

# A Simulation on HAM Band Frequency Interference in VDSL Subscriber Line

Duck Je Park\*, Sang Yep Nam\*\*, In Jung Park\*\*\*

\* Dept. of Electronics & Computer Engineering, Dan-Kook University, Seoul, 140-714, Korea  
Tel : +82-41-550-3544 Fax : +82-41-3544 E-mail: [digitallab@kornet.net](mailto:digitallab@kornet.net), E-mail: [fly21c@airport.co.kr](mailto:fly21c@airport.co.kr)

\*\* Dept. of Information & Computer, Kyungmoon college, PyoungTaek, 459-070, Korea  
Tel : +82-11-662-3536 Fax : +82-41-3544 E-mail: [r13337@unital.co.kr](mailto:r13337@unital.co.kr)

## Abstract:

In this paper, data rate of VDSL system was analyzed in RFI(Radio Frequency Interference) environment. This Paper used Various "VDSL Test Loop" suggested by ANSI DSL Standard group T1E1.4. Many parameters, "Noise Model A", "Noise Model F" and KARL-HAM band are used for more accurate results of the simulation. Most of conditions for simulation are followed to the ANSI Standard "Spectrum management". Many results have been calculated according to the different conditions of the test loops in simulation. Simulation results confirm that using shaped PSD mask to reject RFI is one of factor to decrease the performance of VDSL systems.

## 1. INTRODUCTION

DSL(Digital Subscriber Line) is technology to use a frequency band or above which POTS(Plain Old Telephone Service) uses in order to use it for high-speed data communication. VDSL(Very high-bit-rate Digital Subscriber Line) is the technology that the draft which can be transmitted to it by the maximum 52 Mbps when twisted-pair line(TP,UTP) is used with one kind, and asymmetric is transmitted in theory of DSL technology is deceived, and is used to a communications net. The VDSL which is the next generation subscriber network technology that can consider a technical alternative to take charge of the following level is asked, and it is [1,2] Because VDSL to transmit high-speed data for

next generation multimedia communication uses a frequency band of 1 MHz or above and UTP, a lot of problem occurs. In this paper, KARL-HAM band are used for more accurate results of the

simulation. and the PSD (Power Spectral Density) which formed notch in order not to be affected about RFI(Radio Frequency Interference) influx is used, and Matlab tool is used with VDSL transmission ability, and a computer simulation is going to be done.

## 2. VDSL CHARACTERISTIC

A distance with a subscriber is limited by a 1.5Km (5 Kft) degree in order to transmit high speed data from the telephone track for composition a VDSL network .

A short distance (300m), a middle distance (0.9km), long-distance (1.35km), specify three kinds of distances in ANSI, and it is [4]. Generally there is two kinds of loop structure, the first is a case for a subscriber to be located in 1.5km ,in this case, a lot of Subscriber joint straightly to Central Office(CO) or Local

Exchange(LEx). The second is a case for a subscriber to be located in 1.5km or above with FTTCab (Fiber-To-The-Cabinet). An optical cable is connected to ONU(Optical Network Unit) from CO, LEx, and the existing telephone track is used to a subscriber from ONU. After optical signal transmitted through an optical cable converted into an electric signal from ONU , it becomes Demultiplexing in order to be send a subscriber ,and ONU serves in about dozen of subscriber Also, ONU carries out a function which convertes received data from a subscriber as an optical signal through Multiplexing in order to transmit it a network, and it is [7]

### 2.1. VDSL system reference model

It is reference model as block diagram showing a VDSL system with picture 1, and it is [4,5]. VTU-O(VDSL Transceiver Unit at Optical network unit) is an ONU side, and VTU-R(VTU at Remote) means a subscriber side. VTU-O changes a VDSL signal to come from continuous-time physical-layer in interface into a digital signal, and, on the other hand, VTU-R(RT) exchanges a signal to be delivered from continuous-time physical-layer in interface for a digital signal. VTU-R is connected with one application equipment.

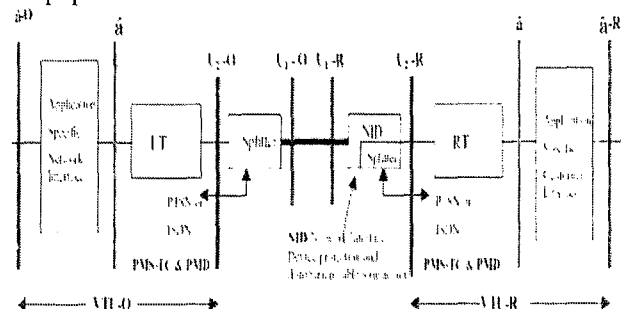


fig.1. VDSL system reference model

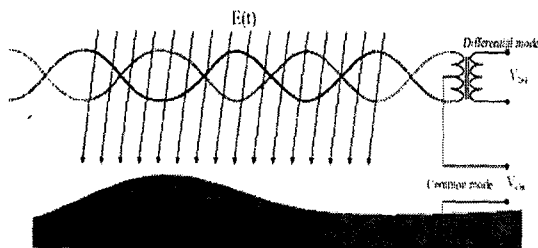
LT : Line termination, RT : Remote termination

It is DS, and data transmission is made VTU-R n VTU-O on a reference model, and the objection is US.

Generally it is upstream(US), and a downstream( DS), transmission direction does the case that is CO, LEx or ONU in a subscriber modem with the case that is Subscriber modem (NT, Network Terminal ) in CO, LEx or ONU a data transmission direction.

## 2.2 . Noise source

In noise source, a factor there is a Radio Amateur RFI, AM/SW Broadcast RFI, impulse noise back in RFI, and signal attenuation of a channel is caused, and to drop a transmission speed is become. It has VDSL to use a frequency band by 20 MHz, and a frequency of radio systems is becoming an allotment to frequency band which VDSL is using. A problem about spectral compatibility of VDSL and a radio system occurs by this. RFI occurs problem because UTP Receives or transmits a radio signal as a huge common mode(CM) antenna.



picture 2. priceful of RFI ingress

Picture 2 is the picture which looks whether a voltage between TP and the grounds is how, and it is flowed on inductance in electromagnetism field changing according to time by TP. A voltager generates on a two line of TP intensely equally at this time, and it is a common mode signal. On the other hand, VDSL transmits and receives a signal with differential mode(DM). Let you countervail the voltage how you twist each other two them, and am induced a voltage of the strong objection polarity that is equally led from another line in twisted 2, one between them. In this way partly differential mode RFI is removed in the 2 that I am twisted, and there is. If a track cannot completely achieve balance, a CM signal is converted into a DM signal. For this reason, if the VDSL system cannot be kept, a CM-to-DM signal is converted into a DM signal. As frequency increase, balance decreases, and it is easily accepted RFI if it is used TP as this reason in a high frequency. It is a HAM (amateur radio) transceiver in the largest element of RFI, and it happens the problem if a TX power is a 50 w~1.5Kw degree, when it approaches a telephone line with several M. on the other hand, a HAM transceiver user uses often exchange a frequency, and it transmits signal with SSB in most. If a frequency band width defined in a frequency band station of the HAM which VDSL offered in ANSI please be used, and you are become, a HAM frequency band station is influenced. Use about HAM substitution (out-of-band) is limited in a VDSL system in this. As for the DMT VDSL system, a HAM band can prevent RFI effluence with what do not use Sub-channel so that passage frequency band (138 KHz~12 MHz) of defined VDSL overcomes this with a HAM band and a 4 place being

piled, and a filter about a frequency band is used in 4 in QAM VDSL, and notch is formed. In addition to some each other a HAM substitution used in North America and Europe || there is a difference, but a design of -80 dBm PSD mask letting limit it below (a depth of QAM : notch filter, -20 dBm) asks Maximum transmit power, of the part where a transmitting department of a VDSL system to stand in order to solve a RFI effluence problem to influence HAM from VDSL in ANSI and ETSI is piled up with a HAM frequency band and PSD, and is [1]. Also, performance of VDSL can be improved by a HAM frequency band is the only or using Sub-channel only for 2 in the place where does not have an influence of HAM by a selection refusal mode, and it is [6].

## 3. EXPERIMENTATION ENVIRONMENT

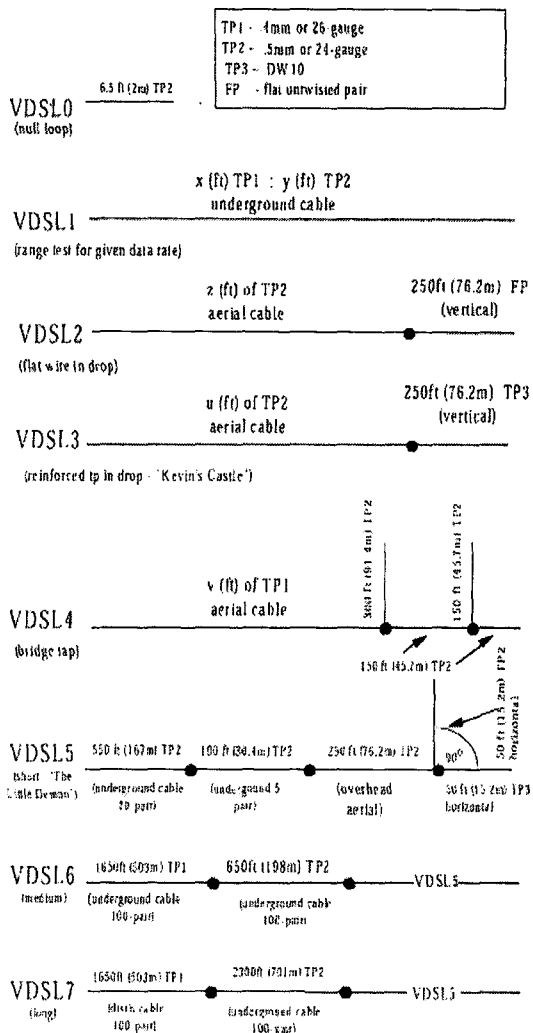
### 3.1. Simulation tool and environment

The VDSL test loop which was offered to ANSI DSL Standard Group T1E1.4 in order to measure VDSL transmission ability in this paper was used as a basis. The application about a line code way calculated a transmission speed of "the VDSL-DMT" which applied "VDSL-theo" and the DMT way that applied a way to calculate it according to theory, and FSAN "Noise model A" and "Noise mode F" were considered for experimentation about configuration of a more complexed VDSL system. PSD Mask was formed in order a frequency band to employ in amateur wireless (HAM) used in korea was applied, and to prevent RFI, and Matlab tool was used, and VDSL transmission ability was calculated through a computer simulation. "XDSL simulation tool 2.01" to provide in "Telecommunications Research Center Vienna" for a simulation of this paper was used. This program is used under a Matlab environment. It was fecundated in several in order to apply this simulation to this paper. first I was fecundated on a HAM frequency band to meet in korea. My source written based on the standard of ANSI was used to a used track, and a characteristic price about attenuation of atrack is input into this source. The duplexing way used FDD to an important environment, and the 998 that was an ANSI standard was used as spectral plan. Also, 4096, ZL=ZS=130 ohm, and WGN are -140 dBm/Hz on the subchannel Wednesday when it was used 4.3125KHz, as a parameter as for the frequency band per a 35.328 MHz, subchannel as for the 10.00%, BER=10-7, Sample rate as for the 11.5 dBm, Efficiency Loss as for the 4.2dB, SNRmax=48dB(11\*3 + (SNR ref + xtalk\_magin-conding gain), Maximum Power as for the 0dB, coding gain as for the 6dB, signal\_margin as for the 9.8dB, xtalk\_margin as for the 5.6dB, SNRref as for the Shannon gap spent on VDSL-DMT.

### 3.2. Test track

A test model of a VDSL transmission channel used for this paper || for a test and an evaluation of the VDSL

system that is proposing it to picture 3 in ANSI T1E1.4 DSL Standard Group like what foretold || "is VDSL Test Loop", and is [4]"



picture 3. VDSL Test Loop (ANSI)

Test loop VDSL 1 applies TP1 (0.4 mm; 26-AWG) and TP2 (0.5 mm; 24-AWG), and, as for the short range, 1000ft(300m), medium-range is showing 4500ft(1,376m) with 3000ft(914m), long-range. Only TP2 of VDSL test loop 1 was applied to experimentation of this paper to a standard track, and three kinds of tracks were used, and the VDSL test loop three kinds that considered an influence of a different kind Cable Core to VDSL 7 to VDSL 5, the total was six and used. The number of the VDSL system which is connected is 25 at this time. The following is a simple comparison matter about each VDSL Test Loop

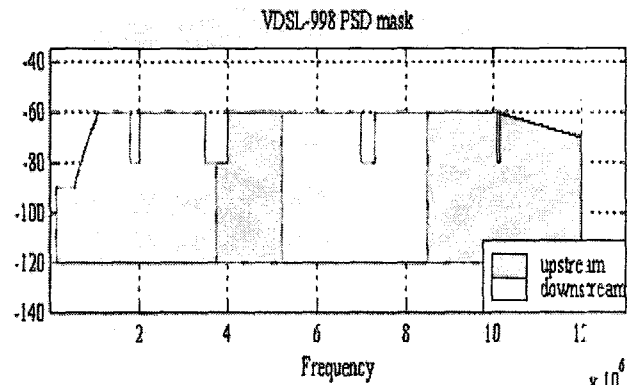
### 3.3. RFI frequency band

A simulation about the speed decrease that was expected if the PSD Mask which formed notch in order to reduce an influence of RFI in this paper was used was done.

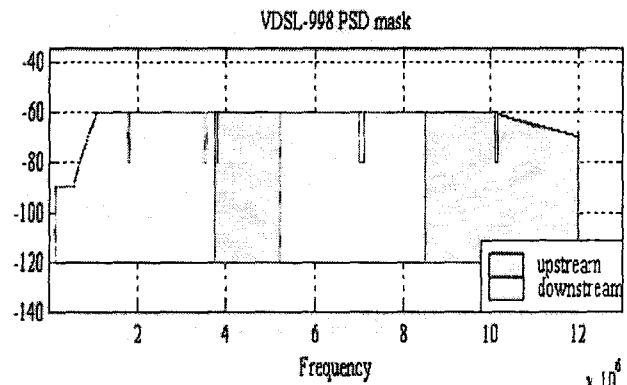
Table 1. Amateur radio bands of KARL-HAM

Standard frequency (MHz)	1.8	3.5	7	10	14	18	21	24	28	
Wave length (m)	160	80	40	30	20	17	15	12	10	
Start frequency (MHz)	1.800	3.500	3.790	7.000	10.100	14.000	18.068	21.000	24.890	28.000
End frequency (MHz)	1.825	3.550	3.800	7.100	10.150	14.350	18.168	21.450	24.990	28.700

Notch based on HAM band defined in ANSI and KRAL(a Korean amateur wireless league) on frequency allotment way 998 with picture and picture 5 can be compared Frequency allotment way 998 and KRAL-HAM were used in this paper, and a simulation was done.



picture 4. ANSI-HAM Band



picture 5. KARL-HAM Band

## 4. RESULT AND EXAMINATION

Use a frequency allotment of KARL-HAM || of RFI || formed notch to a pertinent frequency band in order not to be affected, and calculated a VDSL transmission speed. (table 2) Of the RFI which occurs when use HAM on VDSL-DMT || formed notch in pertinent frequency band in order not to be affected, and

calculated a VDSL transmission speed. Also, test loop of VDSL test loop 1, TP2, short, medium, long and VDSL test loop 5,6,7 was used on "VDSL-theo" and "VDSL-DMT", and met me in domestic misgovernment, and a HAM band specified in KARL was used, and an influence about RFI was measured.(table 3). It was used, and this case calculated a VDSL transmission speed with the PSD which formed notch in pertinent frequency band in order not to be affected of RFI.

Table 2. VDSL transmission speed calculation of using shaped PSD mask to RFI (unit : Mbps)

Line Code			Theory	Simulation Result
RFI Test Loop			KARL-HAM	KARL-HAM
Loop 1 (TP2)	S	DS	36.09	36.23
		US	16.81	16.19
	M	DS	29.14	29.04
		US	9.06	8.08
	L	DS	18.42	17.45
		US	2.80	2.52
Loop 5	DS	39.97	39.82	
	US	19.07	18.85	
Loop 6	DS	23.33	22.41	
	US	4.69	4.49	
Loop 7	DS	12.49	12.13	
	US	0.26	0.00	

Table 3. VDSL-DMT transmission speed calculation (unit : Mbps)

RFI X-talk			KARL-HAM application	
Test Loop			Noise Model A	Noise Model F
Loop 1 (TP2)	S	DS	32.28	23.20
		US	15.84	15.24
	M	DS	24.78	5.52
		US	7.46	1.37
	L	DS	14.07	0.35
		US	2.25	0.00
Loop 5	DS	36.14	26.58	
	US	18.33	17.13	
Loop 6	DS	17.52	0.52	
	US	4.01	0.00	
Loop 7	DS	8.40	0.00	
	US	0.00	0.00	

TP2 : type y, 0.5mm( 24-AWG) Coble Core  
 Total length of Loop 5,6,7 289.56m,990.6m, 1493.52m

If the PSD which formed notch on RFI was used, a speed of VDSL transmission speed measurement results 99.50% was displayed. The following conclusion was able to be got on the in case downstream and upstream which applied Noise Model A, Noise Model F.

1. In speed measurement about downstream
  - An average speed decreases to 83.30% in case of Noise Model A.
  - An average speed decreases to 35.52% in case of Noise Model F.
2. In speed measurement about upstream
  - An average speed decreases to 95.30% in case of Noise Model A.
  - An average speed decreases to 67.14% in case of Noise Model F.
3. On the total speed that I added downstream and upstream to
  - A total speed decreases to an average of 85.96% in case of Noise Model A.
  - A total speed decreases to an average of 43.18% in case of Noise Model F.

## 5. CONCLUSIONS

MATLAB was used in order to evaluate transmission ability of a VDSL system in this paper, and it was done a simulation. Line code way VDSL-theo and VDSL-DMT of line code way were applied for this. VDSL Test Loop 1, TP2, Short, Medium, Long and loop 5, 6, 7 provided in ANSI were used as a used track model. And FSAN "Noise model A" and "Noise mode F" and WGN published in ANSI were applied to an external overhearing noise circle. If the PSD Mask which used notch to use in a DMT way in order to consider a RFI influence to occur in HAM used in korea was used, it had been with an average of 1% all, and that transmission speed decrease was was measured. When VDSL-DMT is applied, and the in case transmission speed that there is not is compared with a case with external interference, On the total average transmission speed that included ocean downstream and upstream if there was not external interference First it is decreased to an average of 86.96% if PSD for notch formation is used for RFI prevention, and Noise Model A was applied. Second I confirmed that decrease worked with an average of 43.18% if PSD for notch formation was used for RFI prevention, and Noise Model F was applied. Principal elements a problem and a speed decrease factor to be able to be happened previously before the results of this study are used, and installing a VDSL system in a network have been lighted up, and to drop a speed remarkably are analyzed, and it may be used for VDSL system development. It is for it to intend for the simulation results about too various temporary forms in this paper that each systems please have the maximum efficiency when DSL service of a different kind coexists with VDSL service in the same cable cluster with a base, and a track is composed. Also this study will do it that is meaningful.

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