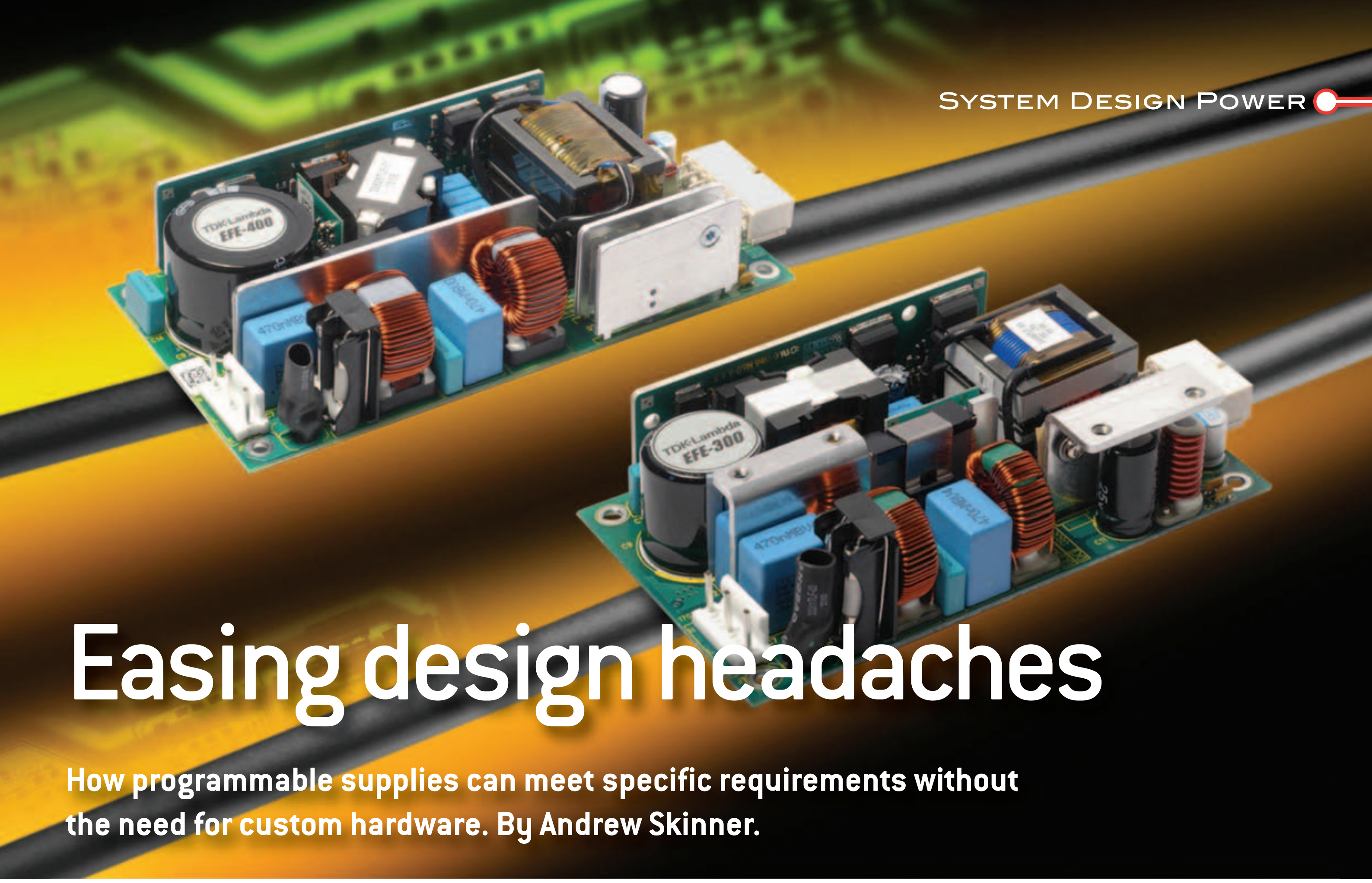


Easing design headaches

How programmable supplies can meet specific requirements without the need for custom hardware. By Andrew Skinner.

Power supplies with digital control are gaining in popularity. However the term 'digital control' has two quite different meanings. 'Digital power management' is where customers communicate with the power supply to monitor status and adjust certain parameters remotely, such as voltage and current limit. 'Digital power conversion', meanwhile – still in its infancy in terms of commercially available products – involves replacement of the common power supply analogue control loop with a digital control loop.

Flexibility is one of the major advantages of power supplies using digital power conversion, where customer specific optimisations can be achieved without the time and expense of changing the hardware.

The programmable soft start characteristic of TDK-Lambda's EFE series of power supplies is mostly used where a system has dc/dc converters being powered by the product. There are two distinct problems that can arise with dc/dc converters powered from ac/dc supplies. The first is the high inrush current required to charge the large input filter capacitance required by most dc/dc converters. The second is the inrush current created when they start up. This second inrush occurs when the supply voltage to the converter exceeds its undervoltage lockout threshold (UVLO). The converter then tries to quickly charge its output capacitance, which can result in a large current at the input.

How the ac/dc supply's overcurrent protection works dictates what happens next – most power supplies would have some form of constant current protection for a short period of time during which the output voltage may stay flat or it may even go down (causing a non monotonic rise) due to the dc/dc converter inrush current. The worst case scenario, as far as the dc/dc converter is concerned, is that the output voltage of the power supply drops below the UVLO threshold because of the current being demanded. At that point, the dc/dc converter switches off. This condition can become cyclic and precisely what that looks like and how long it takes is quite dependent on the

Fig 1: EFE300 start up when driving POL converters

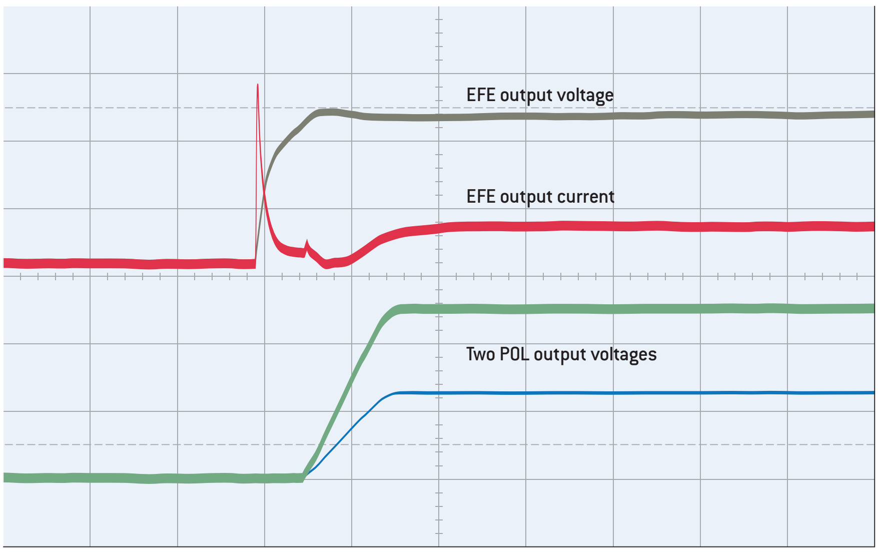
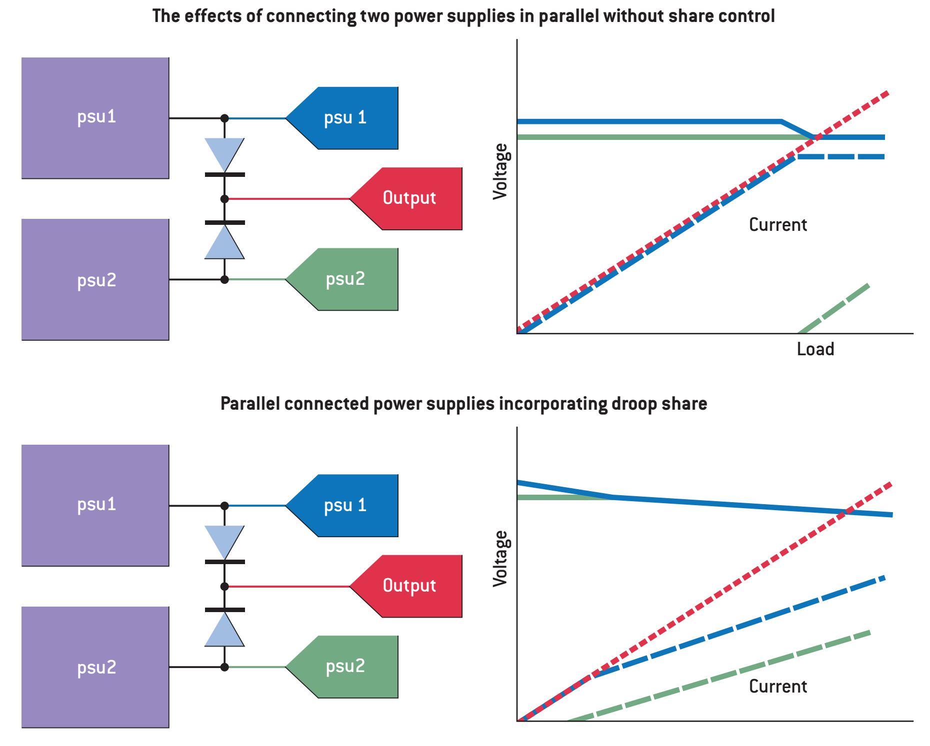


Fig 2: Connecting power supplies in parallel



specific power supply and the specific converter.

Fig 1 shows an EFE300 starting up into five point of load (POL) dc/dc converters and the 7000μF of low impedance capacitors connected on their inputs. The POL converters are paralleled to provide two output voltages with a controlled soft start, resulting in only a small second inrush. In this example, after the initial peak, approximately half the rated current of the EFE300 (25A) is being used to charge the input filter capacitors of the converters.

With the EFE series of power supplies, the soft start characteristics include soft start time, current limit thresholds, allowed current limit on time and the output voltage level at which control is handed over to the main control loop. The handover point can be tailored on a customer specific basis, if needed.

From fig 1, if the voltage at which the POL converters start up was lower, then the second inrush could coincide with the first inrush, causing the overcurrent protection to operate. In situations like this, the current limit characteristics of the EFE series power supply could be modified to enable the application to function correctly during soft start without affecting the normal operating limits. Meanwhile, the customer still has the benefit of receiving standard hardware.

The programmable soft start characteristic can also be beneficial for other applications involving non linear loads, such as fans, motors and drives.

When two or more power supplies are connected in parallel, the one with the highest output voltage will supply the load; the second unit only supplies current when the output voltage of the first falls below the voltage of the second.

For supplies with a small variation in output voltage with load, no sharing may occur until the first power supply is overloaded and enters its current limit (see Fig 2).

The normal solution is to have a separate circuit that forces current sharing – usually a single wire connection between all paralleled power supplies known as a current share bus. The bus effectively acts as a current demand reference and the supplies endeavour to follow this.

In theory, this is a good solution since it maintains load regulation. In practice, it doesn't tend to work well at light loads and it is not uncommon to require a minimum load for sharing to occur.

The current share bus is also a single point of failure – loss of the bus could result in zero demand to the supplies. One of the main reasons for paralleling power supplies is to improve reliability by having an N+1 setup; having a single failure point defeats the object.

A less common solution to provide sharing between paralleled power supplies is to increase the load regulation (the amount by which the output voltage changes with load). If the output voltage changes quickly with load current, not as much current is needed in the higher voltage power supply before the lower voltage one starts to carry current (fig 2). In this scheme there is no share bus and no single point of failure. In some high reliability applications, this is the preferred method of current sharing, called 'droop sharing'.

Clearly, some applications require droop. The normal setting for a single power supply unit with the EFE series is a nominally zero slope. However, for paralleling, rather than having a fixed output characteristic, load regulation is a programmable feature. Effectively, this feature allows the 50% load point voltage to be set within the range from -5 to 10% of nominal and load regulation can be programmed with a positive or a negative slope. The control algorithm is programmed such that the slope is always within the specified output range.

The beauty of digital power conversion in supplies such as the EFE range is that customer specific droop characteristics can be created using simple software changes with standard hardware, thus reducing cost, speeding time to market and improving overall system reliability

Optimising power supply performance has become possible due to TDK-Lambda's strategic decision to develop digital power conversion intellectual property from scratch. In order to take maximum advantage of the flexibility that digital power conversion can bring, designers need to understand the algorithms involved.

Unfortunately, start up issues like these often materialise late in the design process. The way in which the load starts is a very important attribute and one that is not always considered when specifying a power supply.

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