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Understanding the real benefits of flexibility and configurability in power systems design

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How an improved decision flow can help power systems designers reduce materials and development costs and save design time while developing products better aligned with customers' requirements.

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For electronics product designs with a large (>100W) power requirement, the method for choosing a power supply type appears straightforward.

The design team has three basic options:

- A standard part with fixed specifications. Standard parts are available in a limited range of specifications supporting the inputs and outputs which are most commonly specified in circuit designs.
- A full custom design to the user's exact specification for power, number of outputs, form factor, environmental protection and any other required parameter.
- Configurable or programmable power supplies. A configurable power supply unit can support a wide range of power specifications, and a varying number of power outputs, through the selection of appropriate modules housed in a common base unit. A programmable power supply gives the user the flexibility to fine-tune the input and output specifications of any given module.

Conventional thinking about power supply specification applies a hierarchy to the decision flow.

At the top of the hierarchy is the standard part. It is commonly assumed that, if a design can use a standard part, it should do. A standard part, so the traditional thinking goes, provides the optimal combination of cost, size and efficiency for any standard input/output combination.

This is because the standard part is optimized for exactly one input/output specification; and because it is produced in high volumes for multiple customers, so benefits from economies of scale.

If standard parts do not provide the combination of outputs that a power design requires, however, next in the conventional hierarchy is the full custom part: this provides the design team with exactly the specifications it requires, in a design optimized for performance, low materials cost, efficiency or other parameters as dictated by the customer.

But a full custom solution is not appropriate for some product development programs. Most commonly, this is because the lifetime value of the program is not large enough to justify incurring a custom solution's development costs, or because it will take too long to get to market with a custom design.

Traditionally, then, the decision flow only reaches configurable power supplies at the end, once it is clear that neither a standard part nor a custom power supply unit is appropriate. In other words, a configurable power supply is in effect treated as the designer's last resort.

This paper argues that, in fact, configurable power supplies should be the first option that most program managers and power supply designers should consider.

Configurable power supplies: more than a third way?

A configurable power supply combines some of the advantages of both standard parts and full custom units.

Like a custom part, a configurable power supply enables the design team to specify precise output power ratings that are not supported by standard parts, and to support more than the single or dual power outputs commonly provided by standard parts.

A configurable power supply is formed by the assembly in a common base unit of a number of standard modules.

This means that the configuration process is much quicker than the full custom design process, thus providing for a fast time to market, as a standard part does.

Also, the total cost of ownership of a configurable power supply can generally be competitive with that of a comparable fixed-function standard part, and a full custom design depending on quantity.

Nevertheless, conventional thinking dictates that a configurable power supply is only chosen if a standard or full custom part cannot be used.

This appears rational if electronics product design is considered as:

- a discrete process, isolated from previous and forthcoming end product designs
- a predictable and easily manageable process

These conditions might apply for a certain proportion of designs.

But many design teams work in a context in which end products evolve and spawn variants as part of a family of products; and in which design specifications which are in theory fixed at the start of the design process are, in practice, continually modified as the market or technical situation changes during the course of development.

For these design teams, the characteristics of configurable power supplies take on extra significance, and dictate a re-ordering of the hierarchy of the power supply decision flow.

In fact, power systems designers have as much to gain from configurable and programmable power supplies as do users of other flexible device types such as microcontrollers, microprocessors and FPGAs.

Looking beyond today's product: the many benefits of design flexibility

Perhaps the most remarkable feature of the electronics industry is its ability to continually improve the fundamental technology of the integrated circuit by using ever smaller circuit elements operating at higher speed while using less power and costing less to fabricate. Moore's Law means that the relative cost of next year's digital logic will be less than last year's while its performance will be better.

So as digital logic becomes cheaper and more powerful, the scope to implement control loop functions in (programmable) software that previously would have been performed in hard-wired analog circuits grows ever greater. Software control implemented via digital devices provides the designer with two strong benefits:

- **Feature enhancement** – algorithms can provide for far more sophisticated and complex control functions than are possible with analog circuits.

- **Flexibility** – a control loop implemented in software can be changed simply by uploading new code to memory, a process which can be repeated infinitely during product development. Making the same change in an analog device requires a circuit re-spin. Amending, adapting or enhancing a digital design specification is therefore far easier and quicker than amending the equivalent analog design.

In fact, the benefits of programmability and software control have led to sweeping changes in the architecture of electronics designs across the board, and have led to the mass adoption of flexible, programmable device types such as FPGAs, microprocessors and microcontrollers where, previously, fixed-function ASICs or application-specific standard parts (ASSPs) were used.

Indeed, the industry's gravitation towards programmable or configurable architectures has a long history: Intel's success in microprocessor technology began in the early 1970s when Federico Faggin realized the benefits of implementing a business calculator design for the first time with a general-purpose microprocessor executing computational functions in software, rather than with a hard-wired ASIC.

Why has the flexibility of configurable or programmable device types proved so attractive?

It is because their flexibility is the most effective response to the volatile environment in which design teams work:
Product marketers commonly change the specifications of the product that design teams are developing during the development process

Component suppliers constantly introduce new products with improved performance, additional features or lower costs.

Design teams will frequently modify designs during the design process and even after the product design has been completed in order take advantage of new technology as soon as it is available.

OEMs seek to restrain design and manufacturing costs by re-using both IP and production tooling across families of products.

OEMs commonly aim to address different market segments and different customer requirements with multiple variants of a single base product.

These pressures affect the design of the power system as much as any other element of a circuit design.

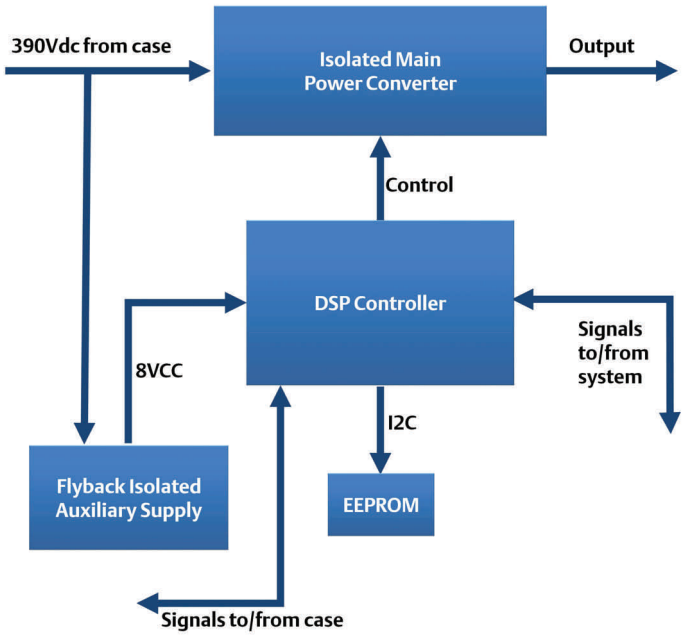
So can power supplies also use digital logic to provide the flexibility that power system designers need?

How much flexibility is offered by configurable and programmable power supplies?

Flexible power supplies are available in the form of configurable power supply units (such as the µMP Series from Emerson Network Power) and fully programmable power supplies (such as Emerson's iMP Series). The two types make different uses of digital technology to provide the user with design flexibility.

A configurable power supply consists of an AC-DC digitally-controlled power conversion front end with Power Factor Correction (PFC), together with a range of modules which can be chosen to provide the required combinations of voltage and current outputs.

Changing the output values requires the simple replacement of one module with another; the



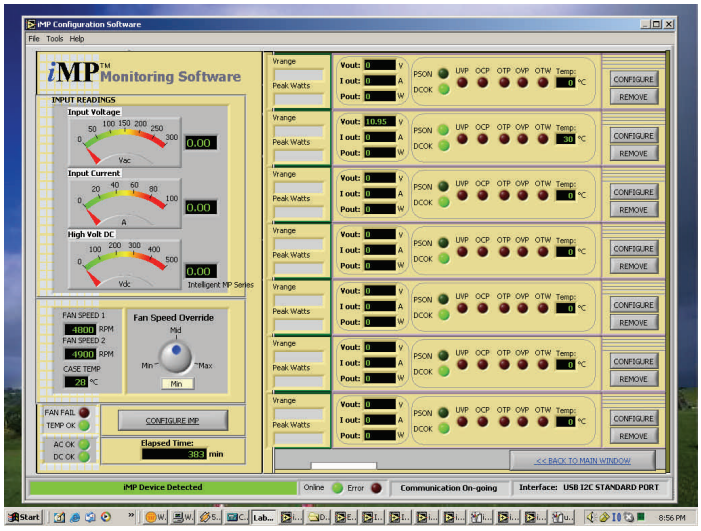
Block diagram of a typical DSP-controlled output module in a configurable power supply

footprint and board connections of the base unit remain constant.

A fully programmable power supply uses digital technology to control both the AC-DC front end and each individual module.

This provides even more flexibility and controllability: the software interface provided with a programmable power supply enables the designer to not only fine-tune the voltage and current outputs, but also to control other important functions such as over-temperature thresholds and fan speed.

In Emerson's iMP programmable power supplies, power conversion in each module is



Software in the iMP Series of programmable power supplies from Emerson Network Power enables the user to monitor system status in real time

fully digitally controlled, and this supports the implementation of intelligent power schemes such as battery-charging routines.

These advanced power supplies provide power system designers with flexibility during and after the product development process. Having determined the appropriate input and output power range, the system design team can implement a board layout with a power supply footprint and connections that will remain constant for the life of the product. Changes to output voltage or current values, or the addition of extra outputs, can be implemented through the selection of the appropriate modules and, in the case of programmable power supplies, through software changes to the digital control loop.

A module can be replaced instantly, with no requirement for extra design time, and with no non-recurring engineering (NRE) or tooling costs, because the footprint of the base unit remains constant.

Modifications can also be made to finished designs in production, to enable changes to the power profile without requiring a change in footprint or any new factory tooling.

By contrast, replacing a fixed-specification standard part to provide different power outputs will normally require a new board layout and terminations, significantly extending the design process and raising design cost. The implications of change are even greater in the case of a full custom power supply, which will require additional NRE fees to support a changed specification, as well as a delay while the new power supply is designed and manufactured.

How flexibility changes the hierarchy of power system decision-making

Volatility and change are the ever-present companions of the electronics design engineer. A flexible, configurable power supply enables the designer to respond to change quickly, decisively and at competitive cost.

As a result, for tomorrow's power system designers the hierarchy of the power system decision flow looks set to change: for many designers, the first decision will become '*flexible or fixed-function power supply?*' not '*standard part or full custom?*'

The decision to choose, from the outset of the design process, a configurable or programmable power supply will be appropriate for design teams which face any of the following circumstances:

1. Uncertainty over the power budget

Today, the accepted method of managing uncertainty in the power budget is to over-specify. The conventional power budget estimation process involves predicting the power requirement for each functional block in the design, and adding a margin for error to each. Each estimate is then aggregated to make a global power budget, and a margin for error is also added to this global power budget.

As a result, the actual power requirement of the finished design is often markedly lower than predicted in the global power budget. If a fixed-function power supply is used, the design ends up with an over-specified unit, which is more expensive and potentially larger than required.

By using a configurable or programmable power supply, the power supply's footprint and form factor can be fixed at the start of the design, but the output voltage and current values changed repeatedly throughout the design. Thus early uncertainty over the power budget does not prevent the design team from achieving an optimal combination of power performance, efficiency and cost in the final power supply unit.

2. Uncertainty over the marketing specification

The needs and desires of customers constantly change. New market intelligence can provide a better insight into what customers really want. A newly introduced component can provide new capabilities that customers will desire.

All of these phenomena can lead product marketers to change the specifications they set for OEM design teams, even after development of the end product has begun. In some cases, these changes entail a different power requirement.

A configurable power supply enables the design team to respond instantly to changes in marketing specification, and to avoid the NRE or design costs associated with a change of a custom unit's specification or a replacement standard part. OEMs can therefore benefit from a design process that is more sensitive to customer needs and quicker to respond to changes in customer requirements.

3. Uncertainty over future product modifications

Typical end product marketing strategies call for multiple product extensions based on a common platform. This enables re-use of IP and production tooling while meeting demand from different market segments with products optimized for the customers in each segment.

But how many variants of the platform product will be required? Will they need to be cost-reduced versions with fewer features? Or to provide added value with more features?

Rarely are the answers to these questions known when the platform product is designed. And therefore the eventual power requirement for each derivative of the base product also cannot be known in advance.

A configurable power supply insulates the OEM designer from this uncertainty, enabling a broad range of power requirements to be met with a single board layout and power supply footprint. Responding to diverse power requirements then becomes a simple matter of changing modules within a fixed base unit.

Design teams can therefore be highly responsive to diverse customer requirements, since

they are able to implement optimized power systems for each product variant quickly and at competitive cost.

The many benefits gained from the use of flexible power supplies

This white paper has argued that design teams should elevate the question of whether to choose a flexible or a fixed-function power supply to the start of the decision flow.

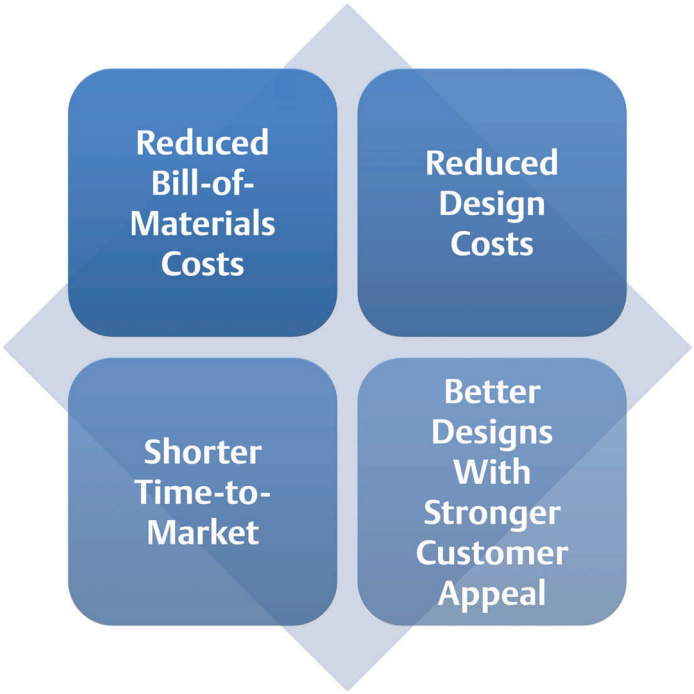
It follows that some design teams will choose to use a configurable power supply even when a comparable standard part could meet their immediate need at a lower cost. They will do so because the value of the flexibility they gain outweighs the small extra cost of using a configurable power supply. Over the lifetime of the product, many design teams will find that choosing a configurable power supply costs less than a reliance on standard parts.

Reduced bill-of-materials costs

The power supply can be specified to match the requirements of the design, rather than over-specified to allow a margin for change or estimation errors.

Shorter time to market

While users of standard parts or full custom power supplies spend time redesigning the board layout and production tooling to accommodate a changed power supply, the user of a configurable power supply simply swaps modules in a fixed base unit.



Reduced design costs

When the power requirement changes, the board layout and terminations can remain constant.

Better designs with stronger customer appeal

Users of configurable power supplies can develop more product variants with more diverse features to appeal more strongly to different market segments. Product variants can be manufactured without any requirement for a new board layout or new production tooling to accommodate a new power specification. A simple power module swap accomplishes the change instantly.

Configurable and programmable power supplies available from Emerson Network Power

Emerson Network Power provides both configurable and fully programmable power supplies.

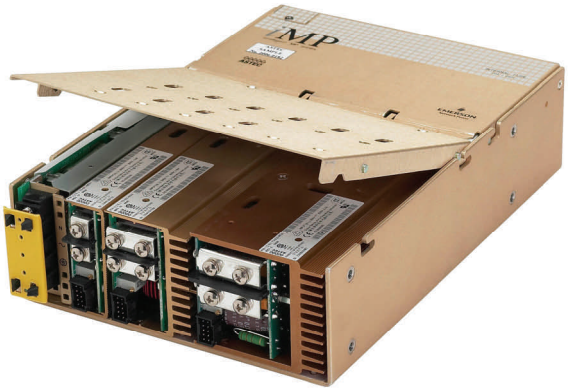
µMP Series

The Emerson µMP Series (MicroMP) configurable power supplies support power requirements from 400W to 1200W in high-density 1U-type power supplies. The µMP series rivals the cost of non-configurable power supplies while providing market-leading density, efficiency and reliability.

The Emerson µMP family carries full EN60950 ITE and EN60601 (medical) safety approvals, and offers up to 12 outputs, smart fan control and monitoring of parameters such as fan speed, temperature, output voltage and output current. Readings are carried via the device's I2C interface using the industry-standard PMBus™ protocol.

iMP Series

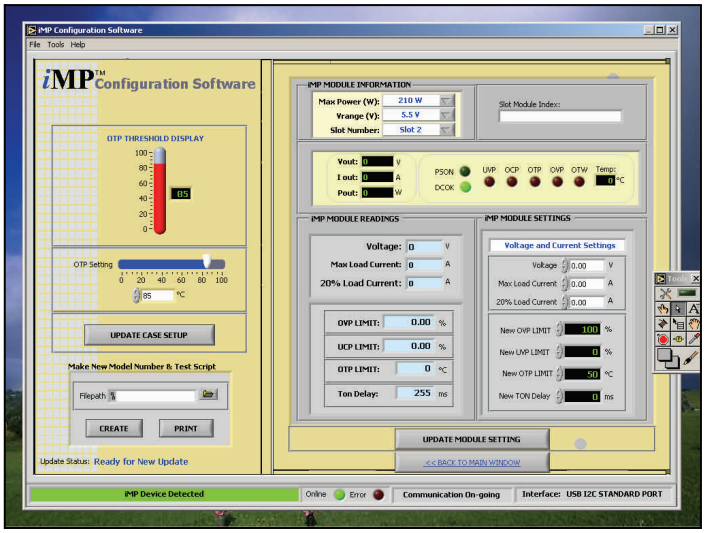
All Emerson iMP Series AC-DC configurable power supplies are fully programmable. Both the case and the individual power modules feature integral microcontrollers to maximize control



flexibility, with all communication between the host controller and the power supply handled using the PMBus protocol.

Setting-up an iMP Series configurable power module could not be simpler. The control software supplied with every iMP series configurable power supply runs under Microsoft Windows® on any standard PC through an easy-to-use graphical user interface.

The same control screen is used for all modules and all operating parameters. As well as defining a module's output voltage and current, the designer can just as easily adjust its OVP, UVP and OTP limits, change its OCP mode and control signal, and even force fan speed override if needed.



Digital control of the iMP Series of programmable power supplies from Emerson Network Power extends to configuration of parameters such as over-voltage protection, over-current protection and over-temperature protection

iVS™ Series

The Emerson iVS™ Series of modular AC-DC power supplies supports high-power applications up to a 4920W output capability. iVS units enable the user to monitor and control many attributes of the power supply via their I2C interface.

The series offers seven types of modules, including single-, dual- and triple-output units, with individual power outputs of up to 1500W. The iVS series offers 25 standard output voltages, from 2Vdc to 60Vdc, and can provide up to 24 outputs.

About Emerson Network Power

Emerson Network Power, a business of Emerson (NYSE:EMR), is the global leader in enabling *Business-Critical Continuity™*. The company is the trusted source for adaptive and ultra-reliable solutions that enable and protect its customers' business-critical technology infrastructures.

The Embedded Power business of Emerson Network Power, which embraces the well-known Astec and Artesyn brands, is one of the world's largest and most successful power supply companies.

The company's standard ac-dc product portfolio covers a power range of 25 watts to 5 kilowatts and includes open-frame and enclosed models, highly configurable modular power supplies, rack-mounting bulk power units, DIN rail power supplies and external power adapters. Many of these products are available in medically approved versions and a large number of the higher power models feature extensive built-in intelligence. A wide range of dc-dc power conversion products includes isolated dc-dc converters, covering industry standard sixteenth- to full-brick form factors and power ratings from 3 watts to 700 watts, and three application-optimized families of non-isolated dc-dc converters.

Renowned for their outstanding performance, reliability and cost effectiveness, Emerson power supplies are used extensively by OEMs and system integrators for diverse applications in the healthcare, communications, computing, storage, test and measurement, instrumentation, military (COTS), aerospace, LED lighting and industrial equipment industries.

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