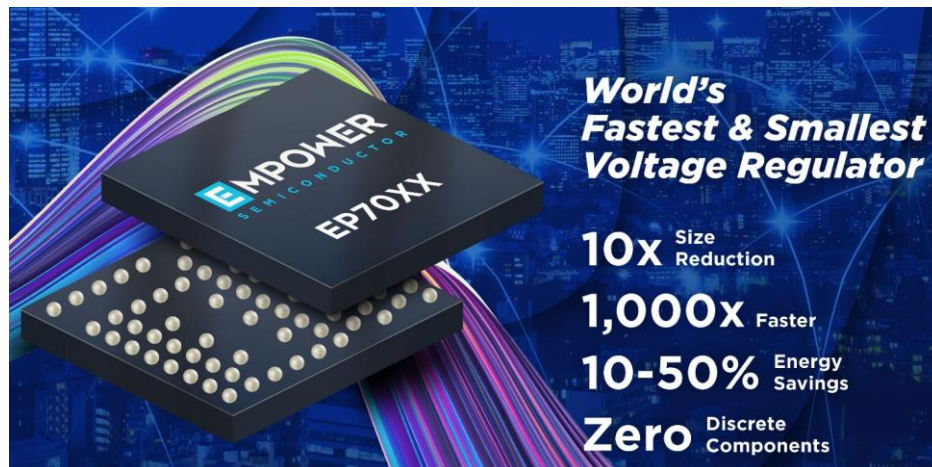


Fig. 1. Empower's IVR, short for Integrated Voltage Regulator, is a high-performance switching regulator that is said to eliminate or integrate all discrete components in a single device. As the photo proclaims, the company is touting the IVR as the "world's fastest and smallest voltage regulator". With the introduction of the EP70XX family of IVRs, these regulator ICs are offered in single-, dual- and triple-output versions with output current ratings from 3 A to 10 A, housed in chip-scale BGA packages, which mostly measure 5 mm x 5 mm.

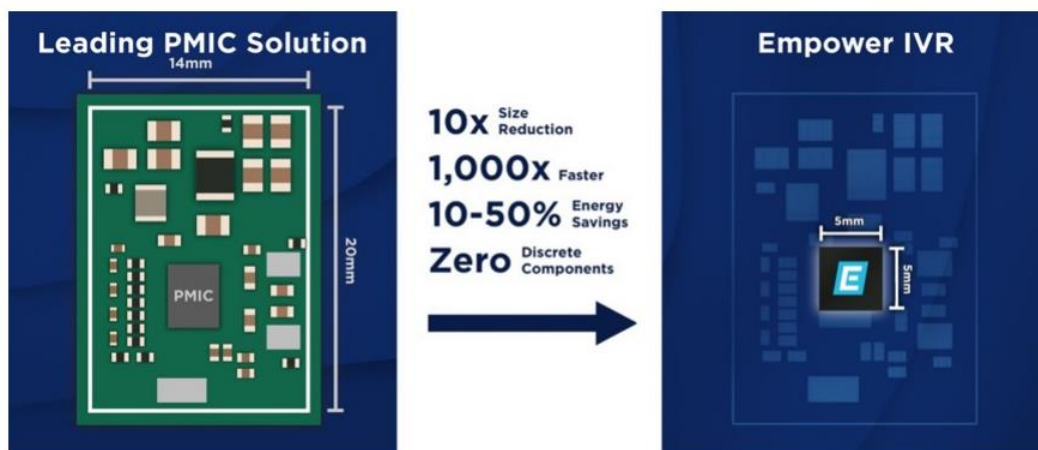
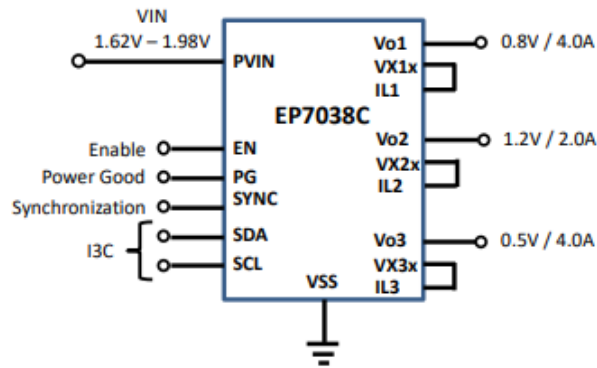


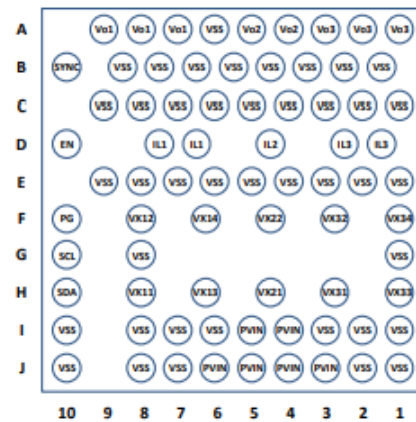
Fig 2. Comparing a typical power management IC (PMIC) design solution versus an Empower IVR. On the left a PMIC solution implementing multiple point-of-load converters (POLs) with up to 11 A of total output requires 40+ discrete components and 280 mm<sup>2</sup> of pc-board space. In contrast, an Empower IVR with multiple POLs capable of up to 10 A of total output requires only one device and occupies only 17 to 25 mm<sup>2</sup> of pc-board area.

Table. Key electrical specs plus package and solution size for the EP70xx Integrated Voltage Regulators.

| Part Number             | Description           | VR Regulated Outputs | Vin Min [V] | Vin Max [V] | VR1 Iout [A] | VR2 Iout [A] | VR3 Iout [A] | Vout Min [V] | Vout Max [V] | Package Type | Package Size (L x W) [mm] | Package Thickness [mm] | Total DC-DC converter PCB area [mm <sup>2</sup> ] |
|-------------------------|-----------------------|----------------------|-------------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------------------|------------------------|---------------------------------------------------|
| <a href="#">EP7010C</a> | Single Output 10A IVR | 1                    | 1.62        | 1.98        | 10           | ---          | ---          | 0.40         | 1.30         | FcCSP        | 5 x 5                     | 0.75                   | 25                                                |
| <a href="#">EP7013C</a> | Single Output 3A IVR  | 1                    | 1.62        | 1.98        | 3            | ---          | ---          | 0.40         | 1.30         | FcCSP        | 4.15 x 4.15               | 0.75                   | 17                                                |
| <a href="#">EP7015C</a> | Single Output 5A IVR  | 1                    | 1.62        | 1.98        | 5            | ---          | ---          | 0.40         | 1.30         | FcCSP        | 5 x 5                     | 0.75                   | 25                                                |
| <a href="#">EP7024C</a> | Dual Output 6A IVR    | 2                    | 1.62        | 1.98        | 3            | 3            | ---          | 0.40         | 1.30         | FcCSP        | 5 x 5                     | 0.75                   | 25                                                |
| <a href="#">EP7027C</a> | Dual Output 10A IVR   | 2                    | 1.62        | 1.98        | 8            | 2            | ---          | 0.40         | 1.30         | FcCSP        | 5 x 5                     | 0.75                   | 25                                                |
| <a href="#">EP7029C</a> | Dual Output 10A IVR   | 2                    | 1.62        | 1.98        | 5            | 5            | ---          | 0.40         | 1.30         | FcCSP        | 5 x 5                     | 0.75                   | 25                                                |
| <a href="#">EP7032C</a> | Triple Output 6A IVR  | 3                    | 1.62        | 1.98        | 2            | 2            | 2            | 0.40         | 1.30         | FcCSP        | 5 x 5                     | 0.75                   | 25                                                |
| <a href="#">EP7037C</a> | Triple Output 10A IVR | 3                    | 1.62        | 1.98        | 6            | 2            | 2            | 0.40         | 1.30         | FcCSP        | 5 x 5                     | 0.75                   | 25                                                |
| <a href="#">EP7038C</a> | Triple Output 10A IVR | 3                    | 1.62        | 1.98        | 4            | 2            | 4            | 0.40         | 1.30         | FcCSP        | 5 x 5                     | 0.75                   | 25                                                |



(a)



(b)

Fig. 3. Typical application diagram for the EP7038C, an IVR that integrates three voltage regulators with outputs of 4 A, 2 A and 4 A. While the package and solution size are small, note the large number of pins in the package pinout.