

Performance Evaluation of DVB-S2X Satellite Transmission according to Sharp Roll off Factors

JongKeun Lee*, **, DaeIg Chang**

*Department of Mobile communication & Digital Broadcasting Engineering

Korea University of Science & Technology (UST), Daejeon, KOREA

**Electronics and Telecommunications Research Institute (ETRI), Daejeon, KOREA

jklee01@etri.re.kr, dchang@etri.re.kr

Abstract—Frequency usage is steadily increased according to growth in communication services. Researchers develop communication technologies to get an additive spectrum efficiency on this account. ETSI also upgrades existing DVB-S2 standard to meet increased frequency usage. The new standard, DVB-S2X, offers sharp roll off factor values to gain spectrum efficiency in satellite communication systems. In this paper, we experiment IF loopback and satellite tests to check validity of DVB-S2X roll off factors. Those tests used by the geostationary Cheonrian satellite. The test results show that 5% roll off factor offers about 14% spectrum efficiency gain, though threshold Es/No has loss of values about 0.3dB than 20% roll off factor value. We conclude that low roll off factor values in the DVB-S2X is effective in the real satellite communication environment.

Keywords— Satellite communication, Broadcasting, DVB-S2X, Roll off factor, MODCOD.

I. INTRODUCTION

Recently, wireless communication technologies have a goal of an efficient transmission in environments with limited resources. Especially, frequency is a limited resource and many researchers suggest various technologies to get high spectrum efficiency. Likewise, achievement of this goal is required in a field of satellite communication. To meet the requirement, European telecommunications standards institute (ETSI) suggests new satellite communication standard in March 2014. This standard is digital video broadcasting second generation extensions (DVB-S2X) [1].

The DVB-S2X is an extended technology based on DVB-second generation (DVB-S2) [2]. The DVB-S2X standard is added additive modulation and coding (MODCOD)s, sharp roll off factor (ROF)s. As a result, DVB-S2X has improved efficiency by up to 51% professional applications and 21% direct to home networks compared DVB-S2 [3]. Furthermore, this technology promotes high spectrum efficiency due to sharp ROF. Sharp ROF reduces carrier spaces and interferences between different networks in a same transponder [3]. However, sharp roll off factor has disadvantages. The low ROF value increases a nonlinear channel loss due to inter symbol interference (ISI) [4]. Bit error rate (BER) performances are reduced by ROF in an existed phase noise and sampling time jitter [5]. [6]. Especially, effect of group error is expended in

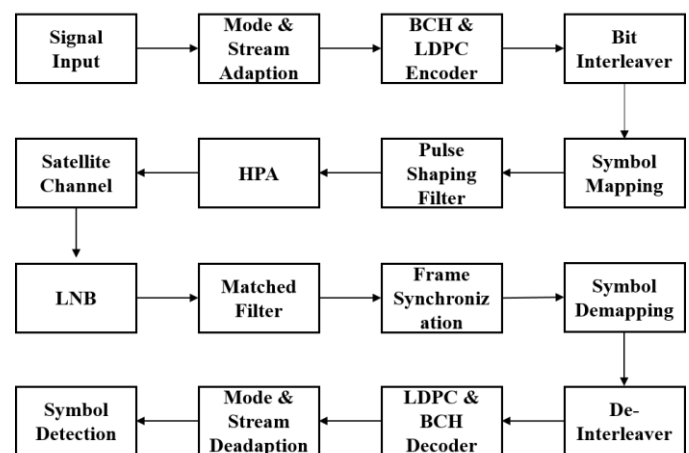


Figure 1 DVB-S2X Block Diagram

the Ka-band communication system [7]. So, the satellite transmission is weaker in ISI effect than other communication.

Although a spectrum efficiency based on ROF in the satellite communication system is a very important factor, there has been minimal research about this. In [8], [9], there are BER performance simulations in the DVB-S2 system. Those simulations are shown by various MODCODs but a variation of ROF values is not included. Also, performance results consist of just MATLAB simulation results. There are measured results in the real satellite communication system in [7], [10], [11]. In [10], field experiment results are provided but those results do not include the effect of diverse ROF values. In [7], there are frame error rate (FER) performances in the DVB-S2 and DVB-S2 extension satellite communication systems having 0.05, 0.35 ROF values. However, those papers are not included the latest DVB-S2X standard. The DVB-S2X performance based on different ROF values are shown in [11]. Conversely, this performance is based on only one MODCOD.

In this paper, we show IF loopback tests and field measurements used the geostationary Cheonrian satellite. We confirm that the DVB-S2X satellite communication system is efficient from test results. Also, minimal energy per noise power spectral density (Es/No) following as various ROF and MODCOD values are represented by this experiment. The paper is organized as follows. In section II, background about

the DVB-S2X satellite communication system is presented. Test results and experiment procedures are shown in section III. Finally, we conclude the DVB-S2X communication system in section IV.

II. BACKGROUND

This section shows the DVB-S2X satellite communication system. Figure 1 displays the DVB-S2X system block diagram. Then we explain differences between DVB-S2X and DVB-S2. DVB-S2X additions are as follows [2]:

- Increase the number of modulation for high SNR such as 64, 128, 256 amplitudes phase shift keying (APSK). Those MODCODs improve the data rate of satellite communication system.
- Increase the number of code rate for diverse communication environments. Code rate numbers which are included DVB-S2 MODCOD is increased
- Very low MODCODs are added. Those MODCODs support mobile communication systems.
- Due to additive low ROF, for instance 5%, 10% and 15%, the carrier space is declined. The DVB-S2X system gets increased spectrum efficiency on this account.

As a result, DVB-S2X system has implemented performances compared to the DVB-S2 system.

The DVB-S2X standard gives sharp ROF. Therefore, occupied bandwidth is decreased. Allocated bandwidth value based on ROF values is shown by

$$\text{Bandwidth} = (1 + \alpha)R_s \quad (1)$$

where α is the ROF value and R_s is the symbol rate. Also, a bit rate value is given by

$$R_b = \frac{k * R_s * N_D * N_s * (K_{BCH} - N_{BB})}{\left(N_D * (N_s + 1) + N_p * \text{int} \left(\frac{N_s - 1}{S_p} \right) \right) * N_{LDPC}} \quad (2)$$

TABLE 1. SPECTRUM EFFICIENCY OF VARIOUS MODCODS

MOD COD	ROF	Rs [Mps]	Band width [MHz]	Rb [Mbps]	Spectrum Efficiency [bps/Hz]
3/4 8PSK	0.2	30	36	65.3	1.815
3/4 8PSK	0.1	32	35.2	69.7	1.980
3/4 8PSK	0.05	34	35.7	74.0	2.074
13/18 8PSK	0.2	30	36	62.9	1.747
13/18 8PSK	0.1	32	35.2	67.1	1.906
13/18 8PSK	0.05	34	35.7	71.3	1.997
3/5 16 APSK	0.2	30	36	69.4	1.928
3/5 16 APSK	0.1	32	35.2	74.0	2.103
3/5 16 APSK	0.05	34	35.7	78.7	2.204

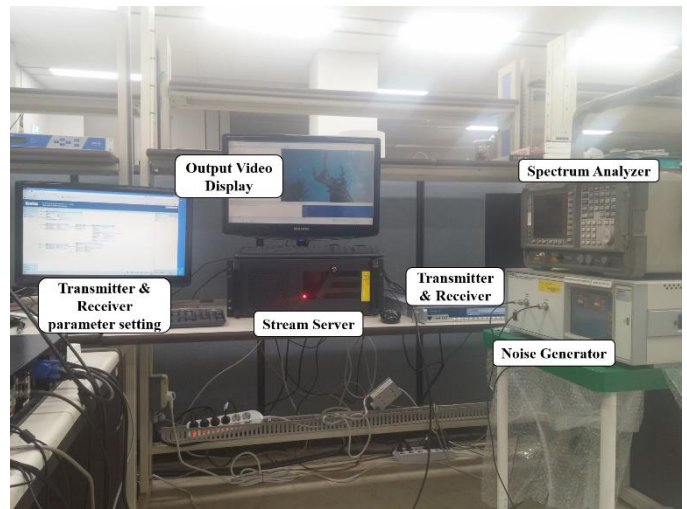


Figure 2 Laboratory Environment

where R_b is the bit rate, k is a modulation index, N_D is a number of data symbol, N_s is a slot number, K_{BCH} is a Bose Chaudhuri Hoc Quenghem (BCH) code uncoded block bit numbers, N_{BB} is a baseband (BB) header number, N_p is a pilot number, $\text{int}(\cdot)$ is a quotient and N_{LDPC} is a low density parity check (LDPC) code block number. N_p value is zero in case of a transmission signal without the pilot symbol. Let the spectrum efficiency from bandwidth and data rate values be represented by

$$\text{Spectrum Efficiency} = \frac{R_b}{BW} = \frac{R_b}{(1 + \alpha)R_s} \quad (3)$$

For example, the code rate is 3/4, the modulation is 8PSK, the ROF value is 20% and symbol rate is 30Mps. This communication system is allocated $30M * (1 + 0.2) = 36\text{MHz}$ bandwidth. Also, the bit rate value is about 65.3Mbps in the system with the pilot signal. In case of non-present pilot, this system has 66.8Mbps data rate. 65.3Mbps bit rate value divides by 36MHz bandwidth, we get 1.815bps/Hz spectrum efficiency value. Table 1 shows spectrum efficiency values of various MODCODs system with pilot signal.

III. SATELLITE COMMUNICATION TEST

In this section, we introduce measurement processes and measured results. We use geostationary Cheonrian satellite to obtain field measurement results. This test is based on DVB-S2X standard MODCODs and roll off factors. We measure minimal E_s/N_0 when video streams are displayed properly.

A. Measurement Process

The satellite experiment process is following steps:

- ① A 4k source stream generator inputs 4k transport stream (TS) video stream into a modulator.
- ② The NEWTEC MDM6100 modulates stream signals such as 8 phase shift keying (PSK) and 16 APSK. Also, this equipment sharpens input signal pulses through a root raised cosine (RRC) filter.
- ③ Shaped signals are transmitted by the Cheonrian Ka-band satellite. Those signals via satellite are received by a ground antenna.

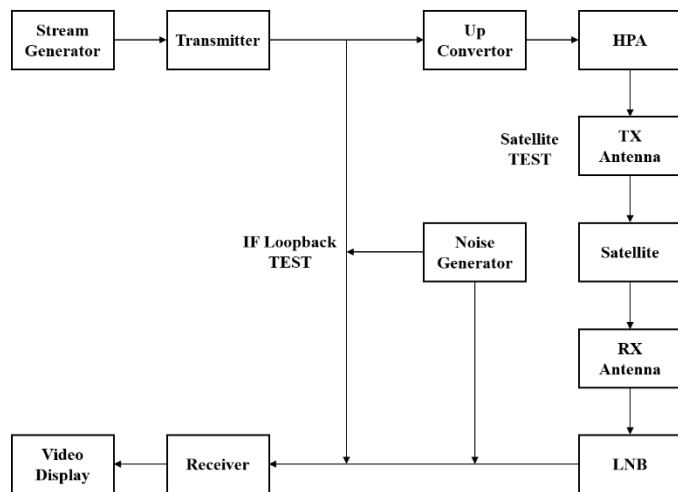


Figure 3 Measurement Process

- ④ A Noisecom UFX7110A, a noise generator, makes additive white Gaussian noise (AWGN) signals. Received signals are added to noise signals.
- ⑤ After signals pass through a matched filter, MDM6100 demodulates those signals
- ⑥ A moving picture experts group (MPEG) analysis & video display unit shows video.
- ⑦ We control AWGN values until non-present error of video output. Therefore, we measure threshold received Es/No.

In addition, we experiment IF loopback test. IF loopback test excludes satellite link and connects directly between modulator and noise generator. Thus, this test process described above except process ③. We obtain different minimal SNR values for the video display via satellite link a by two tests. Those test devices are shown by figure 2. Also, figure 3 represents IF loopback and satellite communication test processes.

B. Measurement Results

We experiment IF loopback and satellite communication tests as described above. Those communication systems are affected by power and bandwidth limitations. Therefore, we assure that limited bandwidth is 36MHz. We also assure that limited ideal Es/No is 8dB value. Test MODCOD parameters have those conditions. Therefore, we set 3 MODCODs, 3 ROF values. Those parameter is shown by Table 1. Other parameter values are set by DVB-S2X standard [2]. Transmission frames

TABLE 2. DVB-S2 3/4 8PSK TEST RESULTS

ROF	TEST Results			
	Ideal Es/No	IF loopback	Ideal Es,sat/No	Satellite
20%	7.91dB	8.1dB	8.86dB	9.3dB
10%	7.91dB	8.1dB	8.86dB	9.4dB
5%	7.91dB	8.1dB	8.86dB	9.5dB

TABLE 3. DVB-S2X 13/18 8PSK TEST RESULTS

ROF	TEST Results			
	Ideal Es/No	IF loopback	Ideal Es,sat/No	Satellite
20%	7.49dB	7.6dB	8.42dB	8.9dB
10%	7.49dB	7.7dB	8.42dB	8.9dB
5%	7.49dB	7.7dB	8.42dB	9.1dB

are the normal frame and we use pilot signals. In case of 3/4 8PSK tests, we use DVB-S2 standard to compare DVB-S2X standard but those tests use DVB-S2X ROF values.

Table 2 shows that IF loopback and satellite tests through ROF where ideal Es/No value is described the DVB-S2 standard and we estimate an ideal Es,sat/No value based on the DVB-S2X standard. The MODCOD in this system is 3/4 8PSK. At first, IF loopback test results show that measured Es/Nos are same value to display normally in contrast with diverse ROF values. Those results also have 0.2dB different values between ideal Es/No and measured Es/No. This is because each communication equipment has noise and loss values. However, satellite test results are different Es/No values according to ROF values. The sharper satellite system has the ROF value, the more this system is affected by ISI. Through each required Es,sat/No values increase about 0.1dB in accordance with ROF values, each system improves about 6% data rate and 4.7~9% spectrum efficiency values. Also, satellite test results have more different values between ideal Es,sat/No and measured Es,sat/No than IF loopback test because center frequency is converted.

Table 3 indicates two test results. This system is conducted by DVB-S2X 13/18 8PSK. Ideal Es/No and Es,sat/No values are based on the DVB-S2X standard. This system uses the different code rate compared table 2. Ideal threshold Es/No and Es,sat/No are reduced in proportion to declined code rate. Furthermore, each bit rate value is decreased on this account. Thus, each bit rate is down about 4% from the table 2. However, demanded Es,sat/No values also is declined by about 0.5dB. The IF loopback test results display different 0.2~0.3dB values compared ideal Es/No and measured Es,sat/No. The satellite test results appear different 0.5~0.7dB values between two

TABLE 4. DVB-S2X 3/5 16APSK TEST RESULTS

ROF	TEST Results			
	Ideal Es/No	IF loopback	Ideal Es,sat/No	Satellite
20%	7.80dB	8.2dB	9.38dB	9.5dB
10%	7.80dB	8.2dB	9.38dB	9.5dB
5%	7.80dB	8.2dB	9.38dB	9.8dB

values.

Table 4 is used DVB-S2X 3/5 16APSK. 16APSK modulation has higher bit rate than 8PSK. However, each signal distance is closer to different signals than 8PSK. Therefore, error rate is increased. This system has small ideal E_s/N_0 value compared 3/4 8PSK. Nevertheless, a 3/5 code rate value in this system offers less ideal E_s/N_0 than 3/4 8PSK system. On the other hand, measured E_s/N_0 is large values in the IF loopback test. This is because the 16APSK modulation is composed of two concentric rings [1]. This causes increased nonlinear amplifier distortions. Therefore, the different value between ideal E_s/N_0 and required E_s/N_0 is about 0.4dB.

IV. CONCLUSIONS

In this paper, we experiment tests according to various MODCODs and roll off factor values in the DVB-S2X standard. The satellite communication system used sharp roll off factor is strongly affected by ISI. We also confirm a ISI effect in real satellite communication system. IF loopback test results show that measured E_s/N_0 s are little different values according to ROF values. However, satellite test results show about 0.3dB different E_s/N_0 depending on ROF values. Thus, the low ROF value offers loss of threshold E_s/N_0 but this value offers 14.3% spectrum efficiency and 13.3% bit rate gain in the limited bandwidth and power environment. As a result, sharp roll off factor values in the DVB-S2X standard provide effective transmission in the real satellite system.

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JongKeun Lee received the B.S. degree in Electronics and Radio engineering from the Kyunghee University in 2015 Yongin, Korea. He is currently working towards his M.S. degree in Mobile communication & Digital broadcasting engineering at the Korea University of Science and Technology (UST) in Electronics and Telecommunication Research Institute (ETRI) campus, Daejeon, Korea. His research interests are in the area of digital communication.



Daelg Chang received his B.S. and M.S. degrees in Electronics and Telecommunications Engineering from Hanyang University, Seoul, Korea, in 1985 and 1989, respectively, and Ph.D. degree in Electronics Engineering from Chungnam National University in 1999. Since February 1990, he has worked in Satellite Broadcasting and Communications Research Section of ETRI as a Principal Research Staff. From June 1991 to July 1993, he worked as a Member of Research Staff with MPR Teltech Ltd, Vancouver, Canada, where he was involved in developing VSAT systems. Since February 2005, he has been a Chief Major Professor in Mobile Communication and Digital Broadcasting Engineering, University of Science and Technology, Daejeon, Korea. His research interests are digital communications, broadband satellite broadcasting systems, channel adaptive digital modem design, and channel coding.