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NASA JPL Smart Breakout Box 2.0

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Jet Propulsion Laboratory

Problem Statement

The JPL Smart Breakout Box 2.0 (JSB2) team was tasked by the NASA Jet Propulsion Lab to design and construct a universal automated breakout box to be used for testing any electrical system at JPL.

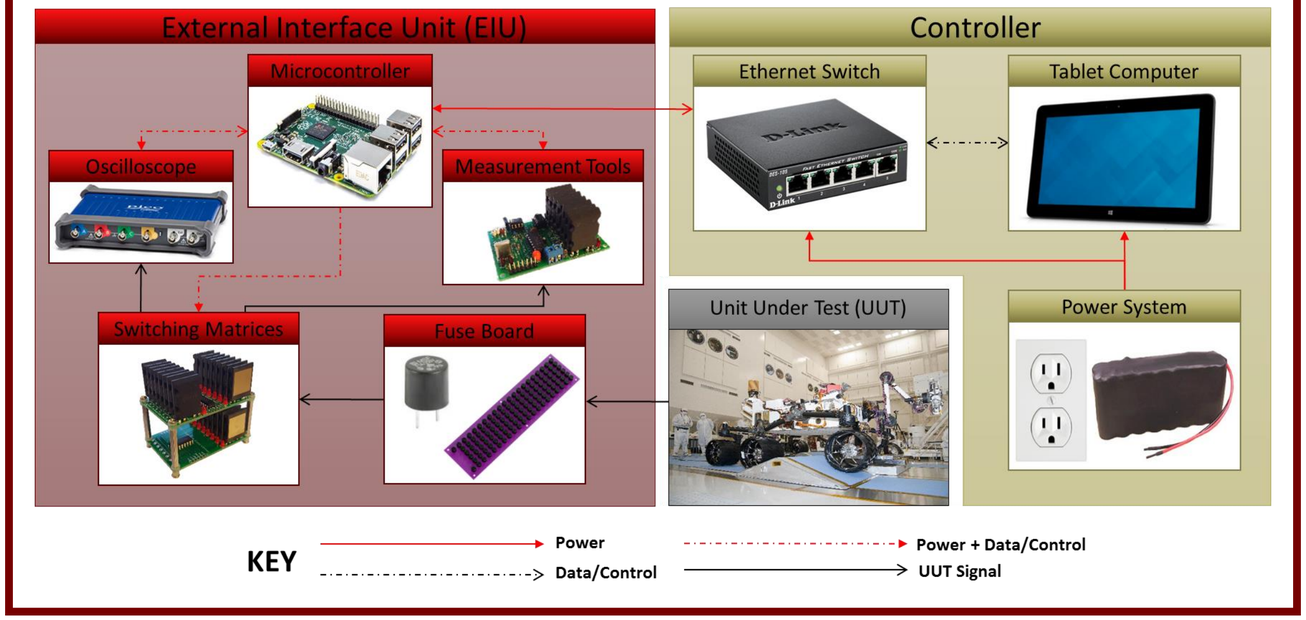
Background

A breakout box, or BOB, is a device used to separate or "break out" all pins from a connector into easily-accessible ports. This allows a technician to manually test the electrical properties of connections with separate measurement tools for validation of the system. In the JPL use case, a BOB has "red" and "black" connections which connect to two UUTs for measurement of signals between them. This method of testing takes a significant amount of time and introduces human error. By automating the process of establishing connections between pins and measuring their electrical properties, the amount of time and the cost of testing a system would be greatly reduced. There are no automated systems on the market that meet the needs of JPL. Last year, the JSB1 team sought to address this issue. This year, the JSB2 project improved and expanded upon the progress of the JSB1, addressing additional requirements from NASA JPL stakeholders in conjunction with the original requirements.

Primary Requirements

- Measure resistance, voltage, and current with an accuracy of 5%
- Measure electrical properties between any black pin and any red pin
- Measure signals with a magnitude of up to 100 V and 5 A
- Connect to multiple UUTs at a time
- Each EIU shall support one UUT
- Provide oscilloscope signal plotting with a 100 MHz bandwidth
- Operate for eight hours on a single battery
- Have a swappable battery for extended use
- Allow users to create, save, load, and run test procedures without external hardware

Simplified System Architecture



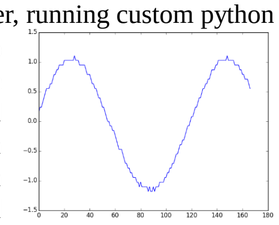
Signal Switching

To direct the signals from the UUT within the JSB2, three unique switching arrays were developed to perform the following tasks: connect pins to the measurement tools, make symmetric connections between the red and black side (e.g. red2-black2), and connect pins to the four channels of the oscilloscope. The first two arrays use the IXYS CPC1918 solid state relay to make connections. The third array uses a series of 16 to 1 multiplexers to route the truncated signals (<5V) to the oscilloscope.

CPC1918

Oscilloscope

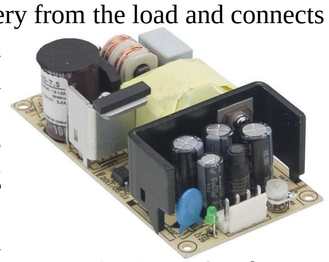
The Picoscope 3405A oscilloscope housed in the EIU has four input channels with a bandwidth of 100MHz. Data is acquired over USB from the scope by the Raspberry Pi 2 microcontroller, running custom python code. The data is passed to the LabVIEW UI on the tablet PC over Ethernet and the data can be processed in software or the waveform can be reassembled and displayed for the user.



Reconstructed AC Signal

Power

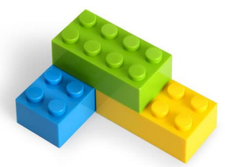
The system can be powered by battery or line power (wall outlet). The battery used is a 14.4V 10.4Ah Li-Ion battery. When plugged into wall power, the system disconnects the main battery from the load and connects it to the integrated Li-Ion battery charger using an electromechanical relay. Power is provided to the connected EIUs using Power over Ethernet, sharing a cable with communication.



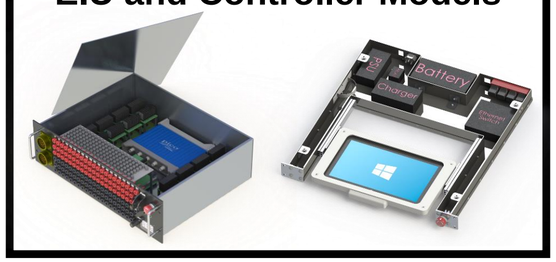
Line Power Supply

Modularity

One of the key considerations in the design of the system is modularity - the system is able to interface with four UUTs at once. For large systems or systems that have not yet been fully integrated, connections for each UUT are typically not next to one another. To allow users to test such systems, or even multiple fully independent systems, the separation of the EIU from the controller is critical. Each EIU supports testing of one UUT and will send test data back to the tablet in the controller.

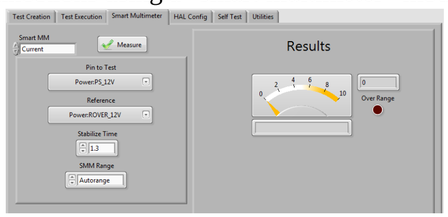


EIU and Controller Models



User Interface

The JSB2 includes an intuitive LabVIEW user interface which displays on the tablet controller. Using this interface, the user can monitor the status of the controller and all connected EIUs, create test procedures, run tests, give custom names to connections, run self-tests on the JSB2, and tests single connections using a "smart multimeter" mode.



Smart Multimeter Mode UI

Future Work

- Internet connected EIUs for remote testing across NASA facilities
- Intelligent mode that takes a set of generalized measurements across active pins without having to create a test procedure
- Redesign components for ease of manufacturing and maintenance

Acknowledgements

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