

Applying Standard Commands for Programmable Instruments (SCPI) to CubeSats

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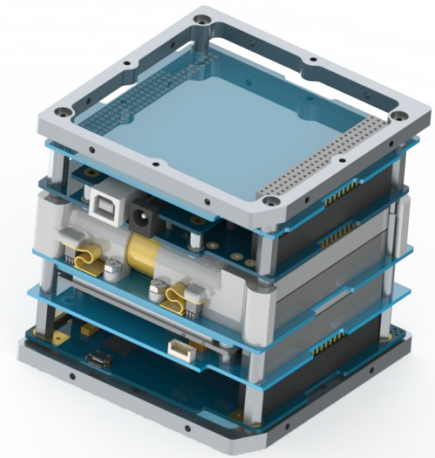
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Common Interface for Instruments

- Command Protocol for CubeSat Instruments
 - SCPI - Commonly used standard
- Easy to test & debug – robust enough for flight
 - Human readable
 - Low resource reqs. (program space / processor time)
- Physical Interface
 - Implement over I2C
 - Shared (electrical) features between instruments
- Improvements over existing protocols
 - All ASCII
 - Well defined data formats in commands



SCPI

- Defines command syntax & structure
- Easy to understand
 - *Measure:Current?*
- Commands arranged in hierarchy
- Long & short command form
 - SUPervisor:RESet □ SUP:RES
- Can pass parameters
- Some standard commands defined – more can be added
- Built-in error checking

- Open source SCPI parser library available



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Device Architecture

- ▮ SCPI functionality implemented on 'Supervisor MCU'
- ▮ Command physical bus is I2C
- ▮ Similarities between modules helps code portability
- ▮ Firmware written in C (~46kB prog. space in GPSRM)



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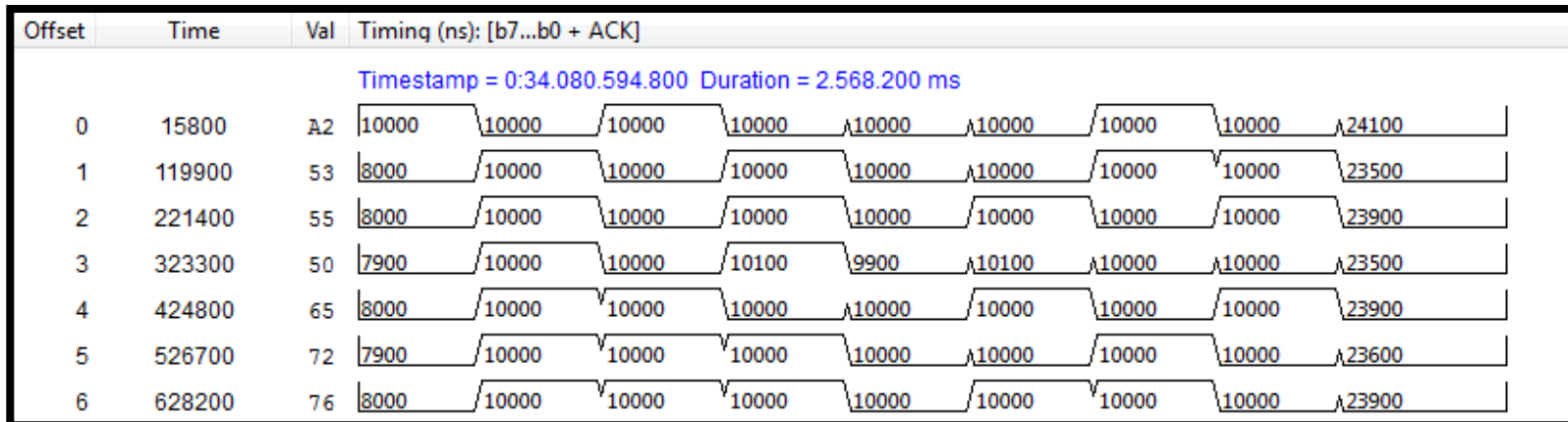
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I2C

- Benefits – 2-wire, 112 devices
- Challenge – hardware buffer is 1 byte – puts demands on MCU (PIC24E running at ~8MHz)
- Clock stretching solves this
- Frees up Supervisor MCU for other tasks
- High reliability



Commands

Common command set for all Supervisor MCU instruments

Keyword	Parameters	Notes
SUPervisor		Top level keyword
:LED	{OFF ON FLASH APPLICATION}	Status LED behavior
:RESet		Reset MCU
:I2C		I2C functions keyword
:RESet		Reset I2C driver
:PASSthrough	{OFF ON}	Set I2C isolator
:CLOCK	{OFF ON}, <divider_value>	Configure clock output
:SELFtest		Run PIC24E self test
:TElemetry?	<index_value>	Request telemetry data
...



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Telemetry

- Telemetry handled via pre-defined table
 - Instruments (slave devices) update data regularly
 - Master requests a set number of bytes
 - Checksum (CRC-8)

Index	Name	Data	Data Length (Bytes)	Read Buffer
1	Clock Ticks	<1...>	10	1
2	I2C Messages	<2...>	10	1
3	SCPI Messages Parsed	<3...>	10	1
...
10	GPS NMEA GGA	<10...>	88	1
...



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Conclusion

▢ Benefits

- Debug off serial port – no protocol analyzer needed
- Code reuse
- Built in error handling
- Low learning curve

▢ Current Supervisor MCU Modules

- GPSRM
- SIM (Solar Interface Module)

▢ Further Development

- Additional modules
- C&DH System Integration – command bus with Linux/Python



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Q&A Session

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Appendix

□ Speaker information

- Shaun Houlihan is a mechanical designer and firmware engineer at Pumpkin. Before joining Pumpkin he worked in the aerospace and consumer electronics industries. Contact Shaun at shaun@pumpkininc.com.

□ Acknowledgements

- Pumpkin's Salvo, CubeSat Kit, MISC and SUPERNOVA customers, whose real-world experience with our products helps us continually improve and innovate.
- Special thanks to Jan Breuer for his SCPI parser library – available on GitHub. <https://github.com/j123b567/scpi-parser>
- For more on SCPI see: <http://www.ivifoundation.org/docs/scpi-99.pdf>

□ CubeSat Kit information

- More information on Pumpkin's CubeSat Kit can be found at <http://www.cubesatkit.com/>. Patented and Patents pending.

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