A Miniaturized NanoSatellite Communications System

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Presentation by: Gerard Aalbers
• Founded in January 2006
• Spin-off from Delft University satellite program Delfi-C3
• Office in Delft on the Delft University of Technology Campus
- Focus on the micro- and nanosatellite niche (1-50kg)
- Products, services and turnkey solutions
- Focus on responsive and innovative applications
- Miniaturization of satellite systems
Delfi-C3 Transceiver

- 100% mission success, both radios show nominal ops
- Strong Signal, receivable with handhelds
- BPSK modulation in combination with soundcard demodulation proven very effective
- Very good command uplink performance
Development goals

- Compatible with the CubeSat standard
- Specifically designed for use in space
- Full duplex design
- Low rate VHF / UHF links (amateur / commercial bands)
- CW beacon for easy spacecraft acquisition
- Easy to receive downlink on VHF with reduced complexity in the link.
- PA DC → RF efficiency > 70%
• AFSK is commonly used on CubeSats
• BPSK is a better choice
• Downside: spectral efficiency
• Spectral shaping $\rightarrow$ non-constant envelope

<table>
<thead>
<tr>
<th>Modulation scheme</th>
<th>EB/ N0 for BER 10^-5</th>
<th>Constant envelope?</th>
<th>Spectral efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFSK</td>
<td>23dB</td>
<td>Y</td>
<td>Bad</td>
</tr>
<tr>
<td>BPSK</td>
<td>9.6dB</td>
<td>Y</td>
<td>Bad</td>
</tr>
<tr>
<td>Shaped BPSK</td>
<td>9.6dB</td>
<td>N</td>
<td>Good</td>
</tr>
</tbody>
</table>
• Step-by-step integration of (MiSat) MST building blocks in satellite transceivers to save power
• Single-board design
• High efficiency PA with variable power settings
• Modular design to allow implementation in a wide range of small spacecraft (not limited to CubeSats)
• Envelope restoration and feedback transmitter structure, allows non-constant envelope BPSK
• Class E PA
• Resonator Synchronized relaxation oscillator
• Example of integrating MST elements (MEMS resonator)
• Optimize for space use
• Matching downlink software - coherent demodulation scheme
• LEO Doppler tracking in software
• **Mass:** < 200gr
• **Mechanical:** 90*96*30mm, on a single Printed Circuit Board
• **Electrical interfaces:**
  - DC power interface
  - Serial data interface
  - RF input: 50 ohm, SMA
  - RF output: 50 ohm, SMA
Applications

- CubeSat / microsatellite low rate TT&CC
- Loopback ranging, determine range and range-rate (non-coherent)
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