Powering Artificial Intelligence In Space

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With predictable Moore's-Law-type evolution, the sophistication of electronics in space is increasing. However, it is still quite expensive to transfer data to a satellite from Earth and back again, so it makes sense to do as much processing as possible locally in orbit.

Transponders alone cost hundreds of thousands of dollars a year to maintain, while bandwidth cost-per-MHz is priced at a minimum of about $3,500 a month, according to Globalcom Satellite Communications (see the reference). Running a satellite at a 36-MHz bandwidth can cost more than $1.5 million a year.

Using artificial intelligence (AI) and machine learning (ML), it is now possible to implement algorithmic tools in space that were inconceivable 20 years ago. AI uses computing platforms to emulate human neural networks in applications such as simulating human judgment, knowledge accumulation and decision-making. ML uses iterative statistical methods to train algorithms to evolve in their ability to classify data and predict useful results.

Other AI/ML-related fields include natural language processing, which enables the parsing of documents and the creation of useful inferences. Speech recognition converts recorded analog conversations to digital using digital signal processing and then converts to human text, while machine vision can translate items from photographs and video into discrete objects that can be analyzed, manipulated, and post-processed.

A common use of processing capacity in space is data compression. An extreme form of data compression is taking raw data like images and identifying the elements of interest, which are then classified and evaluated as objects like people, vehicles, storm fronts and forest fires. This is analogous to the way the human mind works: instead of manipulating huge amounts of raw sensory data, we condense or compress the data into objects of interest, then apply analytical processes to these objects.

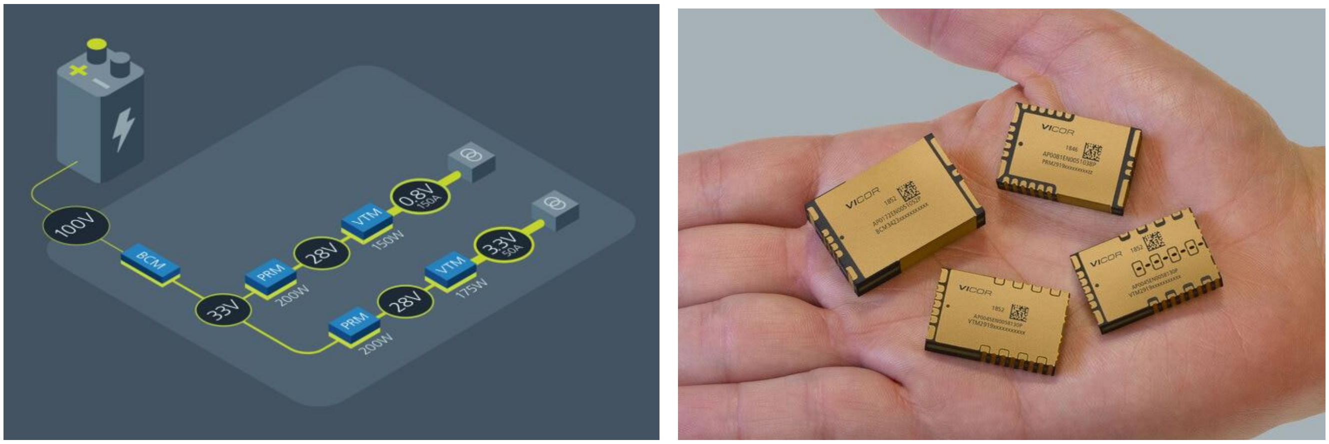
The raw, high-resolution streaming video of a forest fire, for example, could be transmitted to Earth for processing, but it might comprise many gigabytes of data. However, the mission objective could be served with information like the location of firefighters in relation to the leading edge of the fire, recognizing people and vehicles, and analyzing them as objects rather than as groups of pixels. This allows for far faster decision-making with much less orbit-to-ground data transfer.

Complex ASICs, CPUs, GPUs, FPGAs and ML/AI engines require a great deal of electrical power to operate, and this power increases substantially every year. In space power management, there are numerous challenges. Most satellites are powered by solar arrays that charge battery systems. A modern satellite system can consume hundreds of watts or more, so it is important that the power taken from the batteries be used as efficiently as possible and consume as little space as possible. This drives the need for radiation-tolerant, compact and efficient power conversion.

While it is possible to repurpose terrestrial solutions (typically digital, multi-phase power solutions) to deliver more than 100 W for big-chip core power, resonant power modules designed specifically for radiation tolerance and low-noise performance should be seriously considered.

The design cycle of radiation-tolerant power modules must be comprehensive and should include component selection, technology selection (including lithography and semiconductor processes), topology selection, circuit design, internal telemetry, power-disconnect and reset mechanisms, as well as redundant power trains for single-event upsets.

As an example of a ground-up, radiation-tolerant power module design, Vicor's new product line uses a patented Factorized Power Architecture (FPA) to deliver a total of 300 W for "new space" applications (see the figure).



(a) (b)

Figure. The Vicor patented Factorized Power Architecture for radiation-tolerant systems can be implemented using the company's BCMs, PRMs and VTMs shown in blue (a). Examples of the company's 300-W radiation-tolerant power modules are shown in (b).

In this system, the bus converter module (BCM) provides voltage transformation, isolation and downstream power for the other modules. The pre-regulation module (PRM) buck-boost converter provides accurate regulation against input voltage and load current variations. Finally, the voltage transformation module (VTM) current multipliers provide voltage transformation and a low-impedance source to serve loads.

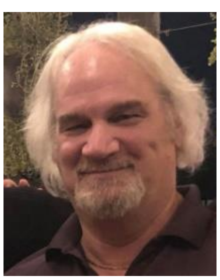
The technical strategies for surviving radiation environments in space are multi-faceted. Components and ASIC technologies are selected for inherent radiation tolerance, including long-term, low-dose effects. Internally redundant rails are used to mitigate against single-event upsets. Worst-case circuit analysis (WCCA) methods are performed to identify and mitigate problem areas. Both total ionizing dose (TID), laser and highly accelerated particle testing is performed to prove the radiation performance.

The vision of the future may be fuzzy, but it is certain there will be many more satellites in orbit and much more processing power in space vehicles. The computing engines found in these spacecraft will need power, and very likely a great deal more of it, in the years and decades to come.

Reference

"The Cost of Building and Launching a Satellite," Globalcom.

About The Author



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For further reading about radiation hardness in power electronics, see the How2Power Design Guide, locate the Extreme Environments category and select "Radiation". Also, see How2Power.com's section on Space Power.