

Applying Standard Commands for Programmable Instruments (SCPI) to CubeSats

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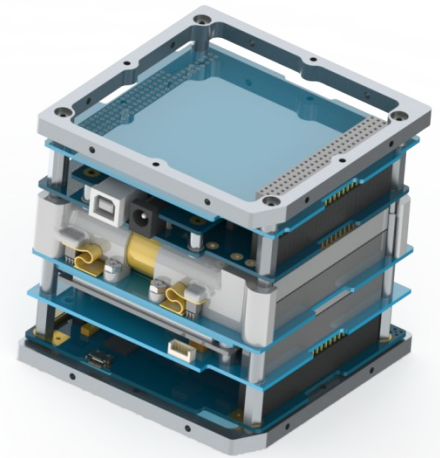
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Common Interface for Instruments

- 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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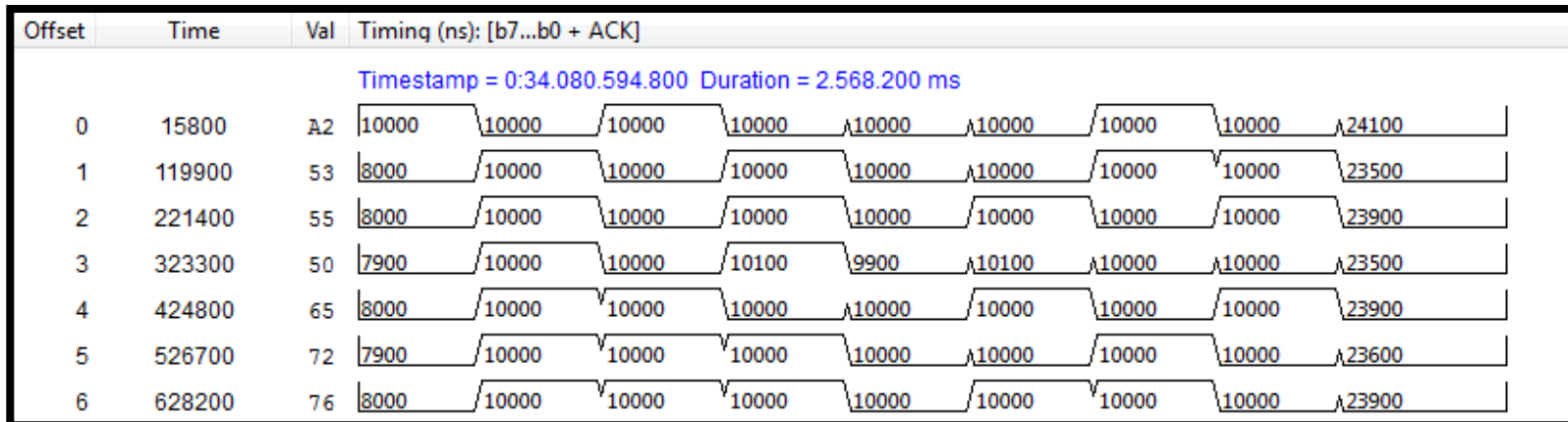
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I2C

- ▮ 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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