

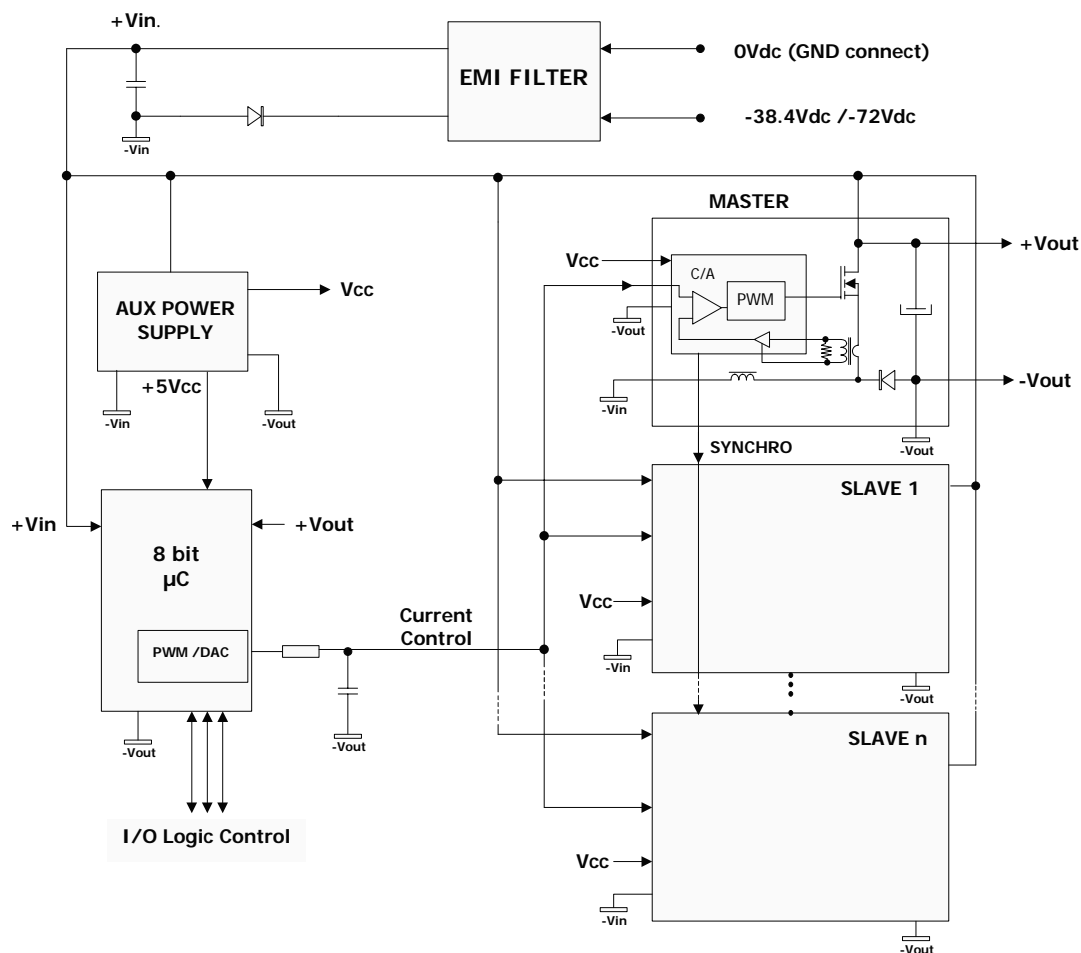


## Using Digital Control to Improve Light Load Behaviour

Since the very first Digital Power Forum which took place in 2004, many articles have been written touting the general advantages of using digital control. It was at this time that ROAL Electronics introduced into the marketplace the first digitally controlled DC-DC converter. Today the majority of the power supplies designed by ROAL incorporate this architecture, and although this practice is now considered common, we are still discovering new advantages of using digital power.

Understanding which is the minimum load of a converter is an important issue for those familiar with power supply design. It is not easy to maintain a stable behaviour at light load, especially when the design requires high output power. Many techniques surfaced in the past years: burst mode, cycle skipping, frequency reduction; but these are not always the best solutions, and it really depends on the final application.

The flexibility of the digital based design platform can help to improve the light load behaviour of the converter. This article will describe the technique implemented in a 3Kw DC-DC converter design to address the light load voltage stability issue.





The diagram above depicts the ROAL base platform for a multiphase digitally controlled telecom DC-DC converter. The input stage covers ANSI and ETSI standards, and includes an EMI filter to meet class A conducted and radiated emissions. An auxiliary converter is taking care of all the bias voltages required for the entire system. The digital part on the left is composed of a low cost 8 bit 10MIBS capability  $\mu$ controller and a 16 bit DAC. It is basically receiving information about the input and output voltages, generating through a DAC, a current control voltage toward the analog part of the scheme. The voltage loop is then managed by the  $\mu$ controller.

It also provides the monitoring and alarm functions, including:

- User interface and sequencing features
- Fan rotation detection and speed control
- Input over/under voltage detection
- Output over/under voltage detection
- ANSI/ETSI input range selection
- Temperature monitoring

The analog part on the right is composed of three synchronised phases, and the current control voltage drives it. Every power phase is designed to manage 1Kw and can be paralleled with the proper shift phase to achieve the total power needed. In this case, the three-phase implementation drives us to choose a 120° shift synchronization feature that also allows a reduced input and output ripple current and lower EMI emissions.

The digital and analog sections are separated because the  $\mu$ controller is not powerful enough to generate the duty cycle for the power mosfets; a standard PWM chip is taking care of the waveform generation. The reason for this fractioning is the extreme flexibility; it is possible to go from 1 to n phases with almost no firmware changes. With the same control voltage the ucontroller can drive n phases, it is just a question of hardware replication!

The specification for this product requires a very stable output voltage, even at no load, but with all three engines working at light load this is difficult to achieve. As a first step we decided to switch off two of the three phases for an output power lower than 100W and this change resulted in a good measure of improvement due to the reduced power per control step, but the design was still critical. An increased loop gain could keep the output stable, but it is not adequate for the entire load variations.

Now we have to think digitally, all the variables are available directly at the  $\mu$ controller pins: output voltage, output load, phase activation capability, so the firmware can find the best parameters based on the above information. The best way to improve the no load performance is make the loop compensation a function of the load and number of phases activated. In this way we optimize the control loop for an output power below 10W and, at the same time, we improve the light load efficiency, since there is no reason to waste power. The improved converter now exhibits stable behaviour at every load, even at no load.

It stands to reason then, that different algorithms can be implemented depending upon design specification requirements. For example, the feedback loop can change on each phase of activation. Another requirement of this design is for a no load to full load dynamic step change that



forces the implementation of a delay in the firmware to avoid excessive over- and under-shoot variations. The non-linear control loop is also making this load variation possible, even with a modest bandwidth of few kHz.

All of this just goes to show that the control loop response can be changed whenever needed - something that is very difficult with an analog approach.

Before the advent of digital control capabilities in power supply design, hardware engineers were alone on the bench with only their tools, forever tweaking and experimenting with different design approaches to solve the many anomalies associated with the behavioural characteristics of power supplies. Now with the firmware side complete, the intellectual process seems very clear to us - we are four hands instead of two. We work side-by-side with our software engineers, combining our particular skill sets and learning to speak the same language – the language of digital control. Through effective teamwork, hardware and software designers can identify and answer design questions like:

- Can this parameter be a function of the input or output voltage?
- Can we dynamically adjust the output voltage?
- Can we implement the output voltage trimming digitally?

This may sound very trivial, but when faced with challenging requirements and shortened times to market, true digital power management has tremendous value, and produces incredible results.

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