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Research paper

Design and Development of an LNB based DVB-S receiver

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Abstract

This paper introduces an LNB-based DVB-S receiver with respect to sync byte detection. The basic configuration of DVB-S for decoding is the major focus of this work, where the main task is to decode the received signal from the satellite with a good SNR. Sync-byte detection is one of the challenges of receiver design. An algorithm is developed to overcome the problems associated with Sync-byte detection which can efficiently perform Sync-byte detection. After decoding the signal, the SNR is found to be 9.62 dB, which represents quiet a good signal. A channel list is identified in the final result.

Keywords: *LNB, STB, PID, DVB, LLR, QPSK, MPEG.*

1. Introduction

DVB-S (Digital Video Broadcasting — Satellite) is an international standard which replaced the analog video broadcasting, is introduced by ETSI (EN 300 421 [1]) and used for digital television transmission and broadcasting by satellite. The structure (EN 300 421 [1]) is constructed to provide direct-to-home (DTH) multi-programme TV services in the (FSS) and (BSS) bands and is addressed to client IRDs, as well as collective antenna systems and cable television head-end stations, with a likelihood of modulation [1,3].

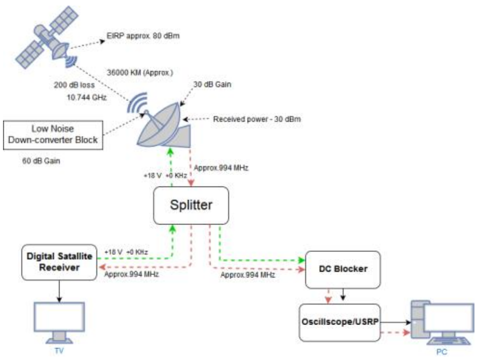

Fig. (1). Basic block diagram of satellite receiver

The progress of digital technologies in production, transmission and emission of TV is rapidly dynamical that established ideas of broadcasting. Providing an attractive package for the various audiences, downloading of multimedia information on the set-top box (STB) for local and navigation, interactive services and electronic-commerce are the main dependency of the success of digital satellite broadcasting [3].

2. System Design Design and Architectural Overview

The system design of DVB-S is a modular structure which is based on independent sub-systems and for this reason; the other DVB systems maintain a high level of community. All the broadcasting systems use a common source coding and multiplexing subsystem, named moving pictures experts group (MPEG)-2 and channel coding and modulation are provided by channel adapters which are particularly designed to enhance the performance on each media. Basically, some facts like sound and picture coding algorithms, service availability etc. are the main dependencies, which ensure the overall quality of a digital TV service by satellites. To achieve the best quality of sound, picture and service continuity, some system optimization is highly recommended [3].

With the development of DVB-S it was possible to broadcast more than one TV channel within one transponder with higher quality. In this work, a DVB-S digital signal should be captured after an LNB and offline decoded in Matlab [4].

This section projects the basic block diagram of a satellite receiver as well as the measurement setup procedure.

Fig.(1). shows the basic system diagram for the satellite receiver. Dish antenna receives the signal from satellite. The basic receiving signal information is given in the TABLE 1 (according to [5]). Signal transmitted from satellite travels approximately 36000 km before it is received by a dish antenna. The dish antenna is connected to a splitter which replicates the signal and sends it to two different blocks. One of the blocks is digital satellite receiver which performs a series of operations to extract video stream from the signal.

TABLE 1: BASIC SATELLITE INFORMATION

Name	Astra 19.2^{0} East	**Transponder**	51 to 106	**Polarization**	H
Frequency	10744 MHz	**Type**	DVB-S	**Symbol rate**	22000KSps
Bit rate	33.79 Mbps	**Modulation**	QPSK	**FEC**	5/6
RRC roll off	0.35				

TABLE II: POLARIZATION OF LNB

Supply		Block		Local oscillator	Intermediate
Voltage	**Tone**	**Polarization**	**Frequency band**	**Frequency**	**Freq. range**
13V	0 KHz	Vertical	10.70-11.70 GHz, low	9.75GHz	950-1950 MHz
18V	0 KHz	Horizontal	10.70-11.70 GHz, low	9.75 GHz	950-1950 MHz
13V	22 KHz	Vertical	11.70-12.75 GHz high	10.60 GHz	1100-2150 MHz
18V	22 KHz	Horizontal	11.70-12.75 GHz high	10.60 GHz	1100-2150 MHz

Then the video stream can be played by a TV. Also the satellite receiver provides the required received voltage and tone to enable the dish antenna prior to receiving. The other block connected to the splitter is DC blocker. There is an oscilloscope connected to DC blocker. Furthermore the output of the oscilloscope is connected to a computer. The job of the DC blocker is to save the oscilloscope from high voltage DC components. The oscilloscope saves and sends the signal to the connected computer for further offline decoding.

In dish antenna, there is a LNB device which has two types of polarization (horizontal and vertical). The transmitted satellite TV signal can have different polarization on the same frequency. To receive signal using this device different types of voltage and frequencies are required to be applied.

According to table 1, 18 volt need to be applied to receive signal having horizontal polarization with 10.744 GHz frequency band. The received signal is split by a splitter. A DC blocker is used to block the DC component which prevents the oscilloscope from DC components. The oscilloscope is used to measure the received signal and save the data for decoding using MATLAB.

The conceptual system block diagram is given in fig. (2). After getting the signal in MATLAB, decoding is required.

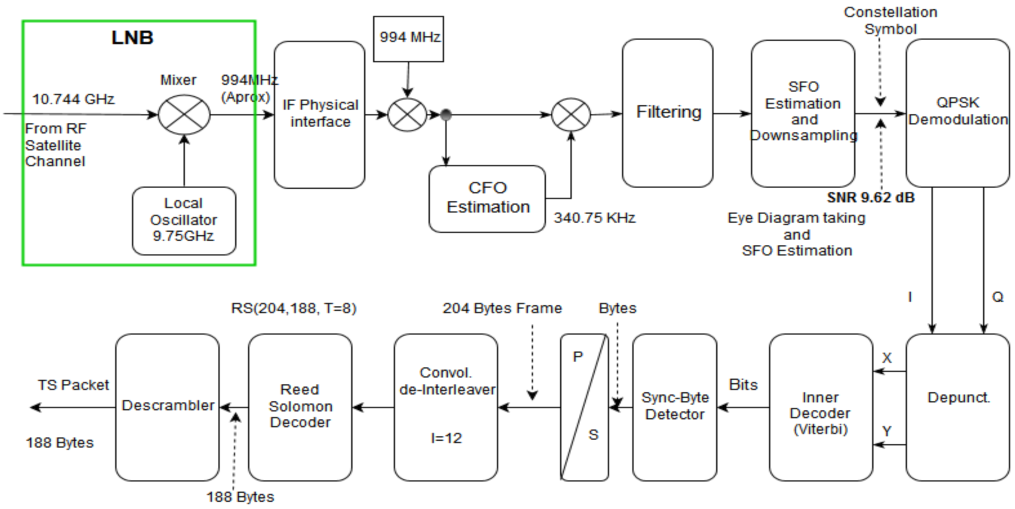

Fig. (2). Conceptual System Block Diagram

The signal comes to a mixer and the local oscillator in the LNB provides the frequency 9.75 GHz. The received signal's frequency is 10.744 GHz. After passing from the mixer, the intermediate frequency is approximately 994 MHz. After demodulation, a carrier recovery is needed which is required to calculate the exact frequency. The next step of carrier recovery is the SFO estimation and down-sampling which is required for fine CFO estimation and get the best time for down-sampling. In fig. 3 the basic carrier frequency offsets (CFO) compensation procedure is examined. To construct the exact constellation diagram sampling time and sampling phase angle is required.

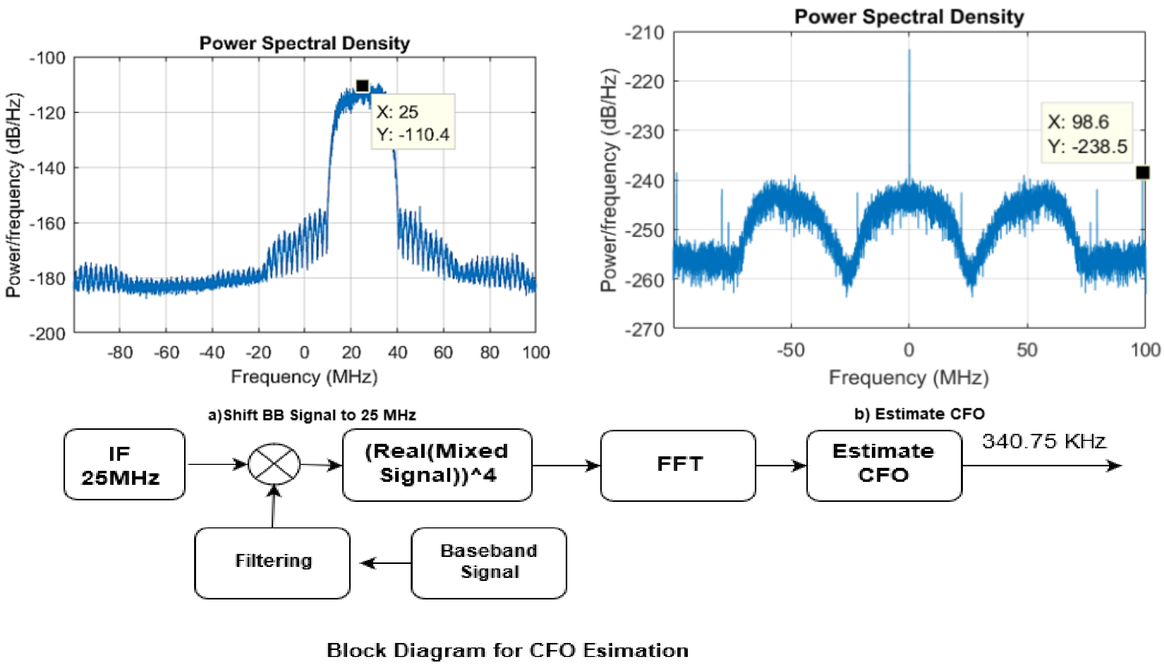

Fig. (3). Carrier Frequency Estimation

All constellation symbols go through a QPSK demodulator. The symbols are demodulated according to the modulation schemes from [1]. The symbol has to separate into real and imaginary part for doing the depunctution. After finishing this part the next step is decoding. Viterbi decoding has been used to find the bits from the complex number. The approx. LLR is performed here. Unquart is used as the decision making process which considers real input values. In this decision making process -1 represents a logical zero and 1 represents a logical one.

Actually, the receiver has received some voltages which needs to be digitized according to receive bit sequences. To fulfill this requirement decoding is needed. Among different types of decoding techniques, the most popular technique is Viterbi decoding. In Viterbi, two types of decision are termed as hard decision decoding and soft decision decoding. If the received voltages are decoded into codeword and correlated with all the possible codeword which gives the minimum selection of Euclidean distance, the process is termed as soft decision decoding. The Viterbi decoder can be used in each case. The hard decision decoding takes an early decision as whether a bit is 0 or 1 which might sometimes leads to wrong decision especially for voltages near threshold [6]. Hence, the soft decision decoding has been considered in this paper.

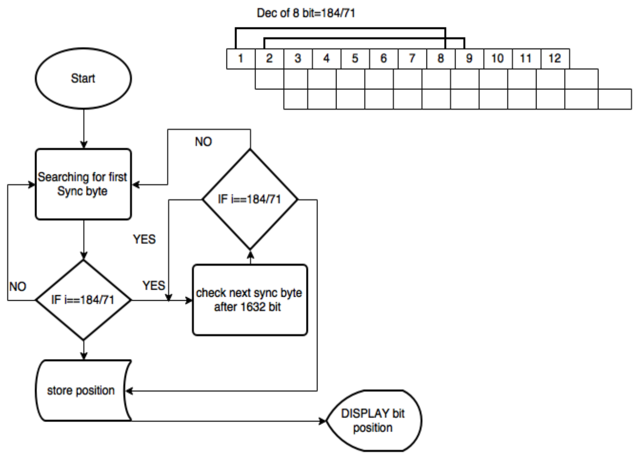

Fig. (4). Sync-byte detection process

The next step gives an idea to find the sync-bytes. After completing the viterbi decoding, a complete bit stream can be found. The sync-byte is given either non-inverted (i.e. 47 HEX, 7 1 Dec) or inverted (i.e. B8 HEX, 18 4 DEC). For QPSK, there are four possible rotations and according to the code rate, 3 symbols is for each rotation. Hence, we have 12 combinations to get the exact sync byte. QPSK demodulator processes 3 symbols at a time and each symbol contain 2 bits. In total 6 bits enter into the depunctuator which inserts extra 4 null bits. The code rate of Viterbi is1/2 .so output of the decoder is 5 bits. It can be observed that the input of the whole decoding process is 6 bits and the output is 5 bits [7]. Hence this code rate is called 5/6 only to find the right symbol blocks. The sync-bytes search is only to determine which of the 12 combinations the right one is. In MPEG-2 TS, there are 8 packet configurations for energy disposal, which need to be detected. That's why further decoding is needed. In every packet a sync byte should present in very beginning. The main job of this sync-byte detector is to detect the regular occurrence of sync-byte. Each packet contains 204 bytes or 1632 bits where the starting 1 byte should be sync-bytes, either inverted or non-inverted. The repetition should be happened in 7 times non-inverted and one time inverted in general case [2]. Here a small algorithm has been introduced to find the first sync-byte.

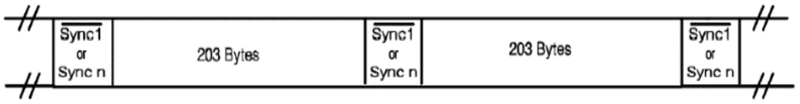

Fig. (5). Frame structure [2]

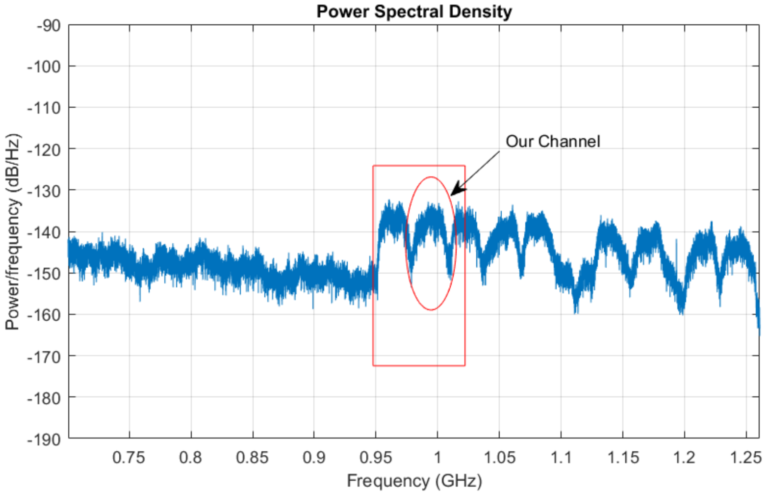

Fig. (6). Received Signal

After starting the algorithm it can take the first 8 bits and convert it into a decimal number if the number is equal to 71 or 184 (non-inverted/ inverted). Then it goes to check the presence of next sync byte after 1632 bits or 204 bytes. Usually the non-inverted bytes can be found after 204 bytes. According to the encoder information from [2], the frame structure is shown in fig. (5).
If first 8 bits do not match with any inverted or non-inverted sync-byte, the algorithm moves forward and starts from next 8 bits. Using the algorithm, the desired sync byte is found after 9th time's shift of constellation, and first sync-byte is found after 381 bits. Actually, from this step further processing can take place at the byte level.
DVB-S has some special type of standards which uses some interleaving and randomization algorithm that secures the packets. Here the value of I=12 which represents the buffer size. Hence, first 12 packets have been ignored during de-interleaving process. The last step is error detection and correction. Reed-Solomon shortened code (RS (204,188, T=8)) is used which can correct up to 8 bits. After that the final message for the MPEG-2 format is formed with some padding. Packet Identifier (PID) which needs to be removed and after removing the inverted sync-byte, the message PID is formed. In MPEG-2 TS, there is some PID which can identify the packet. Additional packets will be discarded at the end of receiver. PID 8191 is reserved for this part.
Null Packet: It is used to ensure that the stream maintains a constant bitrate, a multiplexer may need to insert some additional packets which will discarded at the end of receiver. PID 8191is reserved for this part.

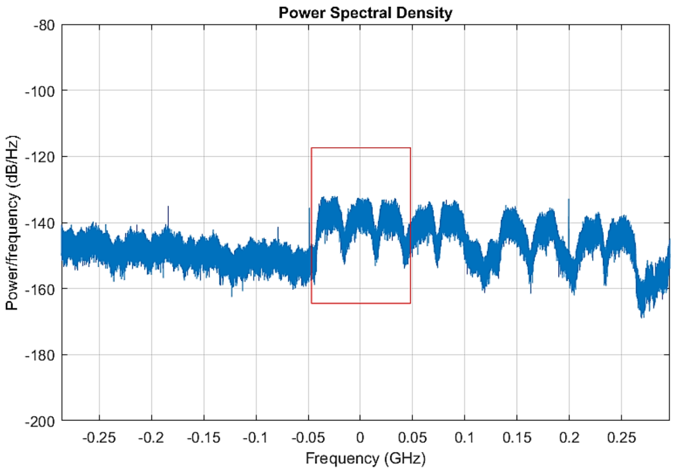

Fig. (7). BaseBand Signal

3. Results

This section discusses about the results of the implementations of this paper. After receiving the transmitted signal from the satellite, it is demodulated following denoising. The output signal shown in the oscilloscope is presented in the fig. 6.

After mixing it in baseband, the higher frequencies are filtered out. The resultant baseband signal is shown in fig. 7.
Following the demodulation, carrier recovery and filtering, timing and phase offset cancellation, decoding and sync byte detection have been performed upon the signal. Fig. 8 shows the frame which started with sync-byte.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	0	0	0	0	0	0	0	0	0	0	3	0
2	0	0	0	0	0	0	0	0	0	0	165	171	0
3	0	0	0	0	0	0	0	0	0	207	65	133	0
4	0	0	0	0	0	0	0	0	206	92	177	164	0
5	0	0	0	0	0	0	0	36	176	81	254	252	0
6	0	0	0	0	0	0	4	177	15	108	82	231	0
7	0	0	0	0	0	128	224	206	137	154	130	100	0
8	0	0	0	0	119	186	206	97	96	184	32	111	0
9	0	0	0	234	134	88	101	212	197	149	207	145	0
10	0	0	147	23	176	166	114	118	193	138	12	8	0
11	0	158	220	81	194	62	79	137	228	143	242	73	0
12	71	29	231	87	57	36	58	36	213	106	184	203	192
13	71	45	229	243	212	66	73	177	38	99	80	248	251
14	71	5	239	76	158	54	187	72	106	78	166	88	42
15	71	222	209	215	53	46	224	24	228	113	10	243	111
16	71	81	210	242	203	239	248	8	84	12	97	42	83
17	71	40	195	234	58	239	113	105	59	153	133	180	234
18	184	2	3	20	139	224	187	33	155	215	248	104	99
19	71	159	40	82	95	248	64	185	159	1	151	231	88
20	71	28	191	90	120	113	195	110	167	215	187	151	81
21	71	44	217	243	44	187	69	13	204	193	61	55	67
22	71	27	229	65	93	64	127	195	191	237	148	140	86
23	71	193	75	215	69	195	96	154	188	160	116	62	199
24	71	80	36	243	228	154	29	233	55	60	60	127	176
25	71	55	245	224	193	233	123	00	223	117	100	194	01

Fig. (8). Sync Bytes with Frame

First 11 frames are lost due to the buffer size. So the first 11 frames can be omitted and started from number 12th. These 11 frames do not contain any information. In MATLAB there is a built in object function which is used for De-interleaving. Using the basic formula of SNR in dB, the SNR has been calculated as 9.1792 and 9.6280 in db.

After RS decoding and descrambling, the pure message is found with some padding Packet Identifier (PID) which needs to be removed and after removing the inverted sync-byte, the message PID has been formed.

The PID list found is given below, according to [5]. In MPEG-2 TS, there is some PID which can identify the packet.

After decode PID number 18 some text has been fond which is given below.

G 00Nÿdeu ù2D-Animationsserie mit 3D-Elementen, Deutschland / Luxemburg / Irland / Kanada 2013Tumult in der Oper von NingxiaEs lebe die Prinzessin! Überall in der Stadt Ningxia hänge G n Bilder mit Shi La. Zu ihren Ehren, sagt sie. Trotzdem müssen Marco, Shi LNÿdeu ùa und Luigi vor einer aufgebrachten Händlerin flüchten und landen in einer chinesischen Oper. Hier w G erden sie für die erwarteten Schauspieler gehalten und müssen gleich auf die Bühne. Das war schon immer Shi Las Traum. Aber die turbulente AufführunNÿ#deu ùg des Stücks "Prinzessin Ki G rschblüte" lüftet ungewollt das Geheimnis um die wirkliche Herkunft von Shi La.Darsteller:Vater Niccolo: Boris Aljinovic- SprecherMarco: Elia Francolino- SprecherLuigi: Linus Dre

The null packet is looks like,

47FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
FFFFFFFFFFFF… and so on.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	71	150	147	234	119	128	4	36	205	207	165	3	192
2	71	29	220	23	134	186	224	177	176	92	69	171	251
3	71	45	231	81	176	33	206	206	19	81	177	133	42
4	71	5	229	87	194	166	101	97	137	108	154	164	111
5	71	222	239	243	57	62	114	212	90	154	184	252	83
6	71	81	209	76	212	36	79	118	197	184	130	231	234
7	184	40	210	215	158	65	73	118	193	149	32	100	99
8	71	2	195	242	53	54	187	136	220	143	207	111	98
9	71	159	3	234	203	145	224	177	213	108	12	145	81
10	71	28	40	20	58	239	248	72	38	99	242	8	67
11	71	44	191	82	139	239	113	24	100	78	184	73	86
12	71	27	217	90	95	224	164	8	228	113	88	203	199
13	71	193	242	229	120	136	87	108	84	12	166	248	176
14	71	80	75	65	44	195	195	35	59	153	10	88	61
15	184	55	38	215	93	62	69	185	159	219	97	243	212
16	71	2	245	69	69	203	127	110	150	1	133	42	112
17	71	159	14	228	228	110	96	52	167	215	248	180	11
18	71	28	132	194	193	219	29	13	204	193	151	164	137
19	71	44	219	54	54	223	123	195	192	237	187	231	98
20	71	27	117	262	162	28	112	154	188	160	61	151	84
21	71	222	129	251	130	44	5	233	59	60	148	55	207
22	71	80	209	73	8	241	221	60	229	117	116	140	34
23	184	41	138	211	238	86	237	71	143	61	60	62	126
24	71	2	255	252	77	78	224	16	241	8	160	227	113
25	71	159	103	239	122	167	4	31	55	181	9	194	226

Fig. (9). After deinterleaving process

Fig. (10) shows the channel information after randomization and here no packet lost has been found in the middle.

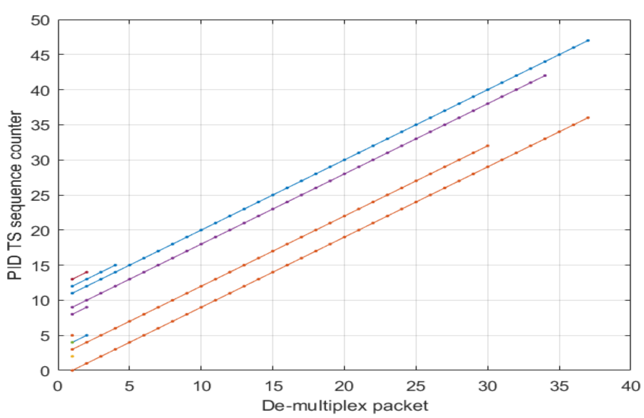

Fig. (10). MPEG-2 channel list without discontinuation

Sender / HDTV / Status / Land	Kategorie	SID	Video PID	Audio PID	PCR PID	VT PID	Update
arte	Kultur	28724	401	402 deu 403 fra	401	404	13.09.2011
ONE	Allgemein	28722	201	202 deu 203 mis 206 AC3 deu	201	204	02.09.2016
PHOENIX	Dokus / Reportagen	28725	501	502 deu 503 mul	501	504	26.05.2016
tagesschau24	Nachrichten	28721	101	102	101	104	23.05.2013
Daten Sender auf 10744 MHz							
Test-R	Verschiedenes	28726	401	402	401	0	25.02.2017

(a) Sending PID information

Channel name	Video PID	Audio PID	PCR PID	VT PID
tagesschau24	101	102	101	
ONE	201	202 deu 203 mis 206 AC3 deu	201	
arte	401	402 deu 403 fra	401	404
PHOENIX	missing	502 deu 503 mul	missing	504

(b) List of received PID

Text and Other PID	18	407	408	1014	2058	
	2171	3088	4163	6672	7470	8013
Null PID	8191					

(c) List of received PIDs

Fig. (11). PID lists from [5] and after decoding the received signal

4. Future Work

Nowadays the DVB technology is the newest technology in whole world. This paper focuses on the decoding of DVB-S standards. There is a new standard comes over DVB-S which is called DVB-S2. It provides better decoding technique and error correction rate is faster than the others. After doing some improvement of DVB-S, decoding DVB-S2 shall be tried in future.

5. Conclusion

This paper discussed about available literature related to digital TV and digital video broadcasting in detail. DVB-S signal is captured after LNB with oscilloscope and also decoded the signal in MATLAB. Furthermore, in offline decoding part CFO compensation, SFO compensation, sampling, Virterbi decoder, sync-byte detection, Reed-Solomon decoder, up to TS-Stream interpretation techniques are adopted to optimize the performance on each media. In previous time there was no digital television, hence that time satellite receiver used to work on the analog signal. DVB technology is totally a new concept and more research work is ongoing. The main task of this paper is to decode the signal which is received from satellite and get the decoded result with a good SNR and after the calculation of SNR, 9.62 dB is found which quiet good signal to decode. In the forward error correction section RS decoding has been introduced that can correct maximum 8 bytes and after descrambling some channel packet is found without any discontinuation.

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