QIKCOM 1 & 2
RE-CONFIGURABLE TRANSPONDER MODULES

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QIKcom Team
Automatic Packet Reporting System (APRS)

Global APRS Real-Time Connectivity

PCsat, ISS, PCSAT2, RAFT, ParkinsonSAT, or ECHO

Global APRS Internet connectivity LIVE!

Footprint Comms

I Gates everywhere on the planet

FindU.com

Pcsat.aprs.org

www.ariss.net

AND Every APRS user connected to the internet is AUTOMATICALLY an IGate to RF for his area (think cellular)
Problem Background

- Automatic Packet Reporting System Protocol (APRS) is the primary communications protocol used by USNA satellites
- With long development time, the response time for short-fuse launch opportunities is limited
- Lack of APRS satellites -> users remain on terrestrial frequency, rarely monitor space frequency
Host Satellite Opportunity: QIKcom1

- NovaWurks to host QIKcom1
  - HiSAT Provides:
    - Power
    - Thermal Control
    - Attitude determination system

- USNA provides capabilities:
  - Transponder to actively notify users
  - Power regulation
  - Antenna release mechanism
QIKcom1 Components: Electrical Power System

<table>
<thead>
<tr>
<th>Load</th>
<th>Operating Voltage</th>
<th>I_{pk} (mA)</th>
<th>Duty Cycle</th>
<th>I_{avg} (mA)</th>
<th>28V I_{pk} (mA)</th>
<th>28V I_{ave} (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beacon (Standby)</td>
<td>12</td>
<td>15</td>
<td>98.3%</td>
<td>14.75</td>
<td>7.14</td>
<td>7.02</td>
</tr>
<tr>
<td>Beacon (TX)</td>
<td>12</td>
<td>600</td>
<td>1.70%</td>
<td>10.2</td>
<td>260</td>
<td>4.86</td>
</tr>
<tr>
<td>MTT4 (TX-users)</td>
<td>5</td>
<td>280</td>
<td>1.7%</td>
<td>4.8</td>
<td>55.6</td>
<td>0.95</td>
</tr>
<tr>
<td>MTT4 (TX-Telemetry)</td>
<td>5</td>
<td>280</td>
<td>4%</td>
<td>11.2</td>
<td>55.6</td>
<td>2.2</td>
</tr>
<tr>
<td>MTT4 (RX)</td>
<td>5</td>
<td>45</td>
<td>100%</td>
<td>45</td>
<td>8.93</td>
<td>8.93</td>
</tr>
<tr>
<td>Power Amp (TX)</td>
<td>12</td>
<td>600</td>
<td>10%</td>
<td>60</td>
<td>260</td>
<td>28.6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>647.3</td>
<td>52.6</td>
</tr>
</tbody>
</table>

| 28 V - Peak Power (W) | 18                |
| 28 V – Average Power (W) | 1.5               |

Power provided by host bus. \( P_{avg} \) of 1.5W consistent with 1U CubeSats, however all is dedicated to comms rather than other subsystems.
QIKcom1 Components: Antenna Deployment Mechanism

- Attached to EPS Board
- 28 V burn signal sent by host spacecraft
- ¼ Watt 220 Ohm resistor
- Approximately 3 Watts power
- Burns through fishing line constraining the antennas in about 5 seconds
- 20 tests conducted with 100% reliability of release
QIKcom1 Components: Beacon and Transponder

- Beacon notifies users when satellite is overhead
- “145.825MHz QSY 4 OPS”

Telemetry Format:

QIKCOM-1>APTT4,ARISS:T#001,28V, Ibus,12V,Base_Temp,Trans_Temp,00000011
QIKcom1: Assembled Structure

- Baseplate with comms on left, Lid with EPS on right
- Iridite Aluminum, Emissivity: 0.11
- Flathead screws with countersunk holes for smooth attachment to NovaWurks host
QIKcom1: Vibe Test

- Conducted 24 Feb 2015
- Shaken in X and Y axes
  - Random vibe to Acceptance Levels of 10 G RMS
  - Both axes lowest resonance in both directions above 400 Hz
  - Satisfied launch provider requirements
  - Pre/post-test sine tests conducted at 0.5G to identify any anomalies; none detected
QIKcom1: Problems

- APRS radios are expensive; 10% users have a radio that can use it
  - Cheap radios cannot send or receive APRS messages or text messages of any sort
- No processing capabilities
  - No reconfiguration possible once launched
QIKcom2: Solution

- Dual-Tone Multi Frequency (DTMF)
- Text to speech + voice synthesizer
- Basic Stamp CPU
- MTT4B APRS Transponder

Mission: Develop QIKcom-2 for under $1000
QIKcom2: DTMF/Voice CONOPS

TX

Audio tones

VHF RX

DTMF

Audio tones

16 Character Language

CPU

Text content

VHF TX

Text-to-Speech

Voice Synthesizer

RX

APRS packet

TX

RX

VHF TX
QIKcom2: APRS Packet CONOPS

DTMF Decoding

CPU

APRS packet

MTT4-B

Ground Stations

APRS Radio

Global APRS
Internet connectivity LIVE
QIKcom-2 Components
QIKcom-2 Components: Electrical Power System

<table>
<thead>
<tr>
<th>Load</th>
<th>Operating Voltage (V)</th>
<th>$I_{pk}$ (mA)</th>
<th>Duty * Cycle</th>
<th>$I_{avg}$ (mA)</th>
<th>28V $I_{pk}$ (mA)</th>
<th>28V $I_{ave}$ (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTMF and Receiver</td>
<td>12</td>
<td>30</td>
<td>100%</td>
<td>30</td>
<td>14.29</td>
<td>14.29</td>
</tr>
<tr>
<td>MTT4 (TX-users)</td>
<td>5</td>
<td>600</td>
<td>4%</td>
<td>4.8</td>
<td>119.05</td>
<td>0.95</td>
</tr>
<tr>
<td>MTT4 (TX-Telemetry)</td>
<td>5</td>
<td>600</td>
<td>1.70%</td>
<td>11.2</td>
<td>119.05</td>
<td>2.22</td>
</tr>
<tr>
<td>MTT4 RX</td>
<td>12</td>
<td>60</td>
<td>100%</td>
<td>11.2</td>
<td>28.57</td>
<td>5.33</td>
</tr>
<tr>
<td>Text-To-Speech Module</td>
<td>5</td>
<td>220</td>
<td>5%</td>
<td>11</td>
<td>43.65</td>
<td>2.18</td>
</tr>
<tr>
<td>(active)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text-To-Speech Module</td>
<td>5</td>
<td>30</td>
<td>95%</td>
<td>28.5</td>
<td>5.95</td>
<td>5.65</td>
</tr>
<tr>
<td>(idle)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SpeakJet (active)</td>
<td>5</td>
<td>5</td>
<td>5%</td>
<td>0.25</td>
<td>0.99</td>
<td>0.05</td>
</tr>
<tr>
<td>SpeakJet (idle)</td>
<td>5</td>
<td>5</td>
<td>95%</td>
<td>4.75</td>
<td>0.99</td>
<td>0.94</td>
</tr>
<tr>
<td>Paralax BS2 CPU (active)</td>
<td>5</td>
<td>8</td>
<td>10%</td>
<td>0.8</td>
<td>1.59</td>
<td>0.16</td>
</tr>
<tr>
<td>Paralax BS2 CPU (sleep)</td>
<td>5</td>
<td>100</td>
<td>90%</td>
<td>90</td>
<td>19.84</td>
<td>17.86</td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>353.97</td>
<td>49.64</td>
</tr>
</tbody>
</table>

**QIKcom-1 EPS with added DTMF and Voice modules**
Dual-Tone Multifrequency Decoder & CPU

- Receives audio tones from amateur radios
- Translates DTMF tones into 16 key codes (4 bits)
- $160

CPU: Basic Stamp 2pe

- Parses DTMF key codes into APRS text packet
- Can alter APRS and Voice formats based upon channel load
- $75
MTT4-B APRS Transponder

- Transceiver
- Flexible frequency range at 145 MHz
- Integrated 10W power amp
- Designed for automobiles
- $250
Text-to-Speech & Voice Synthesizer

- Text-to-Speech chip receives DTMF data from CPU; converts to audio-phoneme codes

- Voice Synthesizer takes audio-phoneme codes and converts it to audio waves, then transmits them down on VHF
DTMF Text Encoding

*Radio memories constrained to 16 digit memories*

QIKcom-2 Keypad Format

**DTMF Grid/Callsign Encoding**

*GGGGGCCCCCNCNNNN#

G – 4 Digit Position Code
C - 6 Digit Callsign
N – 4 Digit Binary callsign decoder

**DTMF Text to Speech Messaging**

CTMMCCCCCNNNNN#

C – C Key to indicate message
T – Test byte, “9” indicates emergency
M – 2 Digit ARL radiogram
C – 6 Digit Callsign
N – 4 Digit binary callsign decoder
QIKcom-2 Gridsquare Position Reporting
*Maidenhead Grid Square System*

The table at right begins at 00 thru 99 to give worldwide 4 digit Grids for the next APRStt DTMF satellite using DTMF only.
# DTMF Message Encoding Example

*1819 924277 1558#

## DTMF Callsign Encoding

<table>
<thead>
<tr>
<th>Callsign</th>
<th>W</th>
<th>B</th>
<th>4</th>
<th>A</th>
<th>P</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter Key</td>
<td>9</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Letter positions</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Weight</td>
<td>1024</td>
<td>256</td>
<td>64</td>
<td>16</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Sum</td>
<td>1024</td>
<td>512</td>
<td>0</td>
<td>16</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

**DTMF Grid Position Code 1819**
DTMF Position Reporting

18 = “FM”
19 = Inner square coordinates
Maidenhead Grid Square

19 = Baltimore area
DTMF ARL Standard Radiograms

- Located at [www.arrl.net](http://www.arrl.net)
- Have been used for past 60 years for abbreviated radio communications
- Help DTMF users communicate given their limited capability

- Examples
  - 15 Please advise your condition and what help is needed.
  - 70 Go Navy, Beat Army!
Power/Congestion Management

- Depending on system popularity, handling DTMF and APRS can overwhelm QIKcom-2

- Solution:
  - 2 Banks on MTT4B, one includes APRS relay functions and one excludes them
  - Ground Control of multiple speech options (simple, verbose)
Current Work

Breadboard Model

Flight Box
Future Work

- Assembly
  - Structure
  - Text-to-speech board assembly
  - Irridite the structure
  - Circuit Board Stacking

- Vibe Testing

- Acceptance Testing

- Delivery Date of May 15th
Acknowledgements

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Questions?