COMS SYSTEM LEVEL RF COMPATIBILITY TEST SYNTHESIS

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ABSTRACT: During the COMS system level test, the RF compatibility will be performed in order to verify that there is no issue in RF interface between satellite and COMS ground station, namely SOC (Satellite Operation Center) before the launch. As used for KOMPSAT1, the RF coaxial cable was chosen to be used to connect satellite and SOC with various advantages as compared with ground antennas. As the preparation step, RF cable and required multiplexer were tested in advance.
This paper suggests the way for the RF compatibility tests between the satellite and the SOC over RF cable interface and presents the estimated level diagram as the signal power analysis result.

KEY WORDS: COMS, SOC, RF, Compatibility, Power

1. INTRODUCTION

Currently, the integration and test of COMS (Communication, Ocean, and Meteorological Satellite) satellite is being performed at the KARI AIT building. When it is finished, the COMS system level test which covers integration and validation of the overall COMS system (satellite and ground station) is planned before the launch.

The first validation tests of the COMS system level test are RF compatibility (CP) tests to check all data exchanged in RF signals between satellite and SOC on ground.

We can consider a ground antenna or RF coaxial cable as the transmission media to connect satellite and SOC. The antenna-to-antenna method was used for KOMPSAT2 CP tests but the use of antenna to ground tests has following disadvantages comparing to the use of RF cable:

1) Multi-path RF interference caused by the low antenna elevation angle
2) Incorrect power loss measurement at source and destination antenna
3) Difficult to control high accurate antenna pointing
4) Mischievous influence to human body

For these reasons, the RF coaxial cable has been chosen for the COMS program as baseline and existing cable used for the KOMPSAT 1 will be reused as part of the required cables. Besides the transmission media, test multiplexers to transmit the maximum three signals on a line and attenuators to reduce signal power is also considered for the RF CP tests.

The SOC side prepared the COMS RF CP tests in following steps; we selected test configurations reflecting test equipment and real interfaces for each RF CP test cases. Second, characteristics and performance of RF cable and test equipment were measured. Finally the signal power analysis was done using measure power loss at each component to ensure safe tests and the attenuation range.

2. COMS RF CP TESTS

After the launch, the SOC ground antenna will communicate with the on-board TC&R(Telemetry Command and Ranging) and MODCS(Meteorological and Ocean Data Communication Subsystem) antennas in S-and L-band. The RF CP tests are mainly divided for these two kinds of on-board systems and composed of several test cases.

On ground, The TC&R data will be processed at SGCS (Satellite Ground Control System) for the satellite operation and the MODCS data at IDACS (Image Data Acquisition and Control System) for the data pre-processing. All ground units of SGCS and IDACS are identical to the operational COMS hardware and software.

The next figure depicts roughly the location of each system under tests, interface, and test equipment. The test supporting equipment such as EGSEs, attenuators, and spectrum analyzers is omitted here.

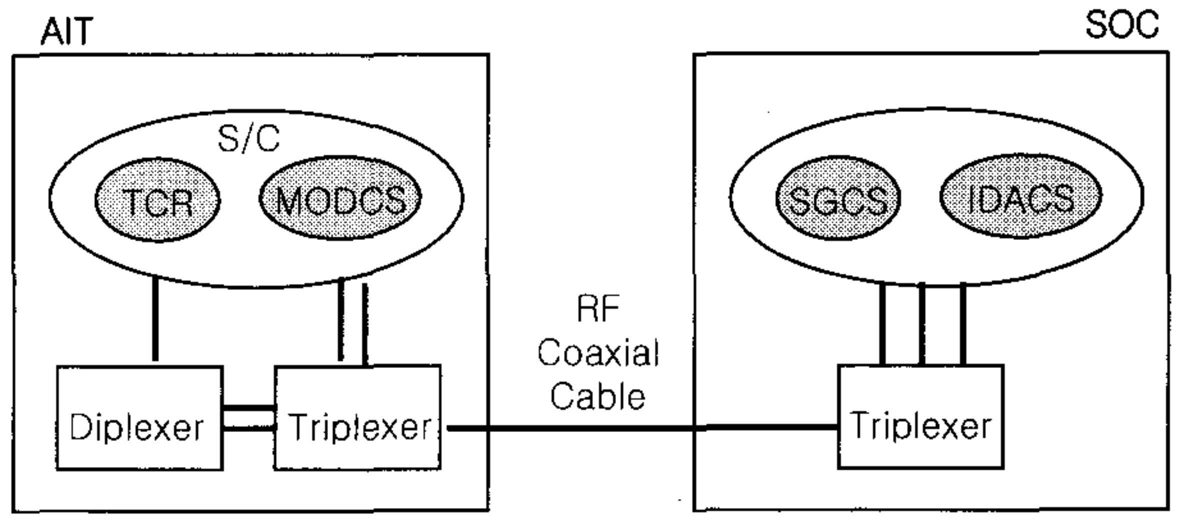

Figure 1. General Scheme of COMS CP Tests

2.1 TC&R and SGCS

The TM/TC/Ranging signal will be exchanged using the TC&R in S-band. During the RF CP tests, the reception and transmission function of above three signals will be checked in incremental ways. When TM reception is checked with ranging mode on, the simultaneous TC transmission would be checked. The in/output signal and power level of all components are plotted and recorded with the spectrum analyzer to check that SGCS' RF and baseband equipment and the TC&R are compatible in predefined dynamic range. The status of SGCS equipment can be monitored by C&M software. Two of on-board antennas will be checked one by one. The test cap will be mounted on both antennas and the RF signal is transmitted to the test input port of the SGCS LNA over the RF coaxial cable.

2.2 MODCS and IDACS

The MODCS will download the sensor data (SD) containing MI and GOCI observation data and distribute LRIT/HRIT (processed data) signal coming from ground to the end-users. The on-board MODCS antenna is composed of the reception S-band antenna and the L-band emitter antenna. The purpose of this CP test is to verify that 3 channel (SD, LRIT, HRIT) reception /transmission are operationally compatible between the MODCS and IDACS equipment. Attenuating power for the operational power range will be also applied to check the sensibility of IDACS equipment.

During the L-band LRIT/HRIT downloading link test, the SOC IDACS equipment will be configurable on behalf of the end-users reception systems to receive LRIT/HRIT signal.

3. PREPARATION TEST

This section describes the performance measurement result of the RF cable, triplexer, and diplexer which will be used for the RF CP tests.

3.1 RF Coaxial Cable Power Loss Measurement

The one series of RF coaxial cable will connect the SOC with the S/C at the AIT building as depicted in figure2. It is composed of following three cables in line,

- Cable #1 (COMS AIT – KOMPSAT AIT)
- Cable #2 (KOMPSAT AIT – KOMPSAT Antenna)
- Cable #3 (KOMPSAT Antenna – SOC)

Test Configuration

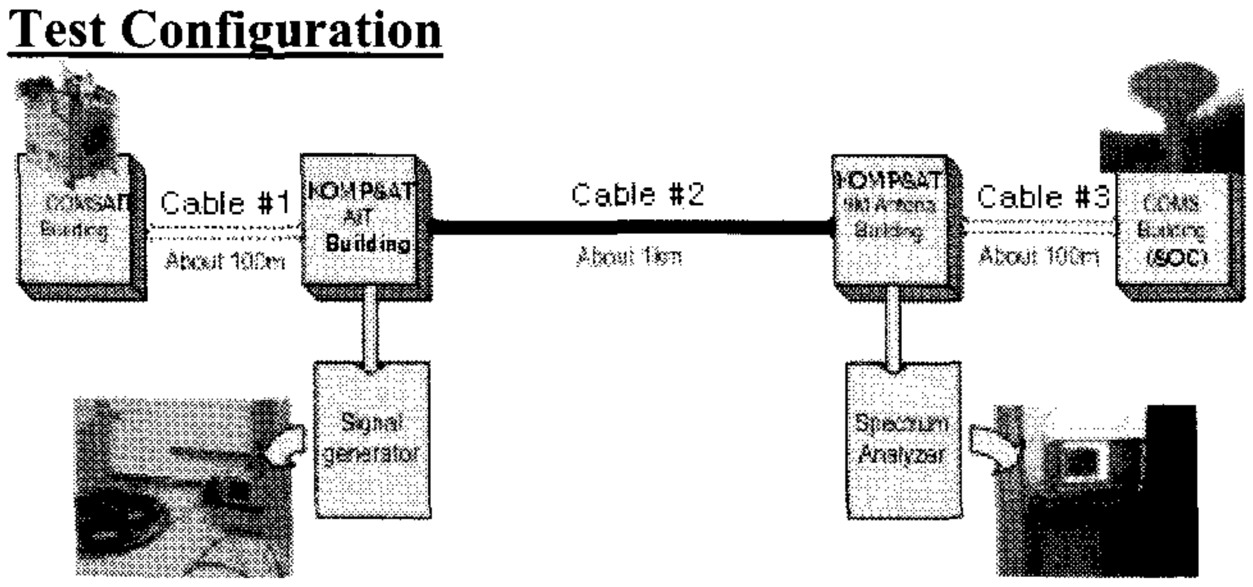

Figure 2. RF Cable Connection

KARI measured the cable loss over the existing cable#2 using the following equipment for TC&R and MODCS frequency band.

- Existing cable type : Andrew Heliax® 7/8"LDF5-50A (See figure 3-(a))
- Signal generator : E8267D Vector signal generator (Agilent) [Calibrated on 22, Mar, 2006]
- Spectrum analyzer : LSA-265 (LIG Nex1) [Calibrated on 07, Nov, 2006]

As the extension cable #1 and #3 will be newly implemented for the COMS program, their loss value at each frequency was referred to the specification.

- Extension cable type : Andrew Heliax® 1/2" FSJ4-50B (See figure 3-(b))
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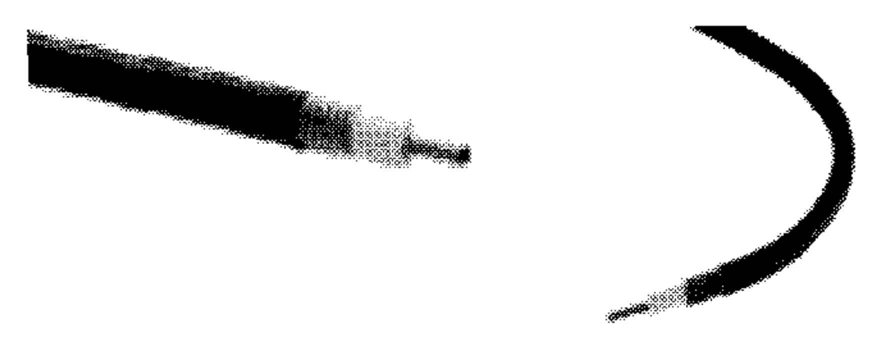

(a) Cable #2 (b) Cable #1, 3

Figure 3. RF Coaxial Cables

The output power of signal generator was set as 10 dBm and frequencies for COMS system were applied. The loss was calculated by comparing the output at a signal generator and measured signal at a spectrum analyzer for each frequency. The cable loss between the measurement equipment and existing cable #2 is also considered to this calculation.

Test Result

It's checked that the power loss of cable between the COMS AIT and SOC is between 79.90 dB and 94.20 dB for COMS S-and L-band frequency band.

3.2 Triplexer Characteristic Measurement

The two identical triplexers were developed by Filtron under KARI's requests to perform RF equipment test and RF compatibility tests. They can multiplex three signals in S- and L-band into a single output.

One triplexer will be located at the COMS AIT building and the other at the SOC as shown in figure 1. Next figure shows one of two triplexers which have identical structure and specification.

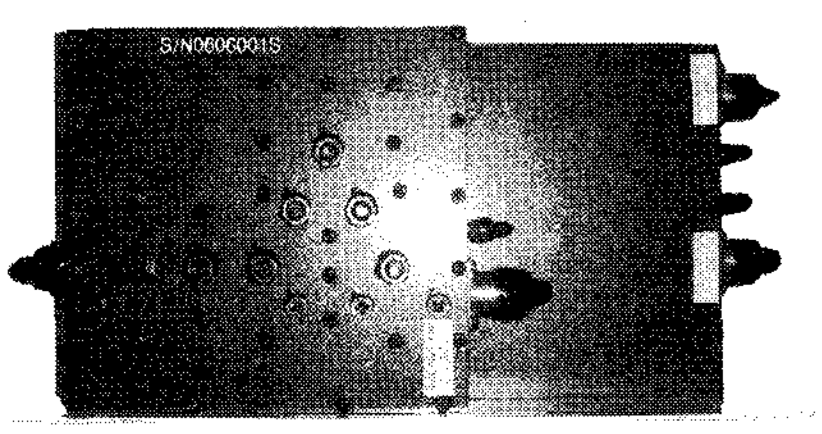

Figure 4. Triplexer

Test Configuration

Following electrical items of triplexers were measured for all ports in the operational room temperature.

- Insertion loss
- Pass band ripple

- Return loss
- Isolation
- Handling power
- Coupling value

Next figure shows the test configuration.

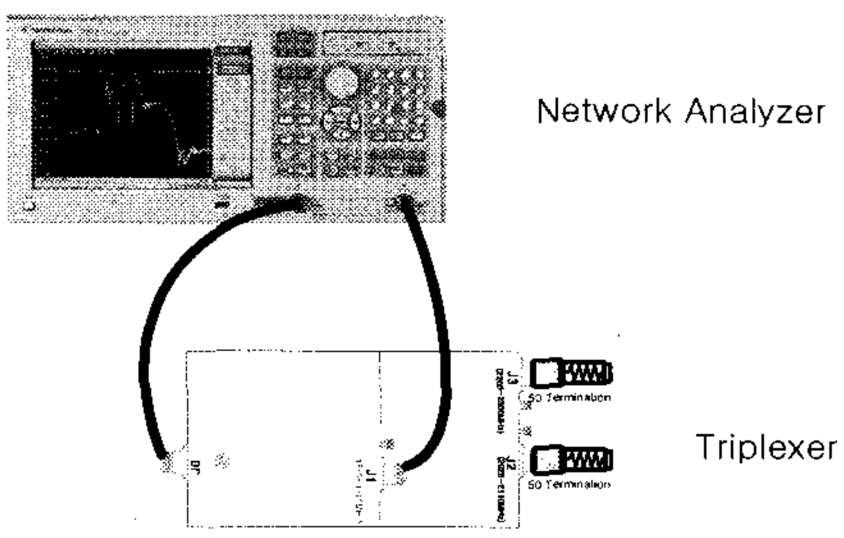

Figure 5. Triplexer Test Configuration

Test Result

From this test, it was verified that two triplexers show almost same characteristics and performance within the specified value.

Table 1. Tripelxer Test Result

◆ J1(1670~1710MHz)

Parameter	Specification	Triplexer_1 Measured Data	Triplexer_2 Measured Data	Pass or Fail
Insertion Loss	0.3dB	0.24(Max) [dB]	0.22 (Max) [dB]	Pass
Pass Band Ripple	0.2 dB	0.1 [dB]	0.1 [dB]	Pass
Return Loss	20dB(Min)	23(Min) [dB]	21 (Min) [dB]	Pass
Isolation To J2	100dBc(Min)	102.8(Min)[dBc]	107.2 (Min) [dBc]	Pass
Isolation To J3	100dBc(Min)	103.6(Min)[dBc]	110.2 (Min) [dBc]	Pass
Coupled Port Value	30dB ±1dB	30.67 [dB]	30.79 [dB]	Pass

◆ J2(2025~2110MHz)

Parameter	Specification	Triplexer_1 Measured Data	Triplexer_2 Measured Data	Pass or Fail
Insertion Loss	0.5dB	0.35(Max) [dB]	0.37(Max) [dB]	Pass
Pass Band Ripple	0.3 dB	0.11 [dB]	0.1 [dB]	Pass
Return Loss	20dB(Min)	21(Min) [dB]	21(Min) [dB]	Pass
Isolation To J3	100dBc(Min)	102.7(Min)[dBc]	105.5(Min) [dBc]	Pass
Coupled Port Value	30dB ±1dB	30.451 [dB]	30.59 [dB]	Pass

◆ J3(2200~2290MHz)

Parameter	Specification	Triplexer_1 Measured Data	Triplexer_2 Measured Data	Pass or Fail
Insertion Loss	0.5dB	0.17(Max) [dB]	0.15(Max) [dB]	Pass
Pass Band Ripple	0.3 dB	0.1 [dB]	0.1 [dB]	Pass
Return Loss	20dB(Min)	21(Min) [dB]	21(Min) [dB]	Pass
Isolation To J2	100dBc(Min)	108(Min) [dBc]	102.8(Min) [dBc]	Pass
Coupled Port Value	30dB ±1dB	29.6 [dB]	30.21 [dB]	Pass

◆ J0 (Ant)

Parameter	Specification	Triplexer_1 Measured Data	Triplexer_2 Measured Data	Pass or Fail
Return Loss	20dB(Min)	21(Min) [dB]	21(Min) [dB]	Pass

3.3 Diplexer Characteristic Measurement

At the COMS AIT building, one diplexer will be used to multiplex two S-band signals into a single output between the S/C and the triplexer. Next figure shows the diplexer.

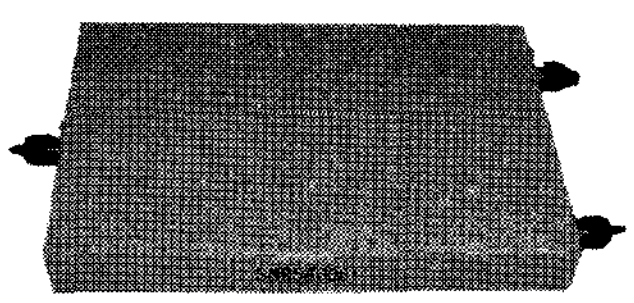

Figure 6. Diplexer

Test Configuration

Following electrical items were measured for the diplexer ports in the operational room temperature. Insertion loss

- Pass band ripple
- Return loss
- Isolation
- Handling power

Figure 7 shows the test configuration using a network analyzer.

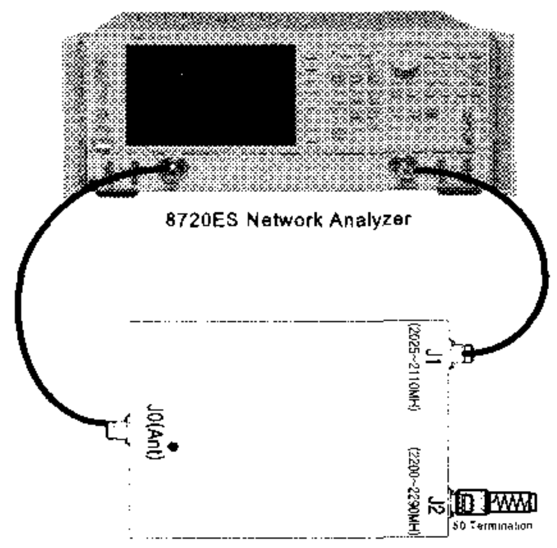

Figure 7.Diplexer Test Configuration

Test Result

It is concluded that the diplexer meets the desired specification. The test results are summarized in next table to compare measurement values.

Table 2. Diplexer Test Result

◆ J1(2025~2110MHz)

Parameter	Specification	Measured Data	Pass or Fail
Insertion Loss	0.5dB	0.29(Max) [dB]	Pass
Pass Band Ripple	0.3 dB	0.11 [dB]	Pass
Return Loss	20dB(Min)	21(Min) [dB]	Pass
Isolation	100dBc(Min)	116(Min) [dBc]	Pass

◆ J2(2200~2290MHz)

Parameter	Specification	Measured Data	Pass or Fail
Insertion Loss	0.5dB	0.35(Max) [dB]	Pass
Pass Band Ripple	0.3 dB	0.15 [dB]	Pass
Return Loss	20dB(Min)	21(Min) [dB]	Pass
Isolation	100dBc(Min)	123(Min) [dBc]	Pass

◆ J0

Parameter	Specification	Measured Data	Pass or Fail
Return Loss	20dB(Min)	21(Min) [dB]	Pass

4. POWER ANALYSIS

Reflecting the power loss value checked during the preparation test in the section 3, we analyzed the power dynamic range of following RF CP tests,

- Downlink TM to SOC
- Uplink TC to S/C (AIT)
- Downlink SD/LRIT/HRIT to SOC
- Uplink LRIT/HRIT to S/C (AIT)

The purpose of this power analysis is to verify required power input range to the satellite and ensure that test configurations prepared by the SOC are adequate so that we progress the RF CP test.

The source and destination of analyzed interfaces are the test cap of the TC&R and MODCS antenna and SOC MODEM/BB equipment and vice versa for cases.

Analysis results are summarized in next table.

Table 3. Power Analysis Result

(a) Downlink TM to SOC

	TLM		
S-Band Output PWR	25	dBm	Test cap port
Test Cable Loss	0.1	dB	Test cap to Duplexer, Assumed
Duplexer Loss	0.35	dB	S/N: 05A0001
Test Cable Loss	0.1	dB	Duplexer to Triplexer, Assumed
Triplexer Loss	0.15	dB	Triplexer_2 (S/N: 0606003S)
RF Cable Loss	94.2	dB	AIT to SOC
Triplexer Loss	0.17	dB	Triplexer_1 (S/N: 0606001S)
Test Cable Loss	0.1	dB	Triplexer to Attenuator, Assumed
Tunable Attenuator	10	dB	Attenuation Range: at least 30 dB
Test Cable Loss	0.1	dB	Attenuator to LNA, Assumed
LNA Coupling Factor	40	dB	LNA input coupling port
LNA Gain	50	dB	
Switch Loss	0.4	dB	LNA internal switch, Assumed
Cable Loss	3.8	dB	LNA to DC, Assumed
D/C Gain	20	dB	
Cable Loss	8.5	dB	DC to MODEM/BB
MODEM/BB Input PWR	**-62.97**	dBm	Input Range: -25 to -85 dBm

(b) Uplink TC to S/C (AIT)

	Command		
MODEM/BB Output Power	-27	dBm	
Switch Loss	0.5	dB	witch to select one of two MODEM/BB, Assumec
Cable Loss	8.5	dB	MODEM/BB to U/C
U/C Gain	20	dB	Attenuator Setting: 10dB
Test Cable Loss	0.1	dB	U/C to S-Band 1kW SSPA, Assumed
1kW SSPA Gain	71.4	dB	
OMUX Loss	0.4	dB	
Coupling Factor	40	dB	Coupler at OMUX output, Assumed
Tunable Attenuator	15	dB	Attenuation Range: at least 65dB
Cable Loss	0.1	dB	1kW SSPA to Triplexer_1, Assumed
Triplexer Loss	0.35	dB	Triplexer_1 (S/N: 0606001S)
RF Cable Loss	88.81	dB	SOC to AIT
Triplexer Loss	0.37	dB	Triplexer_2 (S/N: 0606003S)
Test Cable Loss	0.1	dB	Triplexer to test cap, Assumed
Duplexer Loss	0.29	dB	S/N: 05A0001
Cable Loss	0.1	dB	Duplexer to test cap, Assumed
Test Cap Input PWR	**-90.22**	dBm	Input Range: -90 to -140 dBm

(c) Downlink SD/LRIT/HRIT to SOC

	SD	LRIT	HRIT		
L-Band Output PWR	43.8	43.8	43.8	dBm	Test cap port @ AIT
Test Cable Loss	0.1	0.1	0.1	dB	Test cap to Triplexer_2, Assumed
Triplexer Loss	0.22	0.22	0.22	dB	Triplexer_2 @ AIT(S/N: 0606003S)
AIT-SOC Cable Loss	79.76	79.9	79.88	dB	AIT to SOC
Triplexer Loss	0.24	0.24	0.24	dB	S/N: 0606001S
Test Cable Loss	0.1	0.1	0.1	dB	Triplexer to Attenuator, Assumed
Tunable Attenuator	10	10	10	dB	Attenuation Range: at least 70 dB
Test Cable Loss	0.1	0.1	0.1	dB	Attenuator to LNA, Assumed
LNA Coupling Factor	40	40	40	dB	LNA input coupling port
LNA Gain	54	54	54	dB	
Switch Loss	0.4	0.4	0.4	dB	LNA internal switch, Assumed
Cable Loss	3.8	3.8	3.8	dB	LNA to DC, Assumed
D/C Gain	20	20	20	dB	
Cable Loss	8.5	8.5	8.5	dB	DC to MODEM/BB
MODEM/BB Input PW	-25.42	-25.56	-25.54	dBm	Input Range: -25 to -85 dBm

(d) Uplink LRIT/HRIT to S/C (AIT)

	LRIT	HRIT		
MODEM/BB Output Power	-27	-27	dBm	
3dB Combiner	3	3	dB	
Cable Loss	8.5	8.5	dB	MODEM/BB to UC
U/C Gain	20	20	dB	Attenuator Setting: 10dB
Test Cable Loss	0.1	0.1	dB	J/C to S-Band 1kW SSPA, Assumec
1kW SSPA Gain	71.4	71.4	dB	
OMUX Loss	0.4	0.4	dB	
Coupling Factor	40	40	dB	Coupler at OMUX output
Tunable Attenuator	0	0	dB	Attenuation Range: at least dB
Cable Loss	0.1	0.1	dB	1kW SSPA to Triplexer, Assumed
Triplexer Loss	0.35	0.35	dB	S/N: 0606001S
AIT-SOC Cable Loss	88.81	89.01	dB	SOC to AIT
Triplexer Loss	0.37	0.37	dB	S/N: 0606003S
Test Cable Loss	0.1	0.1	dB	Triplexer to test cap, Assumed
Test Cap Input PWR	**-77.33**	**-77.53**	dBm	Input Range: -52 to -69 dBm

The attenuation value and power loss of test cables connecting systems are assumed, though attenuation range could be adjusted to check the sensibility of signal reception performance.

5. CONCLUSION

This paper reports the RF CP test preparation result and current status prepared by the SOC side. We checked that the preparation test result of RF coaxial cable, triplexer, and diplexer has met the specified value. Currently, KARI and the COMS foreign prime contractor have negotiation to adjust detailed test procedures.

When the review of test procedures is completed, and then the COMS RF CP tests would be started at KARI site.

After the RF interfaces are verified, performance and operational end-to-end tests is followed to qualify all segment and its operators involved in the COMS system are working according to the requirement and ready to begin the launch campaign.

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