Design and Development of the SMAP Microwave Radiometer Electronics

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Soil Moisture Active Passive (SMAP) Mission
http://smap.jpl.nasa.gov

March 2014
SMAP Mission Concept

- L-band Unfocused SAR and Radiometer System, Offset-Fed 6 m Light-Weight Deployable Mesh Reflector. Shared Feed For
  - 1.26 GHz Radar at 1-3 km (HH, VV, HV) (30% Nadir Gap)
  - 1.4 GHz Polarimetric Radiometer at 40 km (H, V, 3rd & 4th Stokes)
- Conical Scan at Fixed Look Angle
- Wide 1000 km Swath With 2-3 Days Revisit
- Sun-Synchronous 6am/6pm Orbit (680 km)
- Launch 2014
- Mission Duration 3 Years
Key Features:
- Two-channels
- Cal ref switch
- Correlated Noise Source

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SMAP Radiometer Back End (RBE) Assembly

Key Features:
- Downconverter
- 1413.5 to 120 MHz
- Provides a 96MHz reference clock
SMAP Radiometer Digital Electronics (RDE) Assembly

Key Features:
- Two-channels IF inputs
- Channelizer & correlators
- Controls calibration sequencing
- Power distribution unit

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RDE Architecture: DSP Data Flow

IF: 120 ± 12 MHz  
Fs: 96 MSPS  
Resolution: 14-bit
Radiometer Timing

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**PRI**

- **Radar Transmit**
- **Radiometer Integration Window ~300 μs**

**Packet**

- **PRI 1**
- **PRI 2**
- **PRI 3**
- **PRI 4**

**Footprint**

- **11 Packets of Scene Observation**
- **Cal Counts**

- **Pulse Repetition Interval (PRI) ~354 μs**

- **Radiometer Packet**
  - 1.4 ms elapsed time
  - 1.2 ms integration time

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SMAP Radiometer “Detector” Counts

- Full-band high-rate, every PRI (300 us)
  - V, H
  - 1\(^{st}\), 2\(^{nd}\), 3\(^{rd}\), 4\(^{th}\) moments, I, Q
  - 3\(^{rd}\) and 4\(^{th}\) Stokes
  - PRF (3.5 kHz) rate

- Sub-banded data, 16 subbands, every 4 PRIs, (1200 us)
  - V, H
  - 1\(^{st}\), 2\(^{nd}\), 3\(^{rd}\), 4\(^{th}\) moments, I, Q
  - 3\(^{rd}\) and 4\(^{th}\) Stokes
  - \(\frac{1}{4}\) PRF (875 Hz)

Time/Frequency diversity: 360 words every ~1ms (packet)

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GSFC Integration and Test

EMC/EMI

LN2 Cal

TVAC Initial Power Up

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## Error Budget $< 1.3 \, K$

<table>
<thead>
<tr>
<th>Error Term</th>
<th>Allocation</th>
<th>Current CBE</th>
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<tbody>
<tr>
<td>Antenna Pattern Correction</td>
<td>0.6 K</td>
<td>0.42 K</td>
</tr>
<tr>
<td>NEAT</td>
<td>0.65 K</td>
<td>0.47 K</td>
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<tr>
<td>Antenna Temperature Calibration</td>
<td>0.5 K</td>
<td>0.45 K</td>
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<tr>
<td>RFI</td>
<td>0.3 K</td>
<td>0.22 K</td>
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<tr>
<td>Long Term Drift</td>
<td>0.4 K</td>
<td>$&lt;0.2 , K$</td>
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<tr>
<td>Atmospheric Correction</td>
<td>0.1 K</td>
<td>0.04 K</td>
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<tr>
<td>RSS Total</td>
<td>1.1 K</td>
<td>0.83 K</td>
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<tr>
<td>Requirement</td>
<td>1.3 K</td>
<td>1.3 K</td>
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<tr>
<td>Margin (Unencumbered RSS)</td>
<td>0.6 K</td>
<td>1.0 K</td>
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<tr>
<td>Margin (Unencumbered Linear)</td>
<td>0.2 K</td>
<td>0.47 K</td>
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</table>
Error after correction – V-pol

Error after correction – H-pol

- Error: 0.20 K without correction, 0.04 K rms with correction
Repeatability Results

<table>
<thead>
<tr>
<th>Plateau</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>7</th>
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<tbody>
<tr>
<td>ΔT_H, warm (K)</td>
<td>0.00</td>
<td>-.13</td>
<td>.02</td>
<td>.01</td>
<td>-.01</td>
<td>.04</td>
<td>.01</td>
<td>.07</td>
<td>.01</td>
<td>-.02</td>
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<tr>
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<td>-.12</td>
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<td>.05</td>
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<td>.10</td>
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<td>0.00</td>
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<tr>
<td>ΔT_H, cold (K)</td>
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<td>-.06</td>
<td>-.01</td>
<td>.02</td>
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<td>-.10</td>
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<td>-.01</td>
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<td>-.19</td>
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<tr>
<td>ΔT_V, cold (K)</td>
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<td>-.05</td>
<td>.07</td>
<td>-.04</td>
<td>.01</td>
<td>-.11</td>
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</tbody>
</table>
Polarimetry

• Differential group delay
  – 155 ps (measured)

• Phase rotation
  – < 0.1° with integration time 4 seconds.

• Correlator efficiency
  – 0.998
Pulsed RFI Evident in TA Data

Example RFI test:

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