SPACE IC

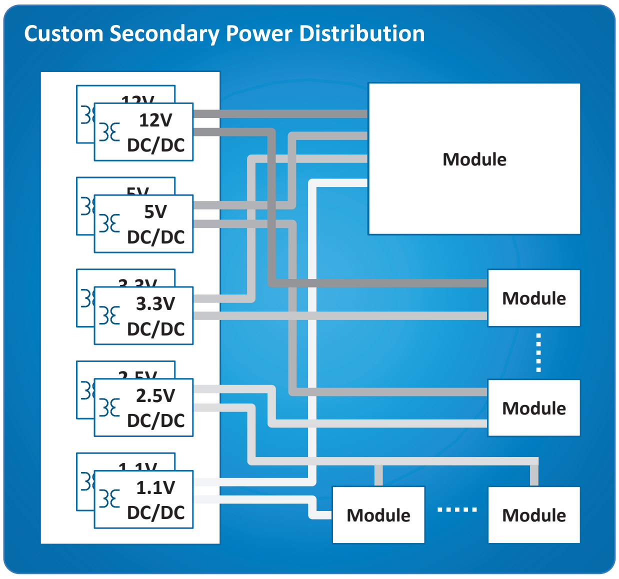
WHITE PAPER

Efficient Secondary DC Power Distribution in Satellites

INTRODUCTION

In todays satellites, a centralized secondary power conditioning unit must supply a wide variety of low voltages, which are required by the payload modules, precisely and without fluctuations even at severe load variations. For this reason, the power conditioning units are very sophisticated and have to be customized for each individual payload.

A complex bus system distributes each of the various supply voltages to all the payload modules. There they are either used directly to supply the module electronics or distributed voltage regulators generate the required output voltages down to <1V from the intermediate voltage.

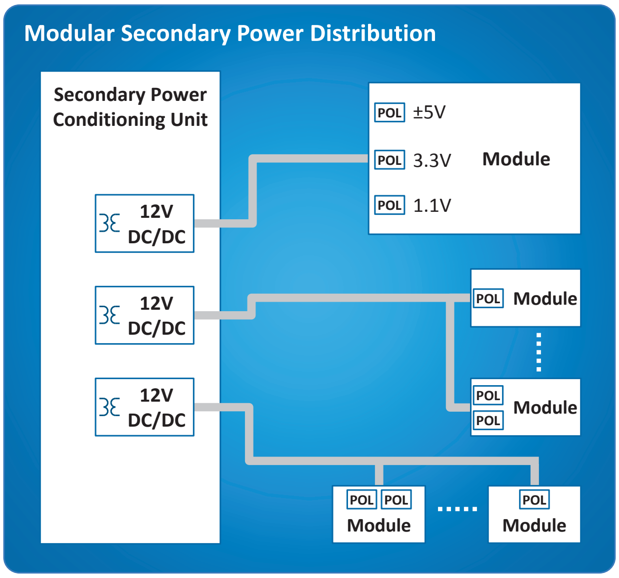


Development, volume, and weight of such power units and power rails significantly contribute to the costs of space missions. Any satellite with its individual payloads requires a specific power conditioning and distribution system leading to high development and qualification efforts. Any alterations in the payload architecture necessarily entail changes in the design of the power supply unit. At the same time, the power distribution to the modules with low voltages and high currents requires heavy power rails due to large cross-sections or suffers from conduction losses or both.

MODULAR POINT-OF-LOAD ARCHITECTURE

The power conditioning and distribution in newer space systems could be realized in a modern point-of-load architecture.
In this case, the secondary power conditioning unit provides only a few intermediate voltages with significantly reduced accuracy for all electronic power consumers in the payload.
A simplified bus system with just a few rails distributes the intermediate voltage to the payload modules.

The supply voltages needed by a module are generated from the intermediate power rails at exactly the right low levels directly at the electronic component to be supplied – the point of load (POL).
This has to be done by compact and highly efficient DC/DC converters which can be flexibly configured to deliver a wide range of output voltages down to <1V from a standard intermediate voltage.



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MODULAR POINT-OF-LOAD ARCHITECTURE (continued)

The modular point-of-load architecture comes with several advantages:

- The secondary power conditioning unit becomes more independent from the voltage requirements of the subsystems and its complexity can be greatly reduced. The diversity of voltages is decreased and no precise control of output voltages is needed. Also, it can be implemented as a scalable power unit with a number of intermediate voltage DC/DC converters which can be extended with the payload power.

- The power distribution requires a few intermediate voltage rails only. The typically required voltages of todays space electronics range from 0.9V to 5.0V. An intermediate voltage of 12V might be a good compromise to minimize the conduction losses in the power rails on the one hand and, on the other hand, to enable an energy-efficient DC/DC step-down conversion. With the reduction of conduction losses due to lower currents the power rails can be built with smaller cross sections for saving weight and volume.

- The local supply of the electronics with POL converters will precisely fit the individual requirements. At the same time it can be realized via a standardized power interface. The re-usability of payload modules built in this way allows development and qualification costs to be transferred to numerous satellites, which means a significant cost reduction per satellite.

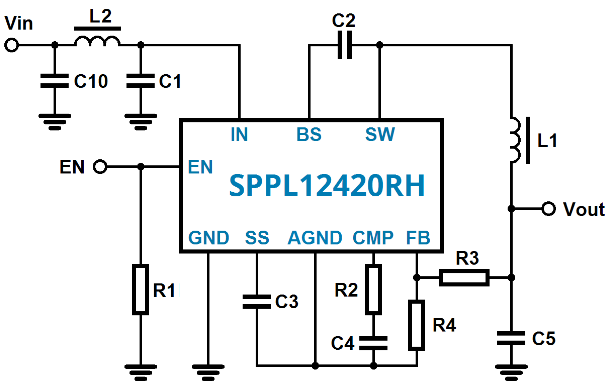
A highly simplified secondary power conditioning unit, the power distribution by a few intermediate voltage rails, and the standardization of the power interface which enables every module to be supplied locally by small POL converters serve to improve both energy and cost efficiency.

EASY APPLICABLE POL SOLUTIONS

The ideal DC/DC POL converter in the above scenario is a space-grade monolithic integrated circuit with:

- input voltage capability of 12V or more
- integrated power switches
- high efficiency
- protection features (e.g. over-current, short-circuit, under-voltage, over-heating)
- a minimum of passive external components
- configurability for a wide variety of output voltages

The figure shows a monolithic POL converter including external circuitry which operates in step-down conversion (buck) mode. Small surface mount inductors are used for input filtering and power conversion.



The output voltage can be easily adjusted for the individual loads by setting the output voltage divider consisting of R3 and R4, as expressed by the following equation:

$$V_{OUT} = V_{FB} \cdot \frac{R_3 + R_4}{R_4}$$

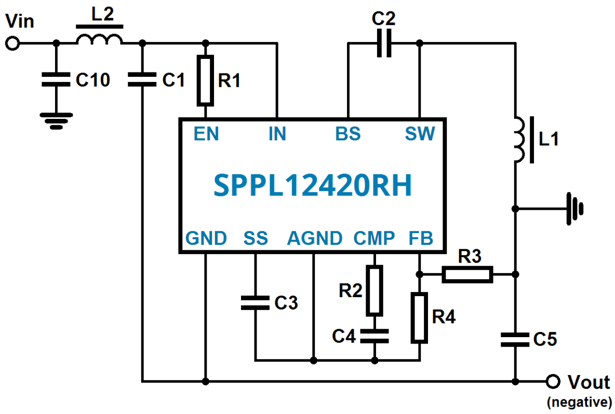
For given values of the R4 resistor and the V_{FB} chip reference voltage, the R3 resistor may easily be calculated for the desired output voltage.

EASY APPLICABLE POL SOLUTIONS (continued)

With a slight change of the configuration above the same POL converter circuit can be operated in buck-boost mode (if supported by the DC/DC converter IC). In this mode negative output voltages can be generated from a positive input voltage without additional hardware.

Note that in this mode the maximum recommended chip input voltage is related to the sum of the input and output voltage absolute values: |V(Vin)| + |V(Vout)|

A further variation of the initial step-down conversion topology is the doubling of the load current capability by running two POL converters in load sharing mode.



With monolithic POL converters very simple and efficient circuits cover operation of a huge diversity of payload modules with different supply voltage requirements from a standard intermediate voltage. The minimum of passive external components ensures a very cost- and space-saving design.

SUMMARY

The evolution of power distribution in spacecraft goes into direction of modular architecture. Especially the secondary power distribution from the satellite bus to the modules can be made more efficient by applying modular design and standard power interfaces.

This requires new approaches in the design of the secondary power conditioning unit, of the power busses and of the local power conversion. Easy applicable solutions for local power conversion are available, which can deliver exactly the required voltages and currents to the load and can be directly integrated into the power consuming modules.

Thus, modern satellite systems can become more cost-efficient by lowering weight and volume for power distribution, by increasing energy efficiency and by saving cost for development and the elaborate qualification of satellite building blocks due to re-use of modules with standard power interface for installation in the platform as well as in the payload.

IMPORTANT NOTICE

The privately held company SPACE IC with headquarter in Hannover, Germany, is expert in the development, manufacturing and qualification of radiation-hard integrated circuits for space applications. The company portfolio comprises analog ICs for power-management applications and robust data interfaces. SPACE IC is the leading supplier of compact switching regulator ICs for point-of-load applications (POL) with input voltage values above 6V.