Performance Specification

for the

SMAP Diplexer

SMAP-RE-SPEC-0001

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Document Change Log

DATE	PAGE NUMBERS	VERSION	CHANGES/COMMENTS

1 Scope

1.1 General

Soil Moisture Active Passive (SMAP) is a three-year, low earth orbit mission, to be launched in 2013 (TBC). The primary objective of the mission is to map soil moisture. The instrument is composed of an L-band radiometer built by NASA/GSFC and an L-Band radar built by NASA/JPL. These two sub-systems share a common antenna feed by means of a diplexer. The two key concerns for the diplexer design are isolation between the radar and radiometer, and multipaction. This specification defines the general requirements for the SMAP instrument L-band diplexer.

2 Applicable Documents

All applicable and reference documentation identified in this document and in the accompanying Statement of Work (SOW) shall apply in the situations where they are specifically referenced. In the event of a conflict between the SOW and this Specification, the SOW shall take precedence.

3 Quality Assurance

3.1 General

This specification document defines the performance, environmental and other requirements for the SMAP diplexers as referenced in the Statement of Work for SMAP Project Instrument Diplexer. General quality assurance requirements for the diplexer are contained in the "Statement of Work".

3.2 Flight Unit Screening

All flight diplexers supplied to this specification shall be subjected to 100% screening as specified in the following sections. Exceptions shall only occur when a specification section explicitly allows single unit test from a lot.

3.3 Engineering Test Unit Screening

All Engineering Test Unit (ETU) diplexers supplied to this specification shall be subjected to 100% screening as specified herein, with the following exceptions:

a. When a specification section excludes engineering models from the test or states the test applies to flight deliverables only.
b. Engineering Test Unit (ETU) model diplexers shall be verified electrically through the following test profile: 8 cycles under TVAC over a range of -30^{o} to +65 ^{o}C.

3.4 Re-test

If any event, including test failure, requires disassembly and reassembly of flight hardware, then all tests performed prior to the event must be considered for repeat. The decision to re-test shall lie with the COTR, upon recommendation of the NASA QA representative.

3.5 Unit Identification & Traceability

All diplexers shall bear unique serial numbers and associated traceability data for each, containing records of piece parts, materials, processes, dates and other such data that provide unambiguous traceability for the unit.

3.6 Traceability Records Maintenance

Any traceability records not subject to contract delivery, shall be kept for a minimum period of 3 years. Records considered for disposal after 3 years, but before 6 years, shall be offered to NASA/GSFC at no charge before disposal. Records kept beyond 6 years may be disposed of without notification of NASA/GSFC.

3.7 Lot Travelers

Prior to the start of the flight model fabrication, the manufacturer shall submit lot travelers for review and approval, Lot travelers shall clearly identify all required test and inspection points, required electrical and environmental testing, test methods, test conditions, sample sizes, manufacturer/customer inspection points, etc.

3.8 Parts List

The vendor shall deliver a parts and materials list to NASA.

3.9 Parts Reliability

Parts reliability shall be commensurate with Class R passives, as outlined in NASA Technical Publication EEE-INST-002: Instructions for EEE Parts Selection, Screening, Qualification, and Derating. Class R: 0.01% per 1000 hrs.

3.10 Radiation

The Diplexer shall operate without performance degradation with an on-orbit radiation total dose of 17.5 Krad, with a minimum of 40 mils of Aluminum shielding, per JPL-D-47629: SMAP Environmental Requirement Document.

3.11 On-orbit Life

On-orbit lifetime for the flight diplexer shall be greater than or equal to 42 months:
36 months nominal operations, plus an additional 6 months for launch and on-orbit test and checkout.

3.12 Shelf Life

Shelf life for the diplexer shall be greater than or equal to 5 years.

4 Performance Requirements

4.1 Functional Description

The diplexer is comprised of three ports: Radiometer Receive port (DIP_J1), a shared Antenna port (DIP_J2), and a Radar Transmit/Receiver port (DIP_J3).

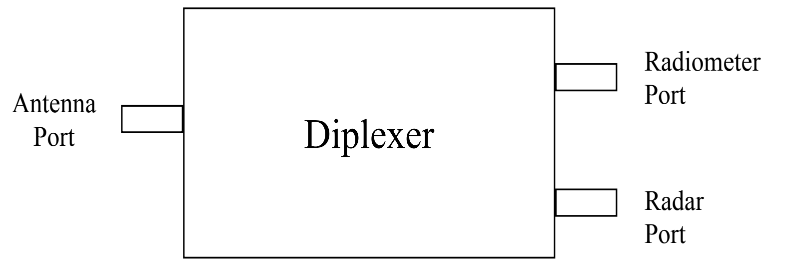

Figure 1: Diplexer Functional Diagram

4.2 Diplexer Performance Requirements

4.2.1 Radar Characteristics

The radar is a linear FM chirp pulse, with an instantaneous bandwidth of 1 MHz in the radar transmit/receive passband. The pulse width of the radar is 40 ms with a maximum duty cycle of 17%.

4.2.2 Radar Power

The diplexer shall transmit a maximum power of 250 Watts (TBC).

4.2.3 Diplexer Radar Transmit/Receive Passband

The radar transmit/receive passband, including guard-bands, shall be 1210-1305 MHz.

4.2.4 Radar Transmit/Receive Passband Insertion Loss

The insertion loss from the antenna port (DIP_J2) through the radar port (DIP_J3) shall be ≤ 0.25 dB(TBC) over the entire radar transmit/receive passband.

4.2.5 Radar and Radiometer Insertion Loss Stability

The insertion loss stability for both the radar transmit/receive path, and radiometer receive path shall be ≤ 0.02 dB (TBC) over 0.1°C (TBC), rms maximum temperature variation over the operating temperature range of -20^{o} to +40 °C.

4.2.6 Radar Transmit/Receive Passband Insertion Loss Matching Between Diplexers

The insertion loss matching between diplexers, in the radar transmit/receive passband, shall be less than 0.1 (TBC) dB, over the temperature range of -20^o to +40 ^{o}C.
(Rationale: Required for CP Instrument operation)

4.2.7 Radar Transmit/Receive Passband Insertion Loss Tracking Between Diplexers

The insertion loss tracking between diplexers, in the radar transmit/receive passband, shall be less than 0.05 (TBC) degrees, over the temperature range of -20^o to +40 ^{o}C.
(Rationale: Required for CP Instrument operation)

4.2.8 Phase Matching Between Diplexers

The phase matching between diplexers, in the radar transmit/receive passbands, shall be less than 5 (TBC) degrees, over the temperature range of -20^o to +40 ^{o}C.
(Rationale: Required for CP Instrument operation)

4.2.9 Phase Tracking Between Diplexers

The phase tracking between diplexers, in the radar transmit/receive passbands, shall be less than 1.5 degrees, over the temperature range of -20^o to +40 ^{o}C.
(Rationale: Required for CP Instrument operation)

4.2.10 Radiometer-to-Radar Isolation

4.2.10.1 Isolation in Radar Transmit/Receive Passband

Requirement: In the Radar transmit/receive passband, the isolation between the radiometer port (DIP_J1) and the radar port (DIP_J3) shall be 44 dB minimum.

RFI Note 1: This requirement is driven by the need to keep the Radiometer's first LNA well below compression during radar transmit events. This 44 dB rejection, combined with the expected 60 dB rejection from a 'blanking' switch, located forward of the first LNA, will result in a total 104 dB rejection during radar transmit events. This will ensure the first LNA remains 22 dB below its P_{1dB}. If the vendor believes this 44 dB isolation requirement is too aggressive, there does exist trade spaces wherein lower gain LNAs can be considered, as well as higher rejection blanking switches. Vendor feedback and comments are appreciated during this RFI phase.

RFI Note 2: The current mission ops concept is for the radiometer to blank its receiver during radar transmit events; however, if the diplexer featured 114 dB isolation, rather than 44 dB, over the radar transmit/receive passband, the first LNA would remain 32 dB below its P_{1dB} at all times. While NASA does not believe such a diplexer would be practical, vendor comments and feedback regarding such a high-isolation design are appreciated.

4.2.10.2 Isolation in Radiometer Receive Passband

In the Radiometer Receive Passband, the isolation between the radiometer port (DIP_J1) and the radar port (DIP_J3) shall be 35 dB minimum (TBC).

Note: Regardless of transmit frequency, the SMAP radar will always present thermal noise, proportional to its physical temperature (~300K), within the radiometer receive passband. This thermal noise is an error source, adding to the brightness temperature of the observed scene. An isolation of 35 dB between ports DIP_J1 and DIP_J3 will ensure that ~300 K signal is reduced to 0.1 K during radiometer scene observations.

4.2.11 Rejection: 2nd and 3rd Radar Harmonic

The rejection of the 2nd and 3rd radar transmit harmonics at the antenna port (DIP_J2) shall be 30 (TBC) dB minimum.

4.2.12 Rejection: 4th, 5th, and 6th Radar Harmonic

The rejection of the 4th, 5th, and 6th, radar transmit harmonics at the antenna port (DIP_J2) shall be 50 dB (TBC) minimum.

4.2.13 Radar Receive Path Performance

The radar transmit/receive path performance is the insertion loss from the radar port (DIP_J3) through the antenna port (DIP_J2). This performance will encompass the isolation from the SMAP Radiometer, rejection of out-of-band terrestrial sources, as well as the 'in-band' performance of the radar receive pass-band. The performance of the radiometer receive path is provided in Table 1:

Frequency (MHz)	Source	Radiometer Path IL	
1210	SMAP Radar	-0.25	Max
1305	SMAP Radar	-0.25	Max
1400	SMAP Radiometer	-35	Min
1427	SMAP Radiometer	-35	Min

Table 1 Radar Transmit/Receive Path Performance

A graph showing diplexer performance meeting the requirements provided in Table 1 is shown in Figure 2:

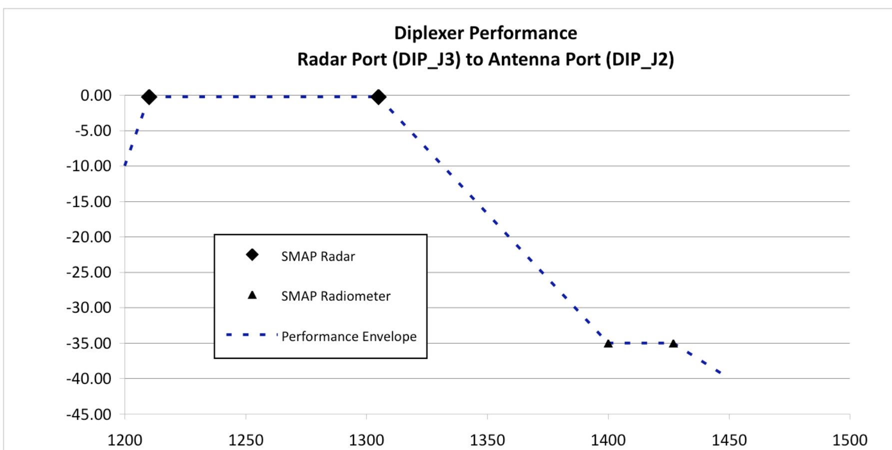

Figure 2 Radar Transmit/Receive Path Performance

4.2.14 Radiometer Receive Passband

The radiometer receive passband shall be 1400-1427 MHz (TBC), centered at 1413.5 MHz.

4.2.15 Radiometer Receive Passband Insertion Loss

The insertion loss from the radiometer port (DIP_J1) through the antenna port (DIP_J2) shall be ≤ 0.25 dB(TBC) over the entire radiometer receive passband.

4.2.16 Radiometer Receive Path Performance

The radiometer receive path performance is the insertion loss from the radiometer port (DIP_J1) through the antenna port (DIP_J2). This performance will encompass the isolation from the SMAP Radar, rejection of out-of-band terrestrial sources, as well as the 'in-band' performance of the radiometer receive pass-band. The performance of the radiometer receive path is provided in Table 2:

Frequency (MHz)	Source	Radiometer Path IL	
1210	SMAP Radar	-44	Min
1305	SMAP Radar	-44	Min
1350	Gnd-Based Radar	-41	Min
1350	Gnd-Based Radar	-47	Min
1375	Gnd-Based Radar	-8	Min
1390	Gnd-Based Radar	-12	Min
1392.6	Gnd-Based Radar	-22	Min
1394	Gnd-Based Radar	-21	Min
1395	Gnd-Based Radar	-21	Min
1398	Gnd-Based Radar	-7	Min
1400	SMAP Radiometer	-0.25	Max
1427	SMAP Radiometer	-0.25	Max
1375	Gnd-Based Radar *	-78	N/A

Table 2 Radiometer Receive Path Performance

* RFI Note 3: One source, located at 1375 MHz, is listed twice in Table 2. The first requirement (-8 dB) will ensure the first LNA remains 22 dB below P_{1dB} during radiometer receive/protect mode; The second 'requirement (-78 dB) would only be necessary if the radiometer was to perform science measurements in the presence of this source. While not a requirement for this diplexer, if the vendor feels this -78 dB rejection is achievable, please provide feedback during the RFI phase.

A graph showing diplexer performance meeting the requirements provided Table 2 is provided in Figure 3:

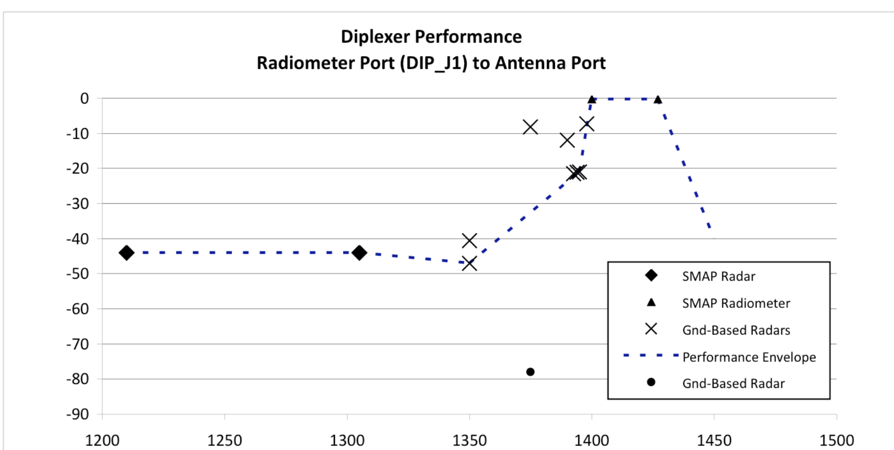

Figure 3 Diplexer Performance: Radiometer Port (DIP_J1) to Antenna Port (DIP_J2)

4.2.17 Radiometer Passband Insertion Loss Matching Between Diplexers

The insertion loss matching between diplexers, in the radiometer passband, shall be less than 0.1 (TBC) dB, over the temperature range of -20 ^{o} to +40 ^{o}C

4.2.18 Radiometer Passband Insertion Loss Tracking Between Diplexers

The insertion loss matching between diplexers, in the radiometer passband, shall be less than 0.05 (TBC) degrees, over the temperature range of -20 ^{o} to +40°C.

4.2.19 Phase Matching Between Diplexers

The phase matching between diplexers, in the radiometer frequency band, shall be less than 5 (TBC) degrees, throughout the temperature range of -20 to +40 °C.

4.2.20 Phase Tracking Between Diplexers

The phase tracking between diplexers, in the radiometer frequency band, shall be less than 1.5 degrees, throughout the temperature range of -20 to +40 °C.

4.2.21 Input and Output VSWR

4.2.21.1 Antenna Port VSWR

The antenna port (DIP_J2) VSWR shall be less than 1.1:1(TBC), over both the radar transmit/receive passband and the radiometer receive passband.

4.2.21.2 Radar Port VSWR

The radar port (DIP_J3) VSWR shall be less than 1.05:1(TBC), over the entire radar passband.

4.2.21.3 Radiometer Port VSWR

The radiometer port (DIP_J1) VSWR shall be less than 1.05:1(TBC) , over the entire radiometer passband.

4.3 Multipaction Modeling Requirements

4.3.1 Design Margins

The diplexer shall have a 6 dB minimum power margin (TBC) from multipaction damage.

4.3.2 Modeling Requirements

The diplexer design shall be modeled for multipaction damage, over the specified operational temperatures and at the radar maximum power level over all Radar and Radiometer operational frequencies. The modeling shall include all critical gaps where multipaction is likely to occur.

4.3.3 Model Validity

The model used shall be verified as a reliable predictor of multipaction in RF devices.

4.3.4 Model applicability

The geometry of the diplexer design shall be such that the chosen modeling tool can accurately predict field strengths.

5 Resource Requirements

5.1.1 Mass

The mass of the diplexer shall not exceed 2.5 kg(TBC).

5.1.2 Electrical Power

The diplexer shall be a passive device and shall consume no electrical power.

6 Interface Requirements

6.1.1 Mechanical Requirements

6.1.1.1 Mechanical Interface

The diplexer mechanical interface requirements are defined in the diplexer interface control drawing # TBD (Attachment TBD). The location of the mounting tabs is subject to negotiated refinement during Phase B cooperative development between the Vendor and the SMAP project COTR.

6.1.1.2 Mounting Surface Flatness

The mounting surface of the diplexer box shall be flat to 0.1 mm (rms), and shall be subject to negotiated refinement during Phase B cooperative development between the Vendor and the SMAP project COTR.

6.1.1.3 Mounting Footprint

The mounting footprint of the diplexer shall not exceed 42 cm x 18 cm (TBC), per the diplexer interface control drawing # TBD (Attachment TBD), subject to negotiated refinement during Phase B cooperative development between the Vendor and the SMAP project COTR.

6.1.1.4 Diplexer Height

The height of the diplexer shall be exceed 5 cm (TBC), subject to negotiated refinement during Phase B cooperative development between the Vendor and the SMAP project COTR..

6.1.1.5 Connector Locations

The connector locations shall be per the diplexer interface control drawing # TBD (Attachment TBD), and shall be subject to negotiated refinement during Phase B cooperative development between the Vendor and the SMAP project COTR.

6.1.1.6 Diplexer Mass Properties

The mass properties of the Diplexer shall be as follows:

Property	**As Delivered Knowledge Requirement**
Mass	+/- 0.05 kg
Center of Mass	+/- 5mm

Table 3 Diplexer Mass Properties

6.1.1.7 Static Loads

The diplexer shall be designed for a minimum load of 50 g's. The minimum factors of safety shall be F.S. Yield = 1.25 and F.S. Ultimate = 1.4.

6.1.1.8 Minimum Natural Frequency

The diplexer shall be designed for a minimum natural frequency of 100 Hz (TBC).

6.1.1.9 Base Material

To minimize materials stress at the mounting interface, the diplexer shall be manufactured from aluminum alloy 6061-T6 per AMSQQA250/11 (TBC – Plating study may yield more optimum Al choice for plating robustness).

6.1.2 Thermal Requirements - Information

The Diplexer box will be mounted with a sheet of Government furnished, thermally conducting Cho-seal (nominal thickness of 10 mil) between the diplexer box and the face to which the diplexer is mounted.

6.1.2.1 External Surface Finish

The outer surface of the diplexer shall be finished with a thermal emissivity ≤ 0.05. The finish method shall be approved by the COTR prior to application.

6.1.2.2 Temperature Control

There are no requirements for temperature control (either active or passive) of the diplexer.

6.1.2.3 Temperature Sensor

A GFE passive temperature sensor shall be mounted on the diplexer box at a site negotiated during Phase B cooperative development between the Vendor and the SMAP project COTR.

6.1.3 Electrical Requirements

6.1.3.1 Port Connectors

The connectors shall be TNC dielectric filled, vented and high power.

6.1.3.2 Grounding - Information

The diplexer box will be mounted with a sheet of Government furnished, electrically conducting Cho-seal (nominal thickness of TBD mil) between the diplexer box and the face to which the diplexer is mounted. Specific grounding methods will be subject to negotiation at the Technical Interchange Meetings.

7 Environmental Requirements

7.1 Operating Temperature

The diplexer shall meet all performance requirements when operated in a vacuum over the temperature range of -20 °C to +40 °C, as measured at the interface.

7.2 Non-operating Temperature

The diplexer shall suffer no degradation in performance requirements when subjected to vacuum non-operating temperatures over the range -30 °C to +65 °C, as measured at the interface.

7.3 Pressure

The diplexer shall meet all performance requirements when operating at atmospheric pressure and at 10^{-14} Torr. Successful operation in the thermal vacuum test environment (10^{-5} Torr) normally satisfies the low pressure requirement (TBC). The diplexer is not required to operate through critical pressure.

7.4 Venting

The diplexer shall have venting adequate to ensure depressurization rate of -0.6 psi/sec (TBC). A vent area meeting the guideline V/A less than 5080 cm (TBC) is sufficient to satisfy the analytic requirements of this document, where "V" is the enclosure volume and "A" is the vent area.

7.5 Relative Humidity - Exposure

The diplexer shall meet all performance requirements, at any temperature in the range of -20 to +40 °C, after the diplexer has undergone an accelerated life-time humidity test, consisting of 80% (TBC) humidity for a duration of 48 (TBC) hours.

7.6 Relative Humidity- Operating

The diplexer shall meet all performance requirements while operating in relative humidity of 20% to 80% (TBC), at atmospheric pressure, at any temperature in the range of -20 to +40 °C.

7.7 Vibration Test

The diplexer shall not suffer degradation in performance after subjected to the vibration test levels in Table 4. The levels shall be applied for 1 minute per axis, for each of the three orthogonal axes at the mounting interface of the assembly. Vibration testing applies only to delivered flight units.

Frequency (Hz)	Flight Acceptance Levels	Qual/Proto-Flight Levels
20-50	+6 dB/Oct.	+6 dB/Oct.
50-500	0.08 g^2/Hz	0.16 g^2/Hz
500-2000	-6.0 dB/Oct.	-6.0 dB/Oct.
Overall	10.0 grms	14.1 grms
Duration	1 min.	2 min (Qual) / 1 min (Proto-F)

Table 4 GEVS Random Vibration Test Levels

7.8 Pyrotechnic Shock Test

The diplexer shall not suffer degradation in performance after subjected to the shock test levels in Table 5. The shock levels shall be applied once per axis, for each of the three orthogonal axes at the mounting interface of the assembly. Pyrotechnic shock testing applies to only to the Qualification units, or to single unit from the Flight lot. The test article shall be chosen by the COTR.

Frequency (Hz)	Peak Shock Response Spectrum (Q=10)
100	60 g
1000	6000 g
10,000	6000 g

Table 5 Pyrotechnic Shock Test Levels

8 Contamination Requirements

8.1 Materials Outgassing

Materials shall be selected in accordance with the requirements set forth in the "Statement of Work for the SMAP Project Instrument Diplexer ".

8.2 Hardware Cleaning

All cables, connectors, boards, metallic machined parts, and other components of the diplexer shall be cleaned of oil, lubricants and other polymeric contaminants before assembly. Subsequent handling of the Diplexer shall ensure that a cleanliness level of TBD is maintained.

8.3 Thermal Vacuum Bake-out

All flight diplexers shall be baked in a vacuum chamber at a temperature of 55 °C, for a duration of 48 hours, prior to shipment. Maximum pressure for initial conditions of bake-out shall be 1×10^{-4} Torr

9 Attachment A

Diplexer interface control drawing # TBD.