SETTING OF HPA OUTPUT POWER IN COMS DATS CONSIDERING IMD CHARACTERISTICS

Durk-Jong Park†, Hyung-Mo Yang, Sang-Il Ahn

Satellite Mission Operation Department, Korea Aerospace Research Institute
P. O. Box 113 Yuseong-gu, Daejeon, Korea
parkdj@kari.re.kr†

ABSTRACT: COMS will receive two different meteorological signals in S-Band from IDACS (Image Data Acquisition and Control System) in ground station before transmitting them in L-Band to user station. MODCS (Meteorological Ocean Data Communication Subsystem) in satellite released the value of required PFD (Power Flux Density) to receive two signals. Thus, DATS (Data Acquisition and Transmission Subsystem) needs to send two signals to satellite with a satisfied EIRP. The value of minimum HPA (High Power Amplifier) output power was estimated by subtracting antenna directional gain and path loss between antenna and HPA from the needed EIRP in this paper. Besides the minimum output power of HPA, the maximum output power was also calculated with considering IMD (Inter-Modulation Distortion) characteristics. IMD is always occurred in the output of HPA when LRIT and HRIT are amplified by using single HPA as COMS application. In this paper, the setting of maximum output power was determined when the IMD of modelled HPA was corresponded to the requirement of MODCS.

KEY WORDS: COMS, DATS, HPA, PFD, IMD

1. INTRODUCTION

COMS scheduled to be launched in 2008 will perform three missions, namely, meteorological and ocean color observation and Ka-Band communication monitoring with three different payloads. Especially, meteorological data generated by MI (Meteorological Imager) is retransmitted to satellite after radiometric/geometric processing at ground system and disseminated to user station. These meteorological data for user station can be divided as HRIT (High Rate Information Transmission) and LRIT (Low Rate Information Transmission) according to datarate. Figure 1 shows the summarized specification of HRIT and LRIT, respectively.

Table 1 Summarized Specification of HRIT and LRIT

Items	HRIT	LRIT
Uplink Frequency [MHz]	2040.9	2037.64
Downlink Frequency [MHz]	1695.4	1692.14
Data Rate [Mbps]	3	≤ 0.256
Modulation	QPSK	BPSK
FEC	Viterbi, R-S	Viterbi, R-S
Bandwidth [MHz]	5.2	1
Uplink Polarization	RHCP	RHCP
Downlink Polarization	Linear	Linear
User Station G/T [dB/K]	11.1	1.9
Expected BER	$\leq 10^{-8}$	$\leq 10^{-8}$

Transmission of HRIT and LRIT is performed by DATS which is one of three subsystems in IDACS. Data generated by LHGS is routed to MODEM/BB in DATS. After the baseband processing and modulation, MODEM/BB sends HRIT and LRIT in IF-Band to S-Band upconverter to convert center frequency of them. Especially, S-Band SSPA makes HRIT and LRIT be stronger to be delivered to satellite. Total output power at the stage of antenna, what is called EIRP (Equivalent Isotropic Radiated Power), is the summation of antenna gain and SSPA output capacity. Consequently, the minimum setting of required output power can be determined by minimum EIRP needed to transmit HRIT and LRIT to satellite. In this paper, the required minimum output power of SSPA was estimated by the needed PFD (Power Flux Density) at the stage of satellite input, which is released by MODCS engineer in Astrium. Furthermore, maximum output power of SSPA was calculated with considering the IMD results by simulating the modelled SSPA.

2. FREQUENCY PLAN

Figure 1 shows the considered uplink frequency plan.

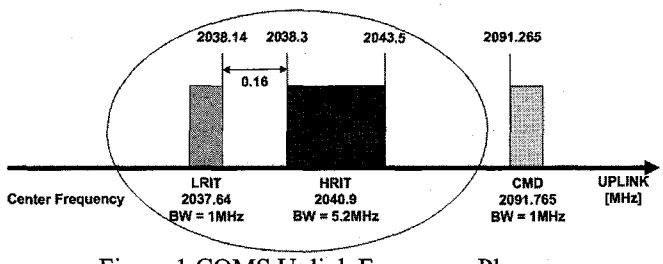

Figure 1 COMS Uplink Frequency Plan

Antenna for the transmission of HRIT and LRIT will be shared with TTC in charge of transmitting tele-command to satellite. Therefore, OMUX (Output Multiplexer) next to SSPA performs combining HRIT and LRIT and tele-command. The spectrum at the input of SSPA is shown in figure 2.

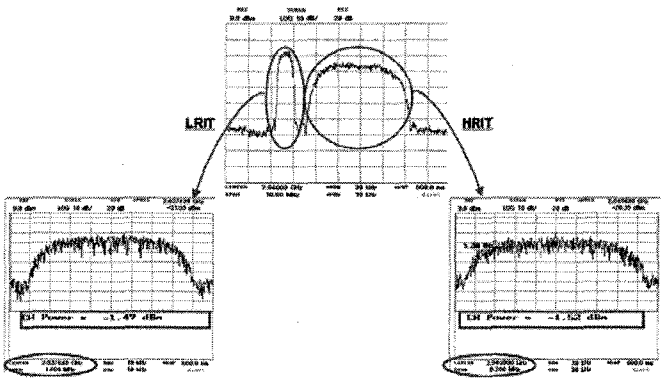

Figure 2 Spectrum of HRIT and LRIT at the input of SSPA

Even though the gap between the upper edge of LRIT and the lower edge of HRIT is slight as 0.16MHz, there is no interference in user's receiver. [1]

3. CONFIGURATION OF S-BAND 1:1 1KW SSPA

Figure 3 illustrates the configuration of S-Band 1:1 1kW SSPA. LRIT/HRIT in S-Band signal routed to S-band 1:1 upconverter is firstly amplified by one of two pre-amplifiers, which is controlled by C&M (Control and Monitoring) module via TCP/IP. The combination of several power modules next to pre-amplifier generates enough power to transmit LRIT/HRIT to satellite. Switch and dummy load performs a blocking of SSPA output whenever loop test is performed or satellite is in emergency status.

4. ESTIMATION OF MINIMUM SSPA OUTPUT POWER

MODCS released a required minimum PFD at the input stage of satellite as -106.5 [dBW/m^2].

term can be calculated including distance loss, atmosphere loss as followings,

- distance loss = 10log (1/4πSlant^2) = 162.42 dB/m^2, where "Slant" indicates the distance in km between satellite and ground
- Atmosphere loss = 0.58 dB

From the above parameters, the minimum EIRP can be calculated as followings,

- $EIRP_{MIN}$ = PFD + distance loss + atmosphere loss = -106.5 + 162.42 + 0.58 = 56.49 [dBW] = 86.49 [dBm]

To know the setting value of SSPA for 86.49 [dBm] of EIRP, antenna gain is estimated as 46.16 [dB] from the following simulated antenna pattern.

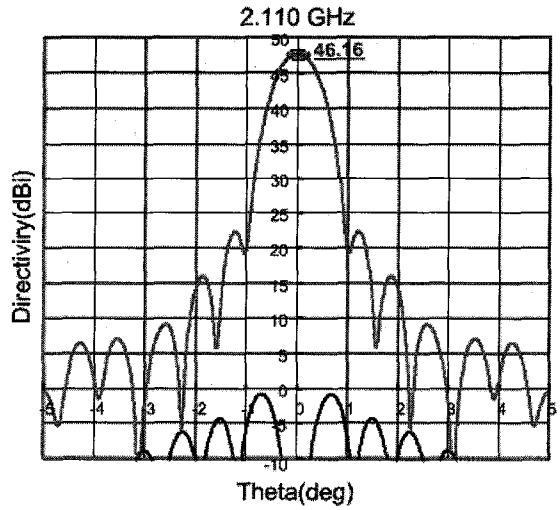

Figure 4 Radiation Pattern of Simulated Antenna

Considering total loss between SSPA output and antenna as 6.46 [dB], the setting value of SSPA is 46.79 [dBm] which corresponds to 48 [W]

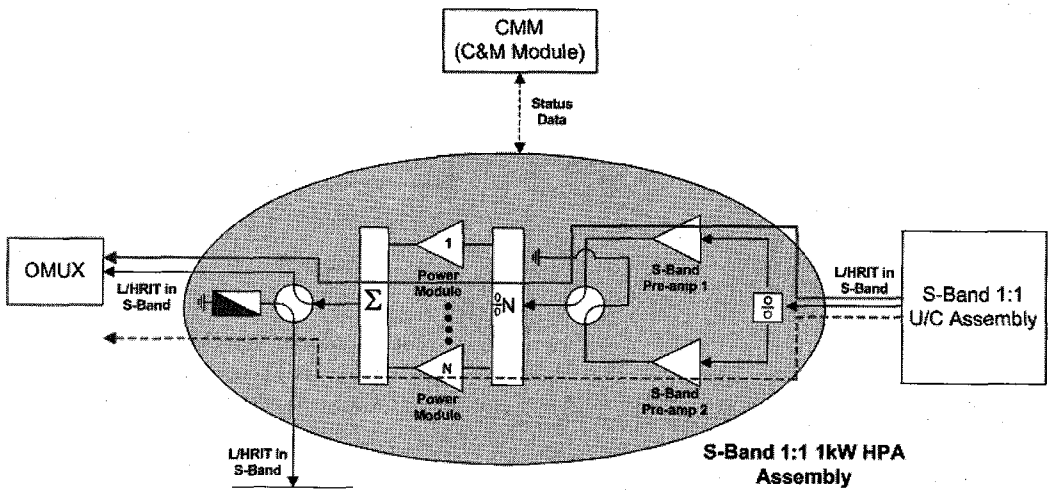

Figure 3 Configuration of S-Band 1:1 1kW SSPA

Considering loss between ground station and satellite, the strength of EIRP is decreased as PFD value. A loss

5. ESTIMATION OF MAXIMUM SSPA OUTPUT POWER

Non-linear equipments like S-Band 1kW SSPA generates various harmonics when two signals are fed into them, simultaneously. These harmonics can be deleted by using filter. However, it is very difficult to eliminate 3rd element because it is located near the wanted signal, which is expressed as IMD (Inter-Modulation Distortion). In receiver, this undeleted element acts as a noise signal, therefore, the receiving performance is worse. MODCS which is in charge of receiving HRIT and LRIT released that the IMD needs to be less than -25 [dBc]. Generally, IMD is worst at the operating point of maximum output power of SSPA whereas it makes no problem when the output of SSPA is small. To estimate IMD, it is best way that two signals are fed to practical SSPA, but unfortunately, SSPA for COMS has not developed yet. Hence, the modelled SSPA is needed. Table 2 shows the requirements of SSPA, which are related to IMD.

Table 2 Specification of SSPA

Items	Specifications
Nominal Linear Gain	≥ 60 dB
Gain Adjustment	≥ 20 dB by 0.5 dB Step
Gain Flatness at 3 dB OBO (Output Back-Off)	≤ 0.4 dBp-p (2037 – 2044MHz)
Output Power at P1 dB	≥ 1000 W
IM3 Products at 3 dB OBO	≤ -26 dBc
Spurious at 3 dB OBO	≤ -60 dBc
RF Sampling Port	≤ -80 dBc
In/Output Return Loss	≥ 17 dB

According to specification in table 2, it can be figured out the input level of P1dB point is 0 [dBm] and output level is 1 [kW] (=60 dBm). The P1dB characteristics oof modelled SSPA is shown in figure 5.

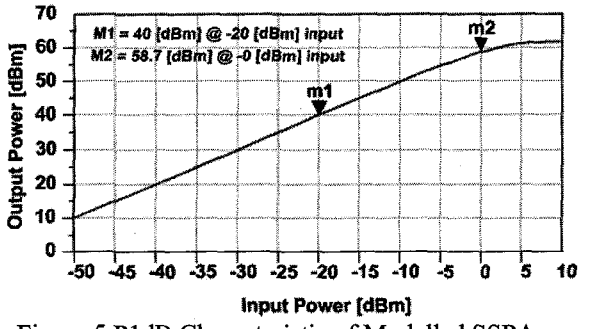

Figure 5 P1dB Characteristic of Modelled SSPA

The 3rd order harmonic's frequency can be estimated when HRIT and LRIT are fed into SSPA, simultaneously.

- lower 3rd order hamonic's frequency: 2×2037.64 – 2040.9 = 2034.38 [MHz]
- upper 3rd order hamonic's frequency: 2×2040.9 – 2037.64 = 2044.16 [MHz]

When HRIT and LRIT are amplified with minimum output of SSPA, 47.08 [dBm], the IMD characteristics is shown in figure 6.

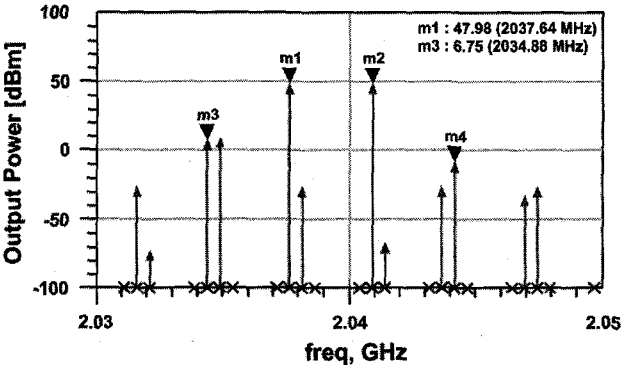

Figure 6 IMD at Minimum Output Power of SSPA

IMD seems to be about -40 [dBc] at minimum output power to transmit HRIT and LRIT. Definitely, this IMD satisfies with the requirements of MODCS. Table 3 shows the summarized IMD characteristics as increasing the output power.

Table 3 Relation between IMD and SSPA Output Power

Output Power [dBm]([W])	Lower IMD (m1-m3) [dBc]	Upper IMD (m2 – m4) [dBc]
47.98 (62.806)	-41.226	-57.061
49.02 (79.721)	-38.970	-58.807
49.94 (98.648)	-36.907	-47.668
50.85 (121.506)	-34.830	-41.986
51.73 (148.782)	-32.736	-37.821
52.57 (180.817)	-30.624	-34.359
53.38 (217.653)	-28.492	-31.292
54.13 (258.822)	-26.343	-28.470
54.82 (303.092)	-24.184	-25.817
55.42 (348.296)	-22.036	-23.304

The available maximum output of SSPA is about 250[W] for HRIT or LRIT when IMD is satisfied with the requirement of satellite.

6. CONCLUSION

For the transmission of HRIT and LRIT, the procedure to estimate the range of SSPA output power is described in this paper. At first, the needed EIRP of ground station

was calculated from the minimum PFD required by MODCS in satellite. The minimum output power of SSPA, 47.08 [dBm] for HRIT or LRIT was estimated by subtracting EIRP with antenna gain and other passive loss. The maximum output power for each user's data was computed by using modelled SSPA. When the output for HRIT or LRIT is less than 250 [W], the generated IMD is within the requirement of MODCS. The minimum and maximum output power of SSPA will be updated when real test is performed with practical SSPA in the future.

7. REFERENCE

[1] Park, D. J, et. al, 2006, Analysis on spectrum for COMS user data, *Proc. KSRS'2006 Spring Conference*, Deajeon, pp. 377-380