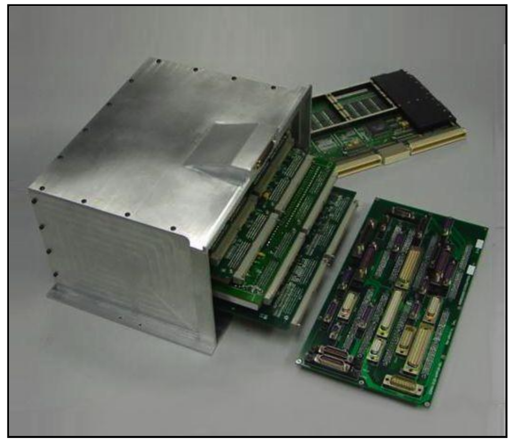
Tiger Innovations' Integrated Electronics Module

Product Specification

IEM Capabilities



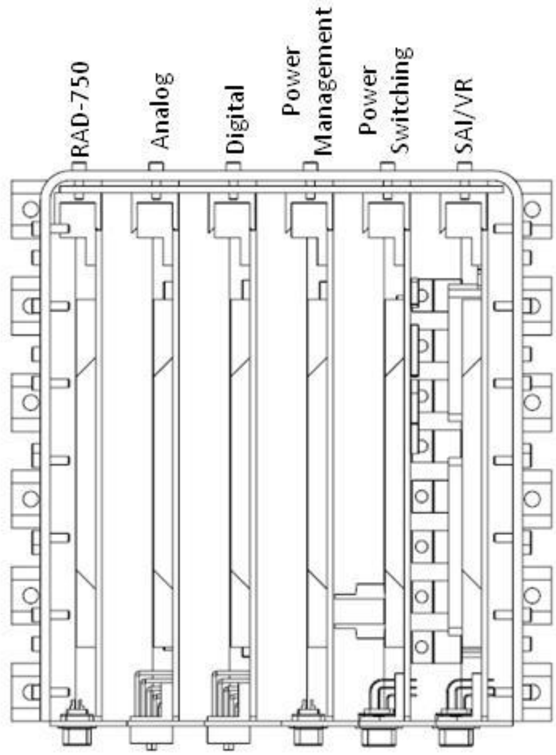
- Complete Avionics Suite for Spacecraft Applications
- Performs C&DH and EPS Functions
    - Integrated unit or separate boxes
- Modular Design
- Radiation Hardened Part Selection
    - 100 kRad, SEL immune
- Low Mass and Power for Micro-Sat Missions
- Hardware CMD and TLM w/o Flight Processor
- Flight Heritage on STPSat-1

IEM Specification – Base Model	
Power Consumption	24 Watts
Mass	< 5.25 kg
Size	7" x 7.125" x 4.437"
Processor	RAD-750
Analog Signals	56
Digital I/O	64 Discrete I/O, 12 RS422 pairs
Communication Ports	Up to 12 full duplex serial ports
Power Switches	42 (from < 1 amp to 30 amps)
Arming Switches	4 x 6 amp switches w/ARM
Solar Array Switches	10 x 5 amp switched inputs, 4 x 5 amp unswitched inputs
Bus Voltage	28 ±6 Volts
Voltage Regulation	+3.3V, ±5V, ±15V

Tiger Innovations' Integrated Electronics Module (IEM) is a complete spacecraft avionics solution, encompassing both Command and Data Handling (C&DH) and Electrical Power System (EPS) functions. The IEM consists of multiple circuit cards that house the central processor, analog and digital telemetry processing, payload interface, power management, power switching, solar array control, and voltage regulation functions. The base model IEM has one card dedicated to each of these functions. However, the modular nature of the IEM facilitates adding multiple cards to meet a wide range of mission requirements. Therefore, if a given spacecraft requires more power switches than the base model IEM provides, a second Switched Power card can easily be added with no new engineering work. This modular design helps to maximize performance and mission flexibility while keeping costs low.

The IEM was first developed for use on the STPSat-1 spacecraft that launched in March 2007 and is currently operating on-orbit. Significant design improvements have been made since the launch of STPSat-1 to incorporate “lessons learned” from that mission and increase the overall capability and performance of the IEM. The resultant design provides a compact, low power, avionics solution for a wide range of satellite missions while maintaining the flight heritage gained from STPSat-1.

System Architecture



The IEM system architecture is designed to be relatively generic and configurable in order to meet the largest suite of requirements possible. The cards are broken down into medium-sized logical blocks (implemented in a 3U Compact PCI form factor), allowing for capability expansion by adding the appropriate card type to the system. The functional breakdown of the IEM has two basic areas: C&DH and EPS. The cards comprising these two functional areas all fit within the 3U cPCI form-factor, and all have a similar overall design structure. These similarities make the mechanical and thermal analysis significantly easier, due to the commonality in each model. The base model IEM is configured with one Analog Collection Card, one Digital IO Card, one Power Management Card, one Switched Power Card, and one Solar Array Input/Voltage Regulator Card. This basic configuration provides 56 analog inputs, 64 discrete I/O, 12 RS-422 pairs, and 46 power switches. For missions that require a greater number of avionics resources, the IEM supports a maximum configuration of up to 4 switched power cards, and 8 additional cPCI cards (one processor, one PMC, and any combination of analog and digital). This maximum configuration provides up to 336 analog inputs, 384 discrete I/O, 72 RS-422 pairs and 184 power switches. Additionally, all discrete I/O signals can be converted to RS-422 lines in all configurations to provide increased digital communication capability. The C&DH cards (including the EPS interface section of the Power Management Card) all reside on the cPCI bus, while the EPS cards simply retain the form factor and reuse the cPCI connector. The IEM is typically configured in a single integrated box, however, C&DH and EPS functions can be separated into two smaller enclosures connected via a serial link (with no change in the Flight Computer interface to the EPS) to meet specific mission requirements.

Communications Interface

The IEM provides a custom set of mission-specific serial communication interfaces. The standard suite of available interfaces includes:

- Asynchronous

- Standard and Clocked Asynchronous (8bit, odd/even/no parity, standard baud rates)

- Synchronous
    - Clocked Synchronous (with or without HDLC)
    - 3-Wire Synchronous (e.g. Ball Star Tracker)

Other custom interfaces or functions can be designed to meet nearly any user requirement, for example CCSDS formatter/de-formatter or a hardware-only backdoor interface on the SGLS/Radio communication link. Since the routing of I/O signals to communication ports is handled within the FPGA, any given serial channel can be set up with TTL/CMOS levels or RS-422 levels, based on the system requirements. All discrete lines are TTL/CMOS compatible in the output configuration, and TTL/CMOS/Positive Voltage >= 2V compatible in the input configuration.

Command and Telemetry

The Analog Collection Card is used to autonomously digitize analog signals and provide the resulting telemetry data to the processor. Each card has 56 analog inputs (each with its own dedicated return). The analogs are sampled at 100 Hz. Additionally, there are 8 high-speed slots, sampled at 800Hz, which can be attached to any analog channel Each input is sampled with at least 12bit quantization. The data is stored in ping-pong RAM memory buffers (inside the FPGA) for collection by the flight processor. The same buffers are made available to the automated SOH packets created by hardware to be sent out an EGSE link and to the transponder, thus making all of the collected analog telemetry available throughout I&T, on the launch vehicle, and on-orbit, regardless of the operational state of the flight software.

The Digital IO Card is used to provide digital interfaces for the C&DH, including discrete I/O, serial communication, and time. Each card supplies 48 discrete I/O lines, 8 RS-422 Transmit lines, and 8 RS-422 Receive lines. An additional 16 discrete lines and 4 RS-422 pairs reside on the analog card for increased capability.

Power System

The Solar Array Input/Voltage Regulation (SAI/VR) Card implements the maximum bus voltage regulation, via solar panel switching, and monitors the individual panel's contribution to the main power bus. The IEM bus voltage is 28 V ±6 V. The SAI/VR additionally houses the main voltage regulators for the system switched voltages, and the cPCI backplane regulated voltages. The card takes in bus voltage and supplies regulated voltages, nominally +3.3, +5, -5, +15, and -15 Volts. The card can accept fourteen solar inputs, with each at a maximum continuous current of 5A. Ten of these fourteen inputs are switched while the other 4 provide un-switched solar array current. There is also an available Shunt Card which works in conjunction with the SAI/VR card to limit the bus voltage for system configurations that require it (e.g. configurations that do not have the battery tied directly to the bus).

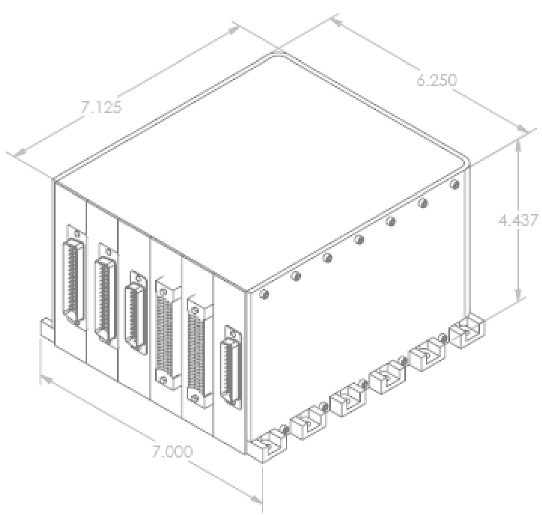
The Switched Power Card provides control over switched voltage loads. It has provisions for pulsed bus voltage switches, switched bus voltage load switches, switched ground switches, and deployment power switches with safe/arm protection. The IEM supports power switching from less than 1 amp to greater than 30 amps. The base model IEM provides 46 power switches, however specific switch configurations can be tailored for individual mission requirements.

The Power Management Card (PMC) serves two primary functions: 1) Flight Computer interface to the EPS; and 2) Low-level power sequence and safety control. The PMC provides a hardware-based Programmable Power Sequencer (PPS). The PPS has sequences of register manipulation commands that allow the system to affect any power state. Common PPS sequences include load shedding, safehold, separation, and user events. The table above shows a breakdown of IEM power utilization in the following configuration: the IEM is powered, the RAD750 is running, all static bus loads are operating at full power, and the solar arrays are delivering 2.5A of current. The IEM power dissipation is very dependent on the amount of load being carried. The above scenario and analysis uses a representative micro-satellite to simulate bus loads and arrive at a conservative nominal power number.

IEM Circuit Card	Power (W)
RAD750	10
Analog	2.11
Digital	3.27
Power Management	2.62
Switched Power	4.20
SAI/VR	1.89
Total	24.08

Mechanical Design

The IEM structure is designed to handle the harsh launch environment while minimizing mass. The mass and volume numbers shown are for the base model IEM. If additional cards are required, the mass and volume increases appropriately.



IEM Circuit Card	Mass (kg)
RAD750	0.50
Motherboard	0.30
Analog	0.37
Digital	0.35
Power Management	0.30
Switched Power	0.59
SAI/VR	0.67
Structure	2.10
Total	5.18

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