THE RELATION BETWEEN HPA AND COMS MULTI-CARRIER

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ABSTRACT:

The relation between HPA (High Power Amplifier) and COMS (Communication Ocean Meteorological Satellite) multi-carrier is analyzed in this paper. MODAC (Meteorological and Ocean Data Application Center) has a primary mission to transmit processed data, HRIT (High Rate Information Transmission) and LRIT (Low Rate Information Transmission), which is normalized and calibrated by pre-processing. It is also replaced with the SOC (Satellite Operation Center) in emergency case and can transmit the command and ranging tones for operation of COMS. From the result of simulation with modelled HPA, it is found that the multi-carrier in one HPA can give rise to an inter-modulation which makes harmonic and spurious elements increase in-band. Under the environment of these increased parasitic elements, the degradation of multi-carrier's quality is estimated from the ratio of the amount of noise to total output power of HPA.

KEY WORDS: COMS, HPA, INTER-MODULATION, NOISE

1.INTRODUCTION

COMS launch is expected in 2008. It will be the first Korean geostationary satellite which has three main missions, i.e. satellite communication mission, ocean monitoring mission and meteorological mission. The raw image data generated by the Meteorological Imager (MI) and the Geostationary Ocean Color Imager (GOCI) are downliked in L-Band in real time by the MODCS (Meteo-rological and Ocean Data Communication System) function to the ground segment, Meteorological/Ocean Data Application Center (MODAC), which is the primary Data Processing Center (DPC). This center generates calibrated image data as well as derived products and uplinks them in S-Band back to the spacecraft, there again through the MODCS function. Data are then disseminated in L-Band to regional users. Satellite operation, mission planning and monitoring is performed by the Satellite Operation Center (SOC). The MODAC will have also back-up function of the SOC to provide against emergency situation of the primary SOC and the opposite can be possible with the exclusive line for the data exchange and transmission.

In this paper, the relation of HPA (High Power Amplifier) and COMS multi-carrier transmission in emergency situation, for example the operation and data dissemination are accomplished in SOC or MODAC is analyzed. Considering the nonlinearity of HPA, intermodulation and spurious generation are the dominant degradation of power efficient. When several signals having different carrier frequencies are simultaneously present in a HPA, the result is a multiplicative interaction between the carrier frequencies which can produce signals at all combinations of sum and difference frequencies. The energy apportioned to these spurious signals (Intermodulation products) represents a loss in signal energy. In addition, if these intermodulation products appear within the bandwidth region of these, the effect is that of added noise for those signals.

Figure 1 illustrates the spectrum of before and after inter-modulation between high and low rate signals in a HPA.

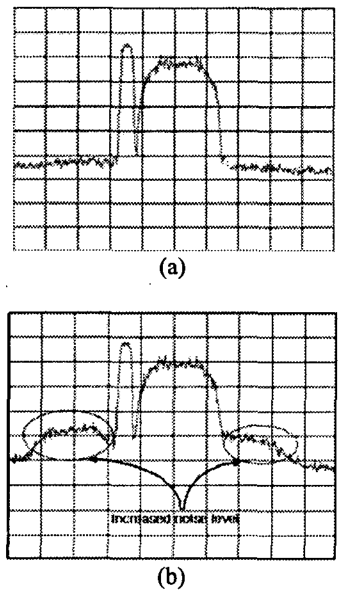


Figure 1. The spectrums before(a) and after(b) inter-modulation

As the noise level is increasing, the power of wanted signal is decreasing and it gives rise to increase the operation point of HPA (High Power Amplifier). Due to the nonlinear characteristic of HPA, the high operation point is also increase spurious level in its in-band.

In the first part, the specification of HPA and verification of its model by using commercial software is illustrated. Then, the parameter of multi-carrier except frequency are summarized, which are based on SRR (System Requirement Review) held on 13-14 June 2005, in Toulouse. Finally, the intermodulation of multi-carrier and the effect of link between spacecraft and ground station are showed.

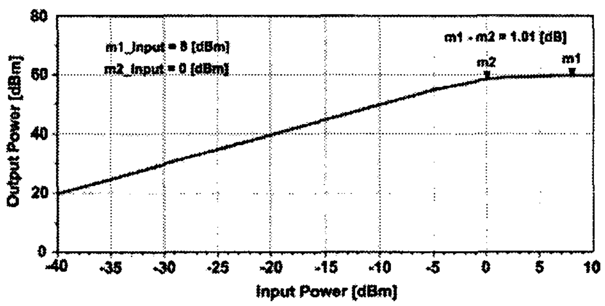
2.HPA MODELLING

Table 1 summarizes the electrical specifications of HPA (TBD, To Be Defined).

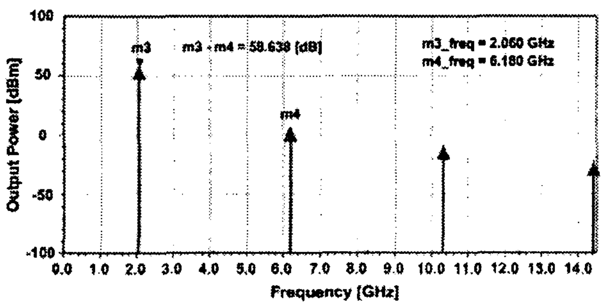
Table 1. The electrical specifications of HPA

Parameter	Value	Units
Frequency Range	2010 - 2110	MHz
Gain at maximum setting	60	dB
Gain Flatness at 1 dB Compression (P_{1dB})	1	dB
Power Output P_{1dB}	1000	W
Two-tone intermodulation at 3 dB Back-off	-25	dBc
Second Harmonic at P_{1dB}	-55	dBc
Spurious at P_{1dB}	-55	dBc
AM/PM conversion at P_{1dB}	5	°/dB
Input/Output VSWR	1.35/1.5	

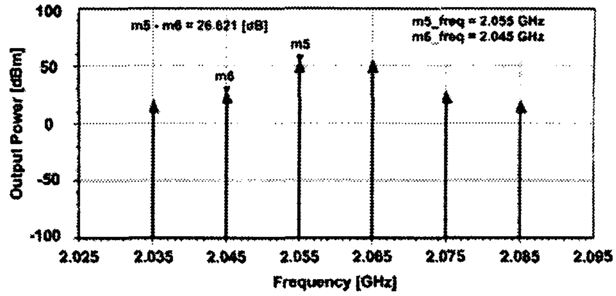
The frequency range complies with the ITU recommendations, so the all carrier frequencies are located in it. Considering 0 [dBm] as the input power of HPA, the gain at maximum setting ensures the 1000 [W] of power output at 1 [dB] compression. When two tones with difference frequencies are simultaneously present in a HPA, the product of intermodulation has a -25 [dBc] difference with carrier power. Figure 2 illustrates the characteristics of modelled HPA.



(a) P_{1dB} Point



(b) Harmonic Response



(c) Two-tone Intermodulation

Figure 2. Characteristics of modelled HPA

P_{1dB} point is indicated at 0 [dBm] of input power from Figure 2(a). The in-band carrier frequency with 0 [dBm] input generates the 3rd harmonic which is satisfied with specification of Table 1. Figure 2(c) shows the intermodulation response by using two signals with a frequency gap of 10 [MHz]. It is also agreed to the specification of Table 1.

3.MULTI-CARRIER

Table 2 summarizes the parameters of COMS multi-carrier based on the SRR outcomes.

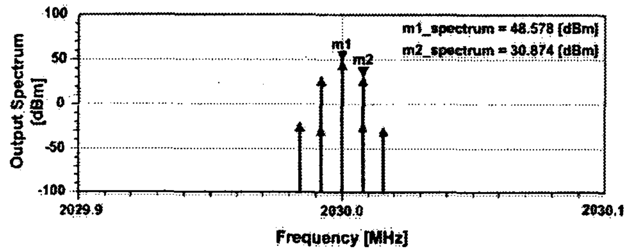
Table 2. The parameters of COMS multi-carrier

Parameter	Processed Data	Command and Ranging
Frequency [MHz]	TBD between 2025 and 2110 - The spacing between H/LRIT is less than 15 MHz - HRIT (QPSK) - LRIT (BPSK)	TBD between 2025 and 2110 - Subcarrier (8 kHz) - ESA-tone Ranging - Modulation index (1.4)
Output Power [dBm]	HRIT (50) LRIT (50)	Command (57) or Ranging (57)
Bandwidth [MHz]	HRIT (6) LRIT (1)	1

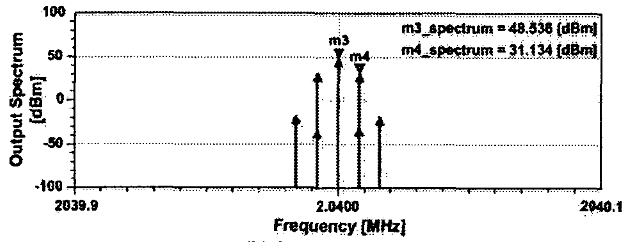
As written in Table 2, the frequency is not fixed yet, so this part will be updated when the specific frequency is released. Especially, the command and ranging has a sub-carrier modulation so, the former is located at 8 KHz from the center frequency and the latter is located at 100 KHz for major tone and 20 KHz for minor tones. The modulation index of them is 1.4 radians. The output power is 100 [W] for HRIT and LRIT each and 500 [W] for command and ranging. Due to the QPSK for HRIT and BPSK for LRIT, the bandwidth is 6MHz for the former and 1MHz for the latter. The sub-carrier modulated command and ranging has 1MHz of bandwidth.

4.INTERMODULATION OF MULTI-CARRIER

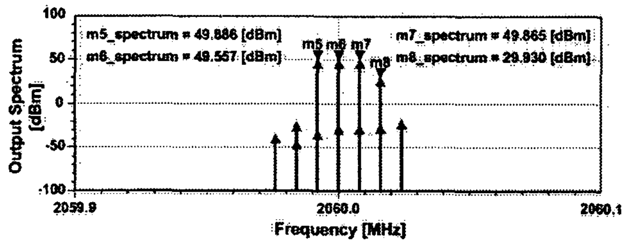
In this paper, the frequencies of multi-carrier is discretionary selected as 2030 [MHz] for LRIT, 2040 [MHz] for HRIT, and 2060 [MHz] for Command or Ranging. Figure 3 illustrates the products of intermodulation in each carrier's bandwidth.



(a) LRIT



(b) HRIT



(c) Command

Figure 3. The output spectrum of intermodulation products

Considering the unwanted signal as noise, the C/N_{uplink} is calculated as written in Table 3.

Table 3. The degradation of link margin by noise

Parameter	LRIT	HRIT	Command
Carrier [dBm]	48.578	48.536	49.865
In-band noise [dBm]	33.874	34.134	29.930
C/N_{uplink}	14.704	14.402	19.935
Degradation of link margin [dB]	0.56	0.739	0.058
Final margin [dB]	5.022	2.596	9.014

From the output of Table 3, HRIT and LRIT is more sensitive to C/N_{uplink} than Command. It results from not only the in-band noise but also COMS G/T, 11 [dB/K] for processed data and -40 [dB/K] for command. Due to the excellent of G/T, the large noise from ground station is dominated to assess noise level at spacecraft.

Figure 4 describes the relation between link margin and C/N_{uplink} for HRIT

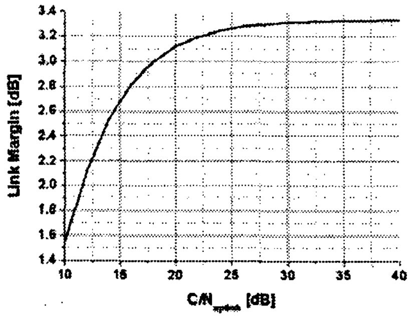


Figure 4. The relation between link margin and C/N_{uplink} for HRIT

To obtain over 3 [dB] of link margin, it is found that C/N_{uplink} needs to be over 20 [dB]. For high C/N_{uplink}, there are so many solutions, for example, by using HPA with high available output or with very good linearity. In this paper suggests using OMUX (Output Multiplexer) which is a kind of filter bank with very narrow bandwidth.[1]

By using OMUX, it is possible to combine the several output power of HPA with considering the pass-band loss which is less than 0.5 [dB]. So, the processed data and command can be isolated by two HPAs, the one is connected to the former and the other is connected to the later. In that case, the products of intermodulation between HRIT and LRIT in one HPA is about -25[dBc], so the link margin is obtained as over 3 [dB]

5.CONCLUSION

Considering the multi-carrier in one HPA, intermodulation and its products, spurious is analyzed by commercial simulator. In the case of COMS multi-carrier in one HPA, the C/N_{uplink} of HRIT is 14.402 [dBc], which causes link margin to be under 3 [dB]. To overcome the degradation by intermodulation of multi-carrier, OMUX is proposed in this paper. By using OMUX, it is possible to separate the multi-carrier with its related HPA. The detailed design of OMUX will be written when the frequencies of COMS multi-carrier are released.

6.REFERENCE

[1] Gerard Maral and Michel Bousquet, 2003. *Satellite Communications System*, John Wiley and Sons, LTD., The Atrium, Southern Gate, Chichester, England.