DESIGN AND IMPLEMENTATION OF ELECTRICAL SYSTEM FOR STU-2 CUBESATS

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microsat

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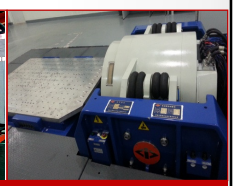
SECM Introduction

SECM- Shanghai Engineering Centre for Microsatellite

- Founded by Chinese Academy of Science (CAS) and Shanghai City Government,
- To build a technical platform and innovation base for micro/small satellites
- Located in Pudong of Shanghai
  - ✓ Offices: ~ 15,000 m²
  - ✓ AIT area: ~12,000 m²
- Able to manufacture 20+ satellites simultaneously

AIT Area

KM3



20T Vibration table

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SECM Introduction

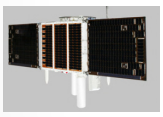
Missions Done

Commni-cationu

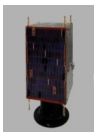
Micro/Nano Satellite

Science

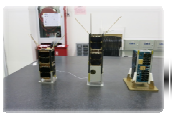
2003 · CX-1(01)
2008 · CX-1(02)
2011 · CX-1(03)
2014 · CX-1(04)



2008 · BX-1

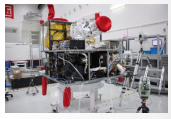


2015 · STU-2 (TW-1) 3 CubeSats



2015 · DAMPE

2016 · QUESS



Over past 10 years, SECM has launched into orbit 9+ micro/small satellites, accumulated 30+ orbit-year of satellite operation.

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STU-2 Mission Introduction

Mission Requirements

- Monitoring sea ice status in polar regions
- Gaining the maritime traffic information via AIS receiver
- Monitor civil aircraft traffic information via ADS-B receiver
- New technology demonstration & validation of Micro-propulsion, dual-band GPS-BD receiver, and Gamalink
- Demonstration of autonomous rendezvous (RVD) flight

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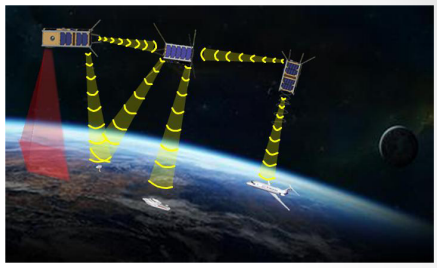
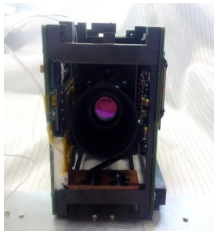
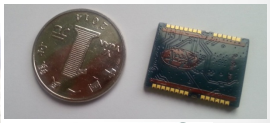
STU-2 Mission Introduction

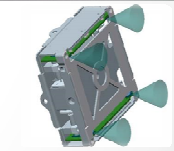
Mission Configuration

- 3 Cube Satellites to carry different payloads:
  - Optical camera;
  - MEMS cold-gas micro-propulsion;
  - Automatic Dependent Surveillance – Broadcast (ADS-B) system ;
  - Automatic Identification System (AIS);
  - GPS receiver
- 2 Ground Stations in Shanghai and Nanjing of China
- Orbit: SSO, 480km, 8:00am
- Launch: Sept 25th 2015
  Jiuquan, China









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STU-2 Mission Introduction

Main specifications for flight model

	STU-2A（3U）	STU-2B (2U)	STU-2C（2U）
Payloads	Optical Camera BD2/GPS MEMS micro-propulsion	AIS Receiver BD2/GPS Receiver	ADS-B Receiver BD2/GPS Receiver
Power Capacity	38.48Wh	38.48Wh	38.48Wh
ADCS	MTM, MTQ, Propulsion, 3 Wheels, Fine Sun Sensor, Star Tracker, GPS/BD APE 1.8° Stability 0.03°/s	MTM, MTQ, Sun Sensor, Momentum biased with wheels APE 8° Stability 0.04°/s	Magnetic control APE 13° Stability 0.04°/s
TMTC Comm	UHF: 4.8kbps S-band：125kbps	UHF: 4.8kbps	UHF: 4.8kbps
Mass/Power	2.9kg/2.9 W	2.2kg/2.9W	1.7 kg/1.9W

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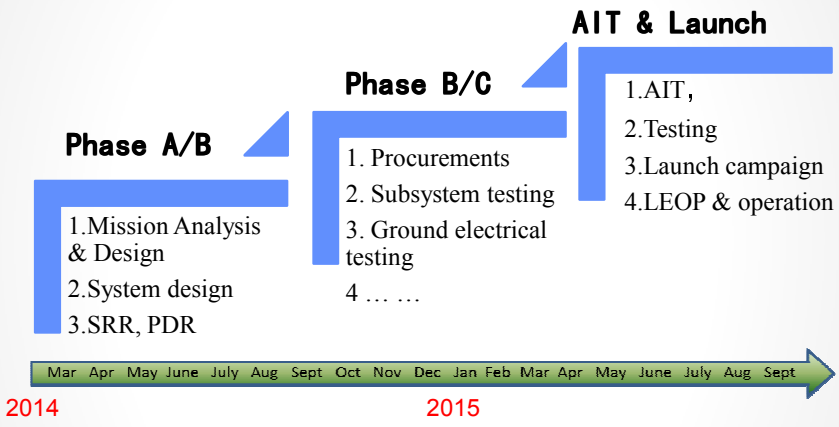
STU-2 Mission Introduction

Project Schedule



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The Electrical System for STU-2

Design Concept:

Adapt all of three CubeSats, managing all the payloads and support enough interfaces.

System Components:

- On-Board Computer (OBC): the software core of control and measurement.
- Electrical Power Subsystem (EPS): to meet the power requirement.
- HUB: a expand board, a multi-purpose interface and utility subsystem

Electrical interfaces:

Most though PC104

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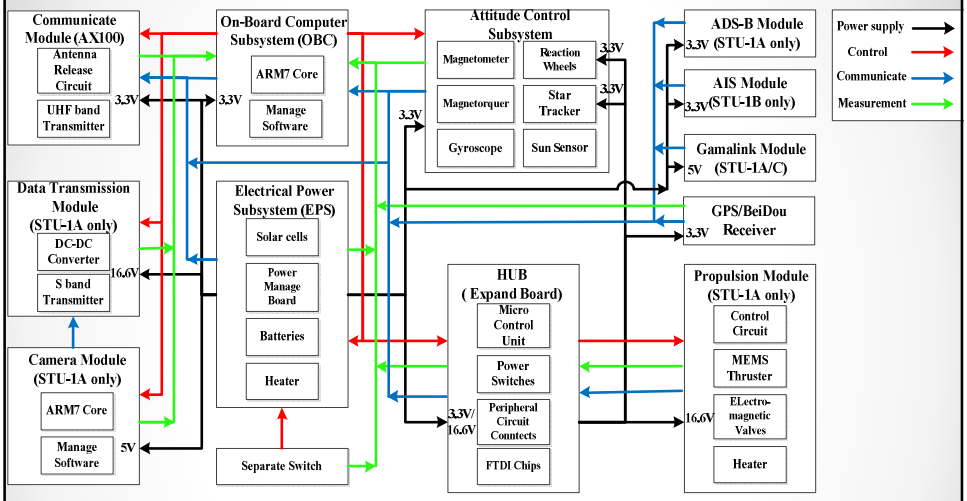
The Electrical System for STU-2



The Electrical System and information flow of STU-2

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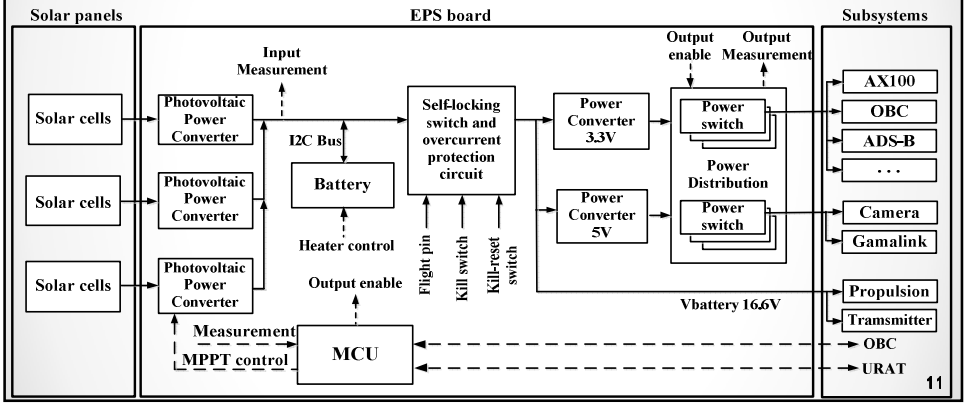
The Electrical System for STU-2

Electrical Power Subsystem (EPS):

- **Solar cells**: AzurSpace 3G30A solar cell.
- **Lithium-ion battery**: four 18650, 2.6Ah, 12~16.8V.
- **Power manage board**: Maximum Power Point Tracking capability; Six individually controllable output switches.



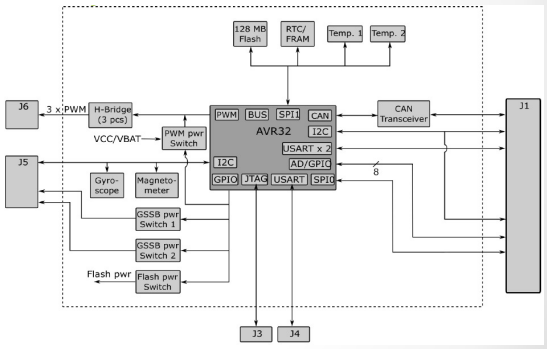
The Electrical System for STU-2

HUB Subsystem:

Suffered from the vacuum limit, one power manage board not enough to manage power output and provide interface. control interface.

Specification:

- control interface: I²C bus
- MCU: AVR32
- serial NOR flash: 128MB
- build-in flash: 512KB
- 3-Axis magnetometer
- 3-Axis gyroscope
- 7 individually controllable output channels



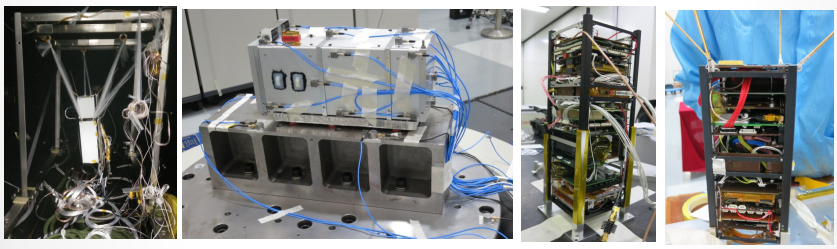
Testing Before Launch

Ground Testing:

- Thermal vacuum testing
- Thermal balance testing
- Vibration testing
- Electro Magnetic Compatibility(EMC) testing

Health Checks and Performance Tests：

The full communication and performance testing of complete satellite.



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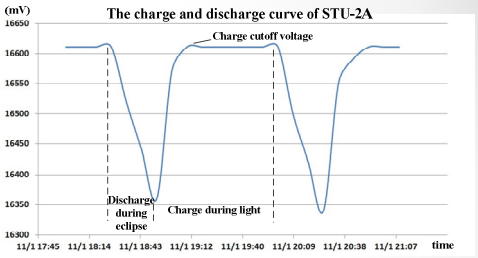
In Orbit Results

Order	Testing items	Design index	In orbit results	Conclusion
1	Efficiency of EPS	>85%	MAX：90.85% MIN：89.1%	Satisfy
2	Depth of discharge	<20%	MAX：9.6% MIN：0%	Satisfy
3	Efficiency of solar cells	>29%	MAX：29.5% MIN：29.3%	Satisfy
4	Power consume of STU-2A	<3W	MAX：2.77W MIN：2.23W	Satisfy
5	Power generate of STU-2A	>3W	MAX：5.84W MIN：3.03W	Satisfy
6	Power consume of STU-2C	<2.5W	MAX：2.23W MIN：1.67W	Satisfy
7	Power generate of STU-2C	>2W	MAX：3.45W MIN：2.10W	Satisfy
8	Vbattery of STU-2A	12~16.8V	MAX：16.61V MIN：14.43V	Satisfy
9	Vbattery of STU-2C	12~16.8V	MAX：16.65V MIN：16.21V	Satisfy
10	Temperature of EPS of STU-2A	-10~40° C	MAX：30° C MIN：-3° C	Satisfy
11	Temperature of EPS of STU-2C	-10~40° C	MAX：27° C MIN：-2° C	Satisfy
12	Overcharge protection	Works	Works	Satisfy
13	Power management (EPS)	Works	Works	Satisfy
14	Power management (HUB)	Works	Works	Satisfy

In Orbit Results

EPS charge and discharge:

The data of battery voltage in two orbits on Nov. 1st 2015.



Power management:

Payload/ Instrument	Design index	In orbit results	Switch control
AX100@3.3V	0～950mA	886mA (STU-2A) 866mA(STU-2C)	OK
OBC@3.3V	0～250mA	116mA (STU-2A) 107mA (STU-2C)	OK
HUB@3.3V	0～60mA	48mA (STU-2A) 53mA (STU-2C)	OK
GPS/BD2@3.3V	0～200mA	134mA (STU-2A) 138mA (STU-2C)	OK
Camera@5V	0～2000mA	1576mA	OK
Micro-propulsion@16.6V	0～2000mA	190mA	OK
Star tracker@3.3V	0～300mA	199mA	OK
Reaction wheels@3.3V	0～500mA	431mA	OK
S-band Tx@16.6V	0～2000mA	750mA	OK

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Summary and Lessons Learned

Summary:

The electric system of STU-2 using an EPS and a HUB work together to enhance the capability of power management and expand interface.

In orbit results prove the design is reasonable and achieves the desired effect.

Lessons Learned:

- A more flexible and easy to install connector or a connector board may be more useful for CubeSat.
- more universalization and integrated EPS will suit the demand of CubeSat
- The heater of EPS need to be improved

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Acknowledgment

This mission is designed and being implemented by a consortium led by the Shanghai Engineering Centre for Microsatellite in China, together with partners including the Nanjing University of Science and Technology (contributed for STU-2B platform), the GomSpace from Denmark (ADS-B and AIS receiver, as well as CubeSat components), the NanoSpace from Sweden (contributed the MEMS micro-propulsion module), and the Tekever Space from Portugal (contributed the Gamalink). The authors would like to express sincere appreciation and many thanks to these partners, together with them this mission has been made feasible and successfully implemented.

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