VERIFICATION ON THE PERFORMANCE OF COMS SOC S-BAND SSPA

Durk-Jong PARK†, Hyung-Mo YANG, Sang-Il AHN

Ground System Development Department, Satellite Operations & Applications Division, Space Application Center,
Korea Aerospace Research Institute (KARI)
parkdj@kari.re.kr

ABSTRACT: The S-Band SSPA is front-end equipment to transmit both LRIT and HRIT to COMS. To provide the required EIRP, S-Band SSPA is designed to generate maximum 1kW power at its 1dB gain compression point (P1dB). Due to the operation for 24 hours per seven days, the verification on the performance of S-Band SSPA was performed thoroughly. This paper presents that major requirements such as maximum 1kW power, maximum -26dBc of IMD characteristic at 500W output and around -57dBc of coupling factor were verified through proposed test configuration.

KEY WORDS: COMS, SOC, DATS, SSPA, LRIT, HRIT

1. INTRODUCTION

COMS transmits observed data of two payloads, MI (Meteorological Imager) and GOCI (Geostationary Ocean Color Imager) to ground station through L-Band frequency. After receiving the observed data, so-called Sensor Data (SD), MSC (Meteorological Satellite Center) and KOSC (Korea Ocean Satellite Center) performs pre-processing such as radiometric and geometric correction. In addition, SOC (Satellite Operation Center) which is primary station for COMS operation conducts identical pre-processing as a backup of MSC and KOSC. Except KOSC, one of MSC and SOC re-transmits the pre-processed data, LRIT (Low Rate Information Transmission) and HRIT (High Rate Information Transmission) to COMS for the broadcasting service of meteorological information. The major discriminator between LRIT and HRIT is transmitting speed, namely data rate. Data rate of LRIT and HRIT is 0.256Mbps and 6Mbps after convolution encoding, respectively. Figure 1 shows hardware configuration for LRIT/HRIT transmission at MSC and SOC.

LHGS (LRIT/HRIT Generation Subsystem) conducts a generation of LRIT/HRIT CADU (Channel Access Data Unit) from the pre-processed meteorological data. After receiving the CADU through Ethernet network, MODEM/BB performs convolution encoding, PCM encoding, and modulation in an order. Since the frequency should be S-Band to transmit LRIT/HRIT to COMS, IF frequency of LRIT/HRIT is converted through UC (Up Converter). After that, LRIT/HRIT in S-Band is supposed to be amplified by SSPA and transferred to antenna and TLT (Test-Loop Translator). In a fact, there is path loss between COMS and ground station, which major factor is distance. To cope with the path loss, it is required for ground station to amplify LRIT/HRIT in S-Band to meet the required level at S-Band antenna in satellite. According to the definition in reference document [1], at least -106 dBW/m^2 of PFD (Power Flux Density) of LRIT/HRIT should be placed at S-Band antenna in COMS and it means that at least 57dBW of EIRP (Equivalent Isotropically Radiated Power) should be provided by the summation of antenna gain and SSPA output power.

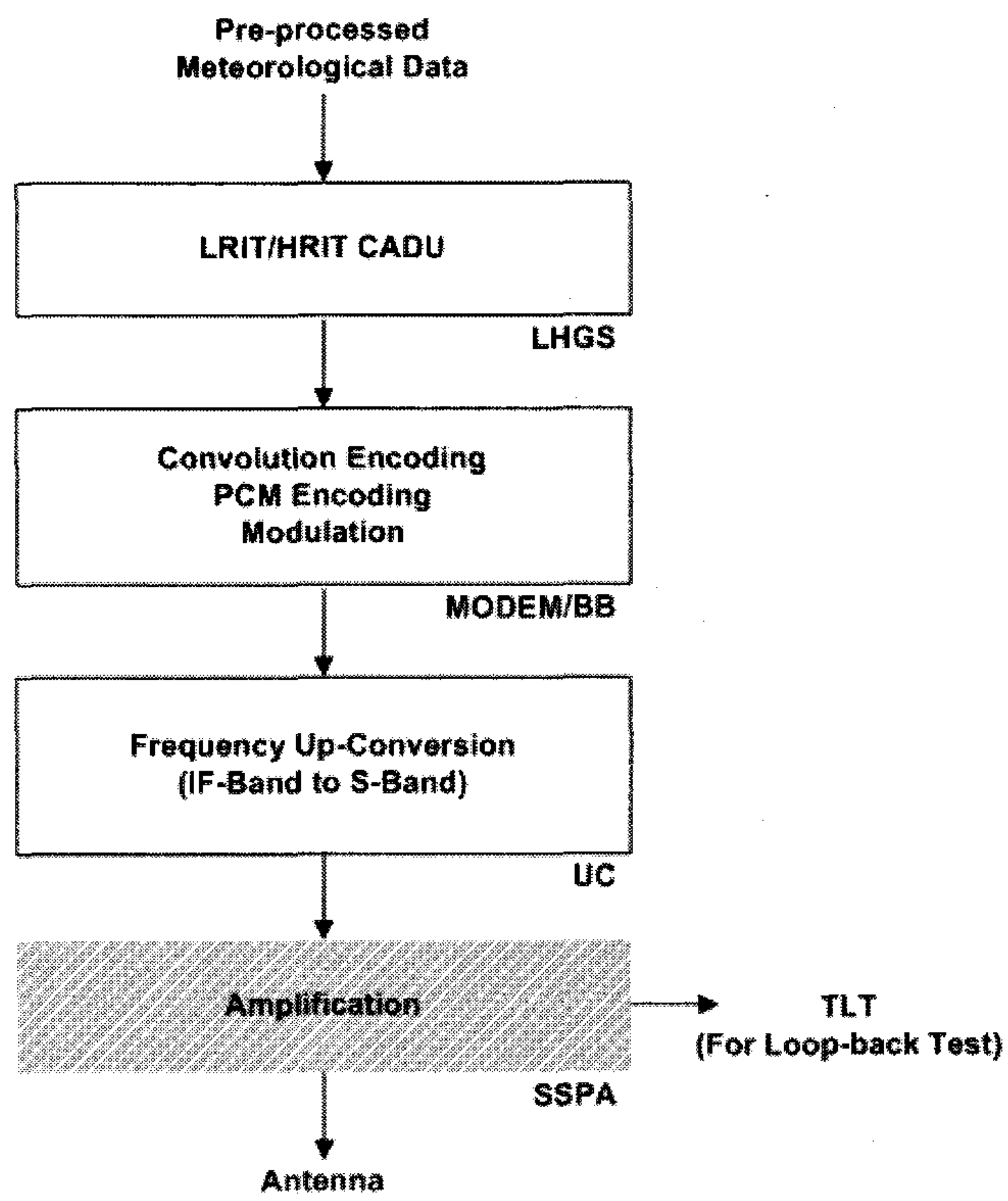

Figure 1 H/W Configuration for LRIT/HRIT transmission

Concerns on the stable operation leads to 1kW of the required SSPA power. Besides the requirement of maximum output power, SSPA should be designed to maximum -25dBc of IMD (Inter-Modulation Distortion) at 3dB OBO (Output Back-Off) when LRIT and HRIT are inputted simultaneously. In June, 2007, FAT (Factory Acceptance Test) was taken place at manufacturer's site with KARI engineer. The primary purpose of FAT is to check that features of manufactured SSPA meet to the requirements. This paper presents the test configuration and results to verify the performance of SSPA based on FAT activities.

2. SSPA OVERVIEW

Figure 2 shows the internal configuration of SSPA. 1kW SSPA consists of dual Pre-Amplifier (PA) in single drawer, eight 125W power modules, RF switch unit in single drawer, and air exhausting unit. Once, LRIT/HRIT in S-Band are inputted into RF input port placed in the back panel of SSPA, dual amplifier increase the signal level of LRIT/HRIT signal, simultaneously. Since the dual PA is operating as hot backup, it takes an advantage of stable operation even though one of two PA is failed suddenly. The output of selected PA is divided as 8 ways and inputted into eight 125W power modules. After summing the outputs of eight power modules through 8 ways combiner with a phase-shifter, LRIT/HRIT signal in S-Band are transferred into RF output. Two coupling ports are available in the path for RF output. One of two coupling ports is supposed to be used for loop-back test as mentioned previously. Thanks to the air-exhausting system, the heat generated by SSPA can be blowing out for the stable operation. For the remote monitoring and control of 1kW SSPA, the dedicated software, so-called DATS C&M S/W can approach to M&C board in single pre-amplifier drawer through Ethernet.

Table 1 shows the major specifications of 1kW SSPA.

Since the signal level of UC output is available up to 10dBm, at least 60dB of nominal linear gain leads to 1kW of output power when 0dBm of input signal is placed at RF input port. Practically, the output power of SSPA is supposed to be set below 500W, so-called 3dB OBO, for the stable operation. Therefore, IMD at 3dB OBO should be equal or less than -25dBc as defined in the reference document [1]

Table 1 Major specifications of 1kW SSPA

Item	Specifications
Nominal Linear Gain	≥ 60 dB
Gain Adjustment	≥ 20 dB by 0.5dB step
Gain Flatness at 3dB OBO	≤ 0.4 dB p-p (2034 – 2044MHz)
Output Power at P1dB	≥ 1000 W
IMD at 3dB OBO	≤ -26 dBc
Spurious at 3dB OBO	≤ -60 dBc
TLT Output Port	≤ -80 dBc

3. GAIN MEASUREMENT

Figure 3 shows the test configuration for gain measurement when PA #1 is enabled.

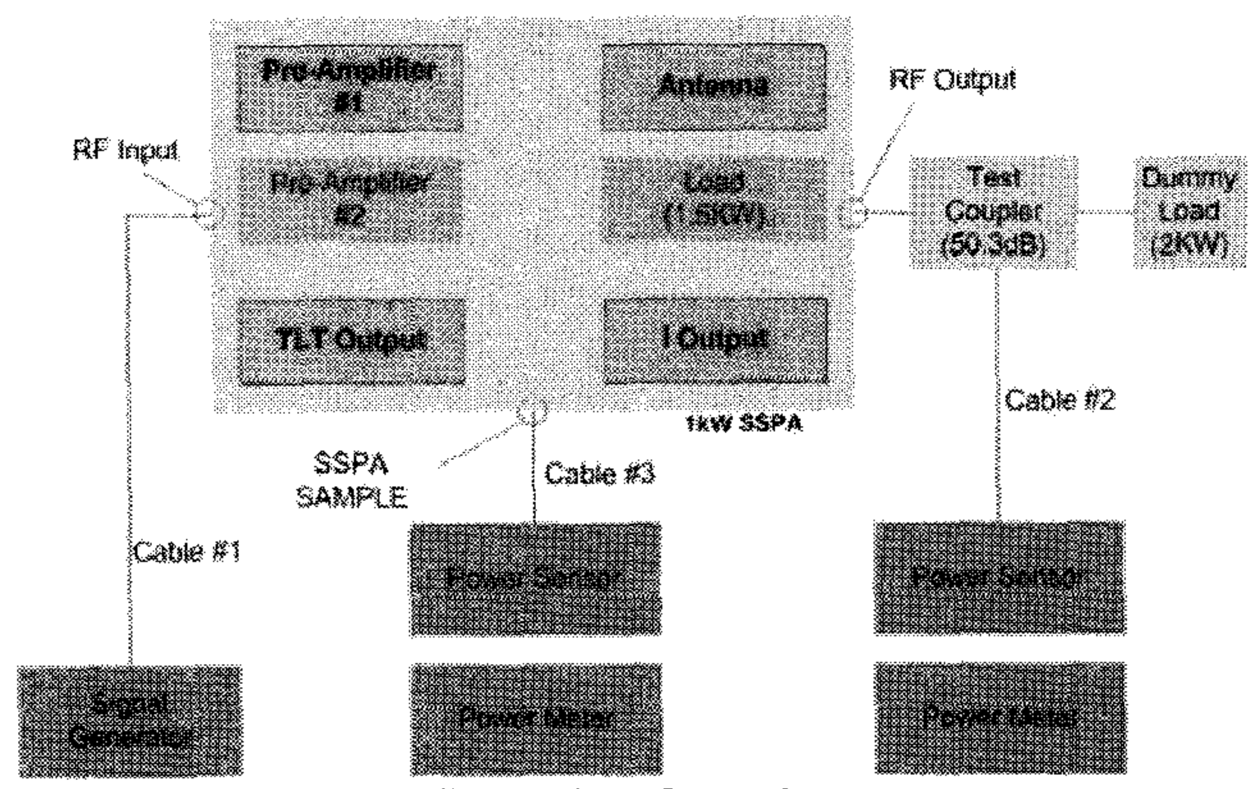

Figure 3 Test configuration for gain measurement

Besides the SSPA gain, coupling factor of two coupling ports, TLT output and I output, can be measured from the test configuration in Figure 3. To represent the connection with antenna, RF output port is connected with test coupler and dummy load. The aim of test coupler is to measure the output signal level with 50.3dB of coupling factor while that of dummy load is to avoid any reflected power which leads to a danger to SSPA.

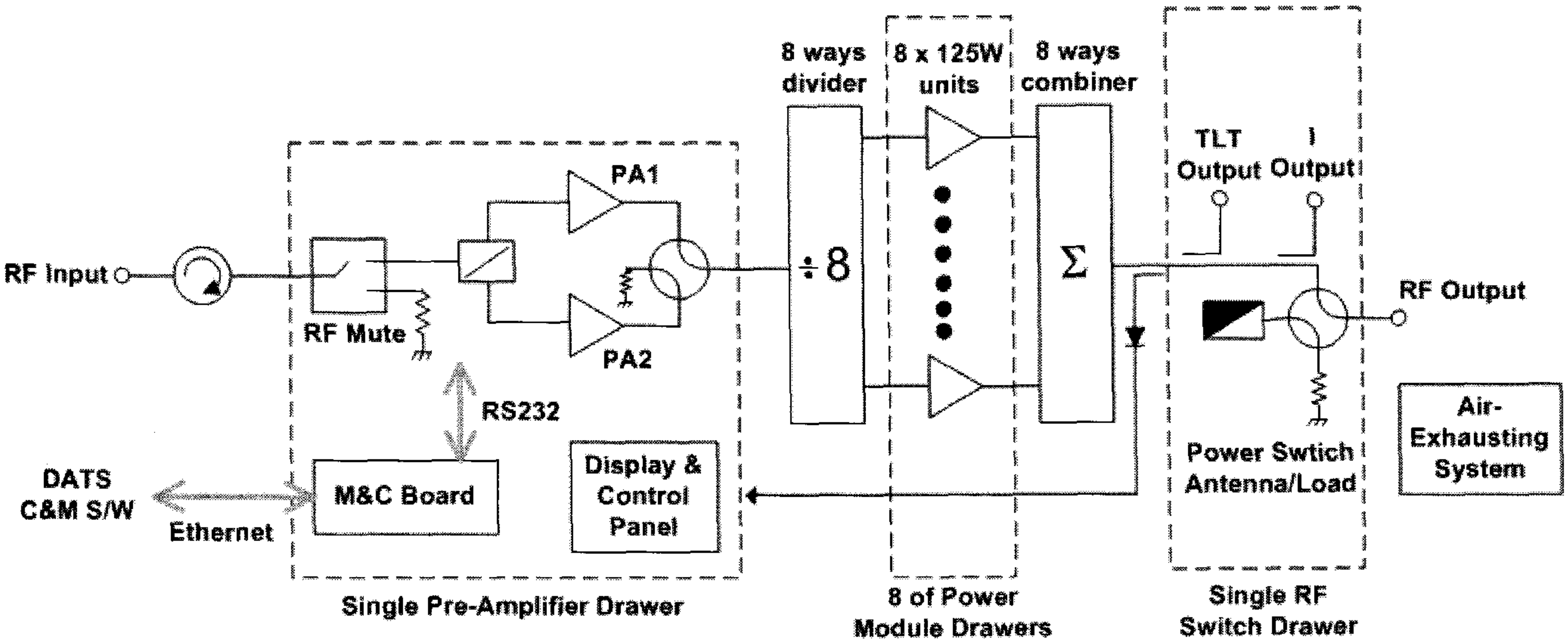

Figure 2 Internal configuration of 1kW SSPA

Once cable #1's loss is known, the setting of signal generator can be adjusted as -30dBm of signal at RF input port. Considering the coupling factor of test coupler and loss of cable #2, the output signal's power can be measured though power sensor and power meter. The ratio of output signal level to input signal level, so-called gain is calculated by subtracting the measured output signal level in decibel [dB] by input signal level in decibel [dB]. The coupling factors of TLT output and I output are also estimated from the signal level measured by power sensor and power meter connected with each output port. Table 2 shows output level at three output ports, RF output, TLT output, and I output when signal level at RF input port is increased from -30dBm by 1dB step.

Table 2 Measured output level at RF output, TLT output, and I output

RF Input	RF Output	TLT Output	I Output
-30	41.43	-12.3	-15.6
-29	42.41	-11.33	-14.64
-28	43.33	-10.3	-13.62
-27	44.43	-9.32	-12.65
......	......	......	......
-15	56.35	2.57	-0.78
-14	57.32	3.53	0.19
-13	58.29	4.5	1.15
-12	59.16	5.36	2.01
-11	59.93	6.12	2.77
-10	60.58	6.78	3.42
-9	61.14	7.33	3.97
-8	61.62	7.79	4.44
-7	61.92	8.1	4.75
-6	62.14	8.33	4.96
-5	62.31	8.49	5.13

From the level difference between RF output and RF input, gain is proved as 71.4dB in linear region. Due to the non-linear characteristic of SSPA, the gain is supposed to be saturated, meaning that output power is not increased as input power is increased. P1dB is the point when current gain is less than 1dB of linear gain. Based on the results in Table 2, when -10dB of RF input is applied, the gain is about 70.58dB which is 1dB different from 71.4dB, meaning the output power at P1dB is 60.58dBm (1.14kW). The coupling factor of TLT output and I output is estimated as 53.8dBc and 57.2dBc, respectively. Based on the measured coupling factor, it is determined that at least 30dB attenuator should be prepared additionally.

4. IMD MEASUREMENT

Figure 4 shows the test configuration for IMD measurement when PA #1 is enabled.

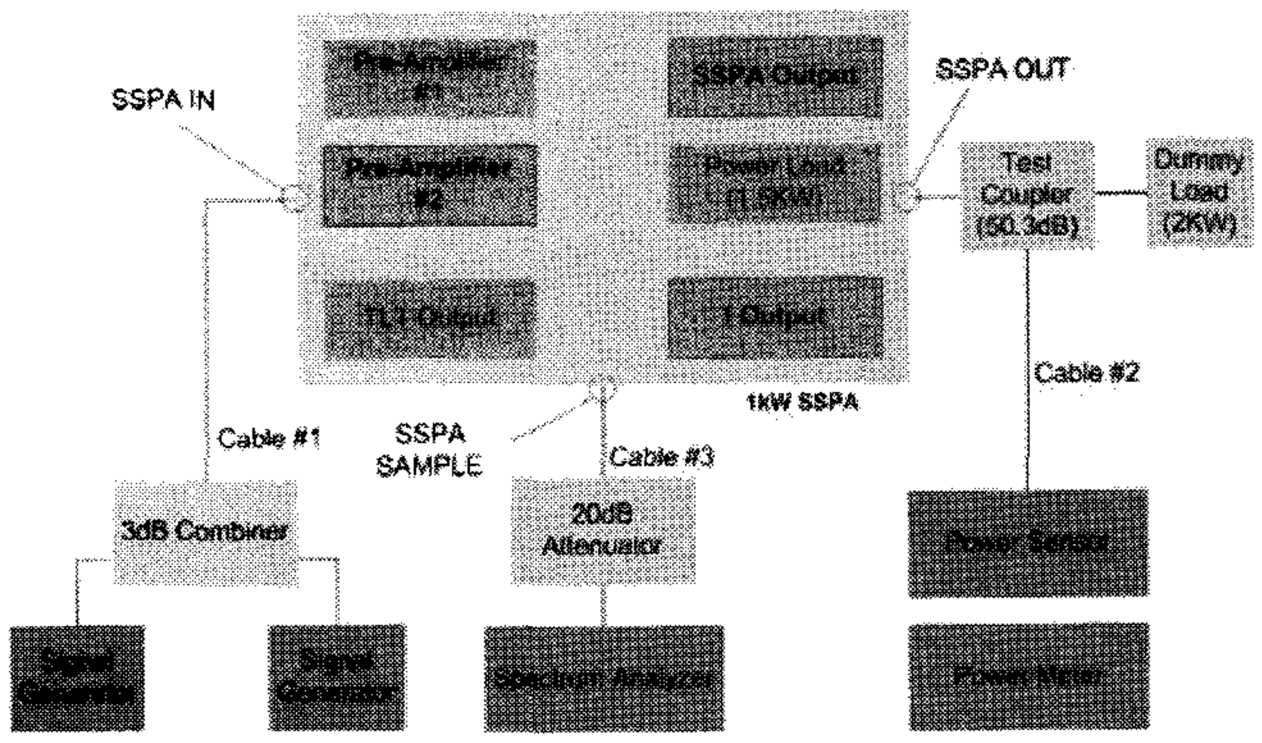

Figure 4 Test configuration for IMD measurement

To measure the IMD caused by the non-linear characteristics of SSPA when two tones with equal level are inputted, the frequency of each tone is set as that of LRIT/HRIT with considering normal operation. Thanks to the power sensor and power meter connected to the test coupler, IMD at 3dB OBO, 57dBm, can be recognized. IMD is estimated from the level difference between main tone and nearest 3^{rd} harmonic element. When 2034.67MHz of LRIT and 2040.9MHz of HRIT are input, the frequency of 3^{rd} harmonic is estimated as followings,

- Upper 3^{rd} harmonic = 2×2040.9 – 2037.64 = 2044.16MHz
- Lower 3^{rd} harmonic = 2×2037.64 – 2040.9 = 2034.38MHz

Figure 5 and 6 shows the upper IMD and lower IMD at 3dB OBO displayed on the spectrum analyzer, respectively.

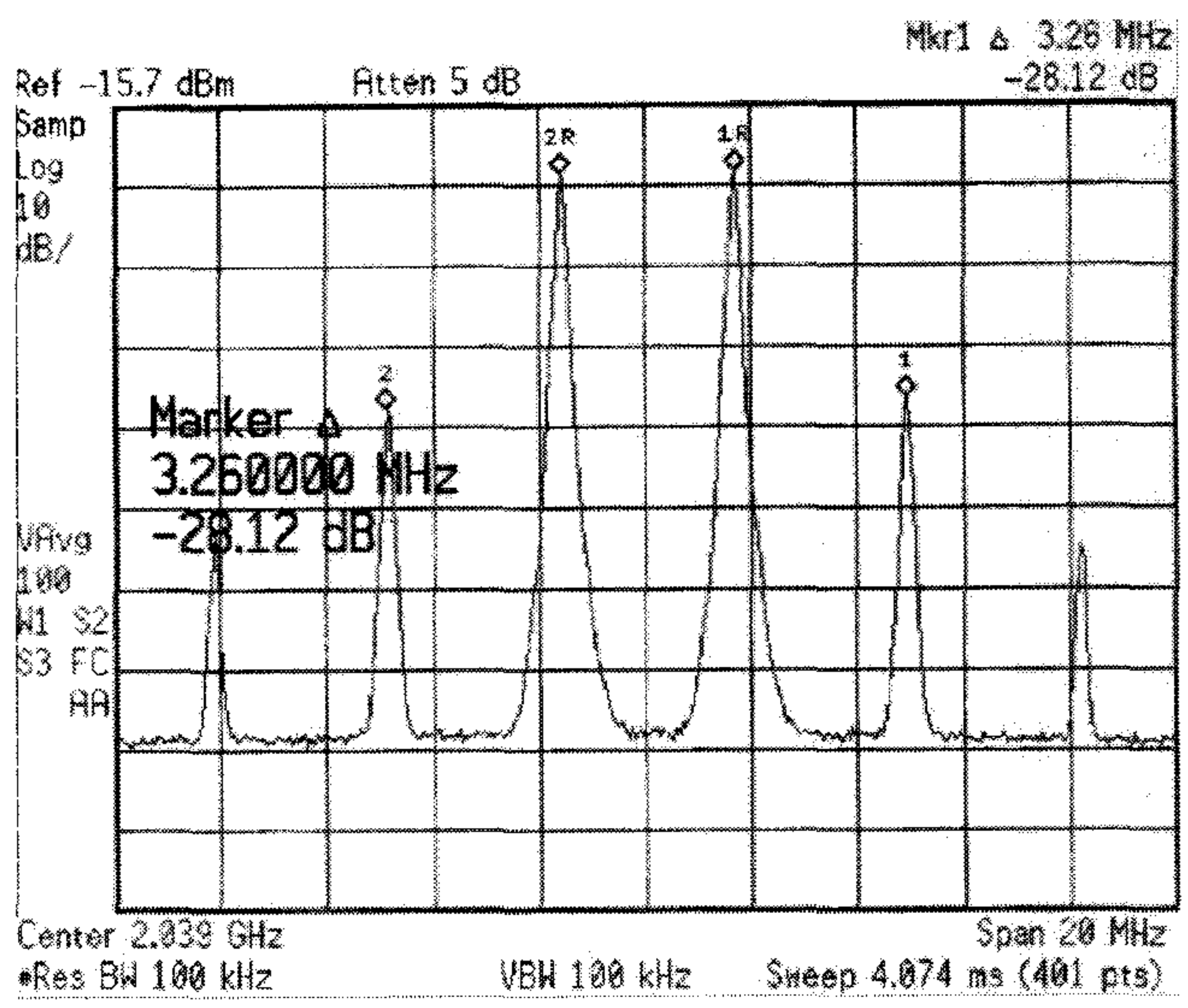

Figure 5 Upper IMD at 3dB OBO

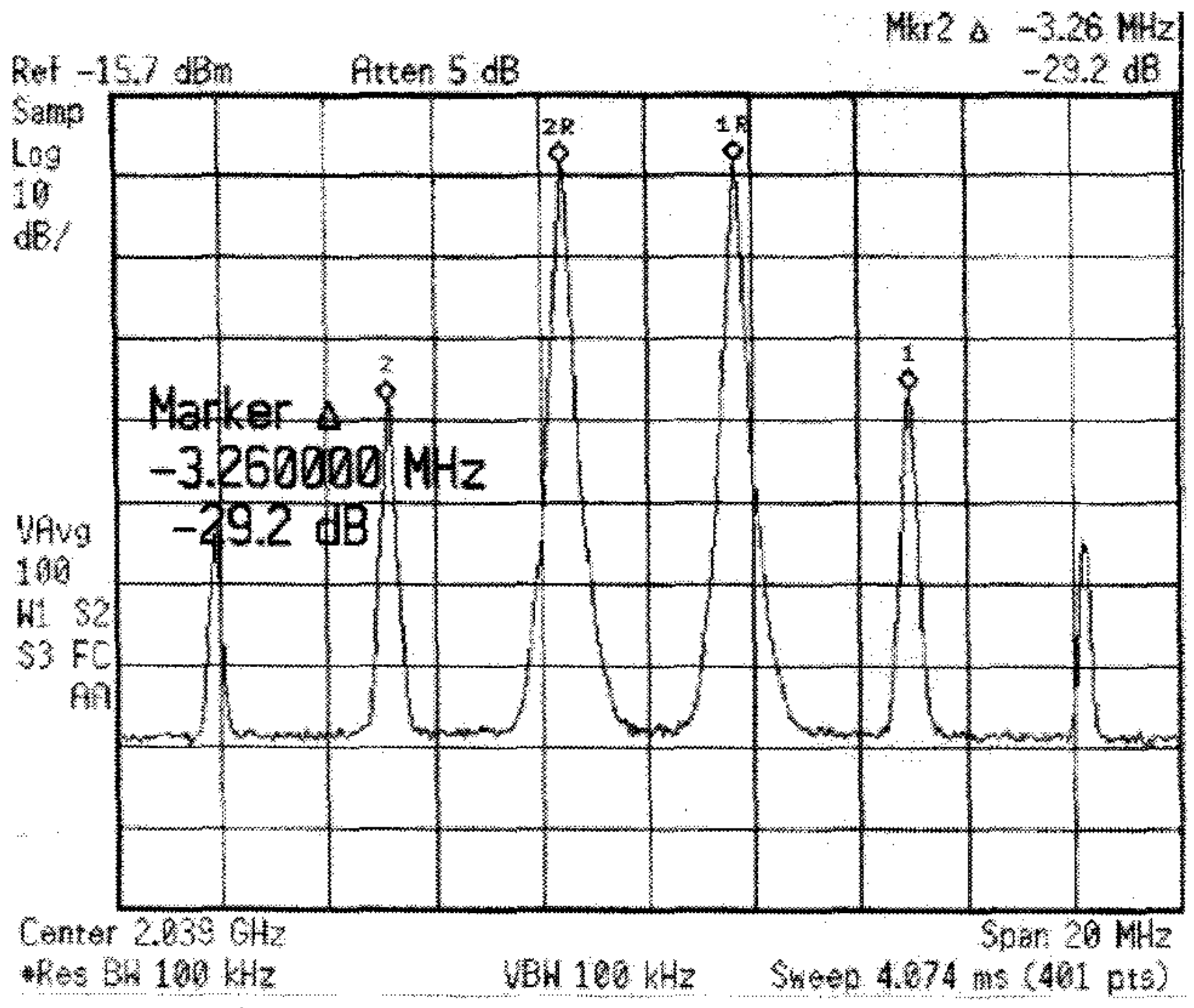

Figure 6 Lower IMD at 3dB OBO

The upper IMD and lower IMD is -28.12dBc and -29.2dBc, respectively, meaning that the -26dBc of requirement is satisfied.

5. CONCLUSION

This paper presents the test configuration and test results of 1kW SSPA which is supposed to be used for LRIT/HRIT transmission. Based on the requirements, major features of SSPA were verified during FAT with KARI engineer. From the gain measurement, it was proved that nominal linear gain is 71.4dB and 1.14kW at P1dB. In the case of coupling factor of two internal couplers, there is discrepancy with requirement. However, this discrepancy can be mitigated by using 30dB attenuator additionally. From the IMD measurement, it was proven that -26dBc of requirement at 3dB OBO is satisfied. Eventually, it was shown that 1kW SSPA is eligible for the transmission of LRIT/HRIT in S-Band

6. REFERENCE

[1] EADS Astrium 2007, MODCS to Ground ICD (Interface Control Document), *COMS critical design review meeting*, Issue 3, Revision 1, Toulouse, France