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LABORATORY EXERCISES FOR SEFRAM 7865 TV ANALYSER

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Ville Jääskeläinen

PREFACE

I would like to thank Helsinki Metropolia University of Applied Sciences and Mr Antti Koivumäki for giving me the opportunity to write this paper, Mr Ville Jääskeläinen as my tutor in writing this and especially thank Mr Olavi Aho for giving me the idea for the laboratory exercise.

Writing this paper has given me opportunity for a further insight into the writing of scientific texts and research papers. It has been a mental challenge to try and find the essential and fundamental things of the equipment I have been writing about and then put it all on paper in a whole and comprehensive way for the reader to understand.

Helsinki, June 10, 2010

Marko Raikaskoski

ABSTRACT

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The paper aims to introduce the Sefram 7865 TV analyser and field strength meter to the reader and to briefly introduce the concepts of the Digital Video Broadcasting.

The intent of this paper is to offer some laboratory exercises for use with the Sefram 7865 equipment in the appendix of this paper as well as some questions and research tasks for the reader as an introduction to the former.

The Sefram 7865 TV analyser is found to be an adequate tool for the maintenance and installation of television reception systems.

The laboratory exercise could be further developed including an oscilloscope and/or spectrum analyser to visualise the signals used and produced in the laboratory exercise.

Key words: Digital TV Broadcasting, DVB, TV Analyser, Laboratory exercises

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Tämän työn tarkoituksena on esitellä Sefram 7865 TV analysaattori ja kentänvoimakkuusmittari ja lyhyesti esitellä digitaalisen videolähetyksen (DVB) käsitteet.

Tämän paperin tarkoituksena on tarjota laboratorioharjoituksia Sefram 786 -laitteelle liiteosiossa jonka lisäksi kysymyksiä ja tutkimustehtäviä lukijalle johdatuksena edelliseen.

Sefram 7865 TV analysaattori osoittautui riittävän hyväksi työkaluksi televisiovastaanottojärjestelmien asennuksessa ja ylläpidossa.

Laboratorioharjoitusta voisi kehittää ottamalla mukaan oskilloskoopin ja/tai spektrianalysaattorin visualisoimaan harjoituksessa käytettyjä ja tuotettuja signaaleja.

Avainsanat: Digitaalinen televisiolähetys, DVB, TV-analysaattori, laboratorioharjoitukset

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1 INTRODUCTION

The aim of this paper is to enable readers to understand the principles and concepts of the Digital Video Broadcasting technology as to serve as an introduction to the use of the Sefram 7865 Field Strenght Meter. This paper is intended for readers with a background in telecommunications and familiarity in the concepts and some of the terminology. This paper does not aim to specialise on DVB and its various standards. The reader is encouraged to refer to the relevant standards of European Telecommunications Standards Institute (ETSI) as authorative source of current information.

The main goal of this paper was to create some practical laboratory exercises for the students. The objective of the laboratory exercises and measurements presented and found in the Appendix to this paper is to familiarise the reader with the Sefram 7865 and demonstrate the features and functions as well as shortcomings specifically in context of DVB and its applications. Some preliminary questions and research tasks are included to prepare and orientate the reader to the laboratory exercises.

In the following section is presented brief history of the digital video broadcasting followed by some structures and concepts in DVB after which we look into the various transmission standards of DVB. This is followed by the evaluation of the Sefram 7865 TV analyser.

Most of the theoretical framework of this study is based on the Hervé Benoit's book Digital Television 3rd edition.

2 DIGITAL VIDEO BROADCASTING (DVB)

Before 1990s it was not seen to be technically or economically realistic to broadcast fully digitized television programmes to the consumers as the bandwidth for live pictures at the typical analog television resolutions was even by today's standards very high. At the time the research for improvement of the quality of television picture was considered important and urgent, though it might be speculated if much of that urgency came from the politicians and technograts, and huge amounts of money was invested in the development of several different High Definition Television systems across the world, in Japan, Europe and in U.S.A.

With increased resolution the HDTV broadcasts would have required four times the bandwidth compared to the television broadcasts with the conventional resolutions used at the time and would have reached bit-rates of one gigabit per second hence most of the HDTV proposals at the time were defined as analog systems with a digital assistance.

Very quick development of efficient compression algorithms at the beginning of 1990s changed the situation drastically and the amount of data required for broadcasting of digital pictures had decreased to below 30Mbps and depending of the content of the picture and the chosen resolution even down to 1.5 Mbps.

Progress in the IC technology allowed realisation of high capacity memory chips and complex integrated circuits at an affordable price. But it turned out the very high costs of display technology prevented the success of the HDTV technology on the consumer market. It seemed the consumers at the time were more interested in the content and amount of programmes than improvement in the picture quality. The economic crises in most countries had its toll on the success of HDTV as well.

European Launching Group was created in 1991 and gave birth to the Digital Video Broadcasting (DVB) project in 1993. It was based on the international MPEG-2 compression standard. MPEG-2 is downwards compatible with its predecessor standard MPEG-1 and defines levels and profiles that enable compatible evolution towards HDTV. This resulted between 1994 and 1996 in the standardisation of three different variants for various transmission media; DVB-S for satellite, DVB-C for cable and DVB-T for terrestrial broadcasting.

In the last years the rapid decrease in price of large flat-screen televisions as well as displays with resolution requirements compatible with HDTV has now made them available to the public at large. Television studios have been for years using various digital video formats for recording and editing the material. Primary advantages of digital formats are that they allow multiple copies to be made without any degradation in the picture quality as well as permit conversion into and distribution of the video material in the various international exchange formats such as NTSC, PAL, SECAM or MPEG. The high bit-rate of these formats at the recording phase makes it unsuitable for these formats to be used for broadcast to the consumers directly without some compression applied prior to the transmission.

2.1 STRUCTURES AND CONCEPTS IN DVB

For the purposes of this paper a brief overview of the DVB system relevant to the functions, properties and the use of the Sefram 7865 is included.

The very basics of a television programme are the pictures and the sound. When the pictures and the sound are digitised into data frames they are called presentation units (PU) in their unencoded forms. These are in turn encoded into access units (AU). The access units are combined into elementary stream (ES) and this forms the compression layer.

For combining the data included by the broadcasting companies with these bit streams various supplemental data is added for the synchronisation of the picture and audio and their separation as well as to allow the service selection by the user. Rules for grouping these into a system layer are standardised. Figure 1 illustrates the multiplexing of Elementary Streams into Transport Stream.

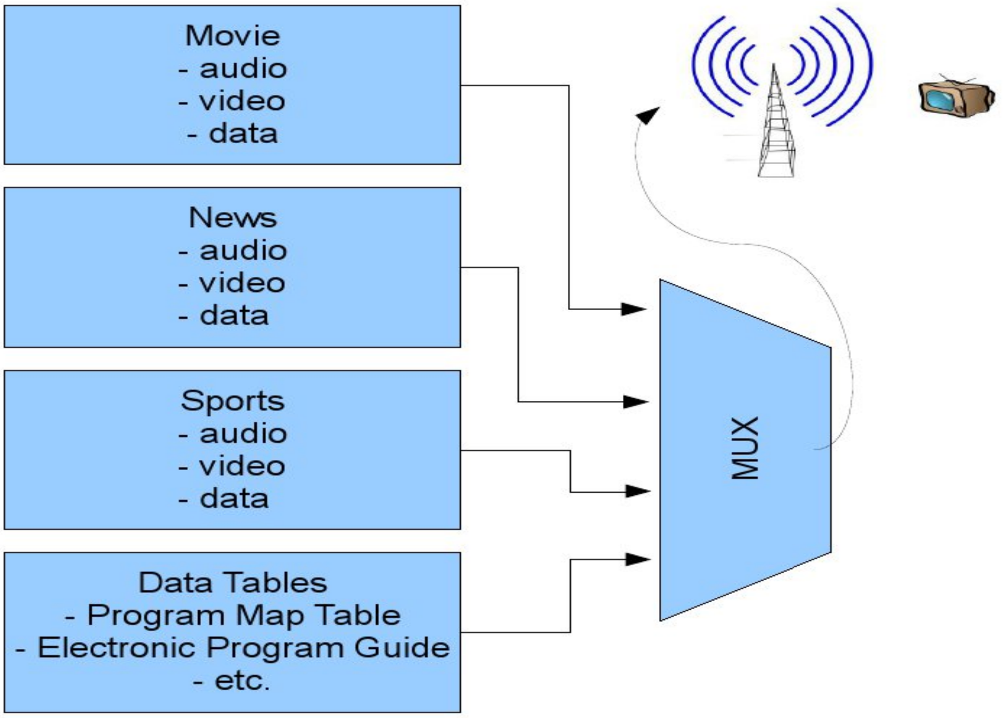

Figure 1: Multiplexing of Elementary Streams into Transport Stream

The system layer is responsible for adding timestamps for playback synchronisation and packaging and combining multiple bit streams into one. The initialisation and management of the decoding buffers of the elementary streams is yet another responsibility of the system layer.

Elementary streams are cut into packetized elementary streams (PES) containing a packet header at the beginning and followed by the data of the elementary stream. These packetized elementary eams are combined into a program stream (PS). (Cf. Figure 1). What is notable here is they all need to share the same system time clock. This stream type is suitable for media in which a very low rate of errors is to be expected.

For transportation of TV programmes over long distances or over media that is error-prone a transport stream (TS) is used. In order to allow efficient compression algorithms to be implemented the packet size is kept relatively small. Transport stream can combine and carry in the same multiplex many programmes that do not need to share a common system time clock among each other.On the other hand for the decoder to be able to decode the programmes the individual packetized elementary streams that constitute the programme are required to use the same clock. Several of these multiplexes can be grouped into a bouquet.

What is needed for the receiving equipment to find and differentiate between the television programmes within the single transport multiplex is four tables defined in the MPEG-2 standard. These four tables together make up the program specific information (PSI). Depending on the importance of each of the tables they consist of one or more sections. The maximum number of the sections is 256 and they can be of 1024 bytes long excepting for private sections which can be of 4096 bytes maximum.

Program allocation table (PAT)

This mandatory table always broadcasted unscrambled indicates for each of the programmes carried by the transport multiplex the link between the programme number and the packet identification (PID) of the packets carrying program map table (PMT).

Conditional access table (CAT)

If even one of the programmes in the multiplex has conditional access this packet must be present. It carries the PID for certain packets used in conditional access systems.

Program map table (PMT)

For each of the programmes there is one PMT in the multiplex and it is used to indicate the PIDs of the elementary streams along with other relating optional private data to

Transport stream description table (TSDT)

This table describes the contents of the multiplex.

In addition to these tables the private tables mentioned earlier carry private data either in free format or in format resembling the CAT.

The DVB standard complements the tables of MPEG-2 with what is called as service information (DVB-SI) with tables of which only some are mandatory. This service information allows the user to navigate the programmes and services and enables the receiver autoconfiguration. The same size constraints apply to these tables as well.

DVB-SI defines four tables as mandatory:

Network information table (NIT)

This table carries information of the channels and frequencies used by a network with more than one radio frequency and thus more than one transport stream.and is used by the receiver to autoconfigure itself.

Service description table (SDT)

The names and other parameters associated with each of the service carrier in the multiplex are listed in this table.

Event information table (EIT), present/following

This table carriers the information concerning the present and following events in the multiplex.

Time and date table (TDT)

This table carriers the current real-time and is used by the receivers to update their internal real-time clocks.

The optional tables defined by the DVB-SI apply to the current multiplex.

Bouquet association table (BAT)

Since the given programmes and services may belong into more than one bouquet this table is present in all the multiplexes of the bouquet and is used for grouping the services for the user presentation.

Event information table (EIT), schedule

(As earlier described)

Running status table (RST)

Sending of this non-recurring table is triggered to update the status only when the status of one of more of the services changes.

Time offset table (TOT)

This table carriers the time offset to the GMT.

Stuffing tables (ST)

Can be used e.g. for clearing the contents of the tables defined by the DVB-SI.

Electronic program guide (EPG) is built within the memory of the receiver equipment using the information contained in the EIT table and is the schedule and guide to the user of the present and future programmes up to one week in advance.

When the channel search is initiated for instance at the time of installation of the receiving equipment a list of available services is build using the information of the PAT and PMT tables and optionally by the NIT table. The list stores the PIDs of the elements of each service or programme so that the user may access them without referring to the PAT and PMT. The potential changes to the services in the multiplex can be regularly consulted from the NIT.

Television transmissions require channels called quasi-error-free (QEF) which have very low bit error rates (BER) in the magnitude of 10^{-10} … 10^{-12} which correspond to 0.1 … 10 erroneous bits per hour in a stream with 30 Mb/s of bit-rate. To detect and correct as many aspossible of the errors introduced by the error-prone physical transmission channel it is necessary to use forward error correction (FEC) or channel coding. Most of the forwarderror correction consists of introducing precalculated redundancy into the signal which on the other hand reduces the efficiency of the channel coding.

Quasi-error-free virtual channel that forms between the input of the FEC encoder at the transmission side and the output of the FEC decoder at the receiver side is sometimes called super channel.

Figure 2 shows the principle block diagram of the Forward Error Correction.

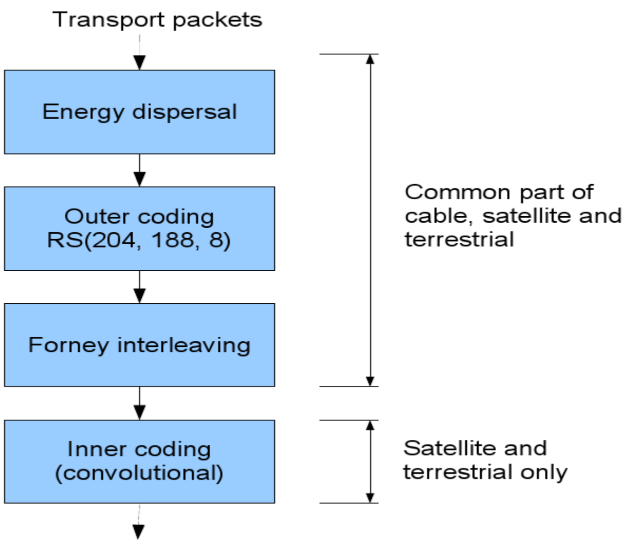

Figure 2: Transmitter side of Forward Error Correction

It is in this view of virtual channel the terms inner coding and outer coding are shown in the Figure 2. above.

However It is not the intention of this paper to delve deeply into the sophisticated error correction codes.

In order to obtain an evenly distributed energy dispersal within the RF channel as long sequences of 1s and 0s would bring the direct current (DC) content of the signal to zero the signal is randomised by means of scrambling. This is achived by feeding the signal through the same pseudo-random generator first on the transmitting side and then on the receiving side. The pseudo-random binary sequence (PRBS) used in generator polynome 1 + X14 - X15. Diagram of the scrambler is shown in Figure 3.

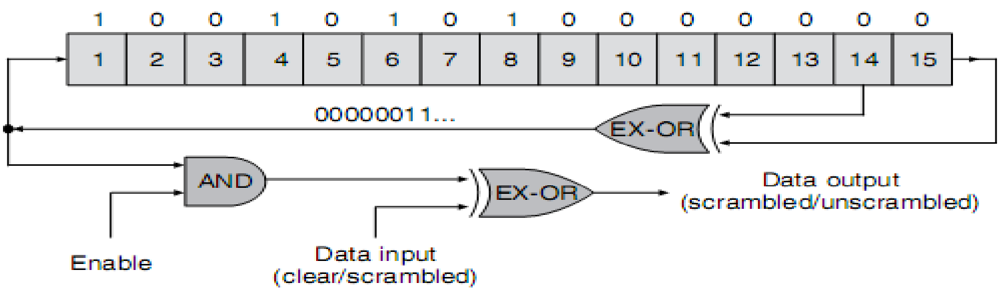

Figure 3: Diagram of energy dispersal scrambler/descrambler [1]

The generator is reinitialised on every eight transport packet by the bit sequence of 100101010000000 and in order to locate the beginning of the sequence the syncronising byte of the first packet in the sequence is inverted. The enable input is kept inactive during the time the synchronising byte is fed through the scrambler. The scrambler remains active even in the absense of signal or even when the signal fed throug the scrambler is non-MPEG-2 compliant.

The outer error correction coding referred to earlier is Reed-Solomon code RS(204, 188, T=8) which in combination with the Forney interleaving allows transmission channel introduced burst errors to be corrected.It is applied to all the packets fed through the scambler including the synchronisation bytes.

The RS(204, 188, 8) algorith can correct up to 8 erroneous bytes per packet. If the packet contains more than 8 erroneous bytes the packet will be indicated as erroneous and incorrigible and the rest of the circuitry will decide how do handle it. The overhead introduced by this algorithm is rather low as it is only slightly more than 8%.

The purpose of the Forney convolutional interleaving is to increase the efficiency of the Reed-Solomon coding by spreading the burst errors introduced by the channel over long period of time as otherwise the errors might exceed the correction capabilities of the Reed-Solomon coding.

So far the process for the different transmission media the DVB standard defines has been the same and at this point we diverge as for the DVB-C the step before filtering and modulation into 64-QAM is to convert the serial bitstream into two I and Q signals. Each of these signals is of 3 bits and they represent the symbols of 6 bits. This operation is called symbol mapping.

Channel coding for the RF transmission media i.e. satellite and terrestrial transmission is efficiently complemented by convolutional coding, the inner coding referred to earlier which aims to reduce random errors caused by noise. See to Figure 4 for the illustration of convolutional coder.

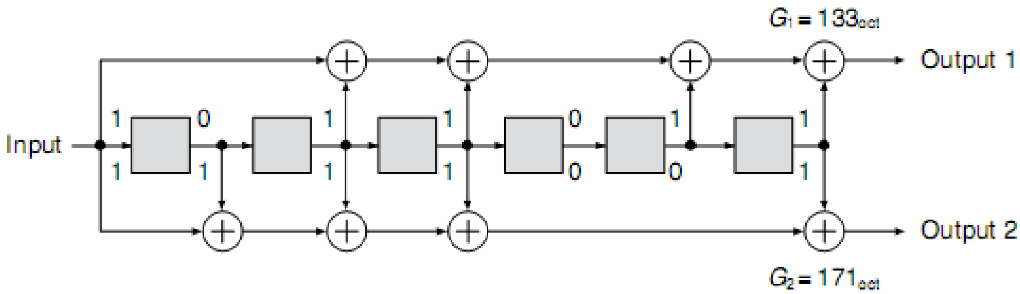

Figure 4: Principle diagram of convolutional coder used in DVB-S [1]

The encoder produces two output bitstreams of equal bit-rate to the original input bitstream. This creates a strong 100% redundancy that allows a very powerful error correction. Although reducing the spectral efficiency of the channel by a factor of 2 it may be especially necessary for very low noise-to-signal ratio (SNR). In the case of DVB-S the two output streams after filtering are fed directly to the QPSK modulator and are thus used for the statellite transmissions. This way the useful bit-rate is half the transmitted bit-rate. Furthermore, the bit-stream used in the satellite transmissions is puctured which means that not all of the two output bits of the convolutional coder will be used and so the redundancy is reduced. DVB standard specifies punctures code rates of 2/3, 3/4, 5/6 and 7/8 which represent the ratio between the useful (input) bits and the transmitted (output) bits. Figure 5 shows characteristics of the inner coding of DVB.

R_c	1/2	2/3	3/4	5/6	7/8
d_{free}	10	6	5	4	3
X	1	10 10	101	10101	1000101
Y	1	11 11	110	11010	1111010
I	X_1	$X_1\,Y_2\,Y_3$	$X_1\,Y_2$	$X_1\,Y_2\,Y_4$	$X_1\,Y_2\,Y_4\,Y_6$
Q	Y_1	$Y_1\,X_3\,Y_4$	$Y_1\,X_3$	$Y_1\,X_3\,X_5$	$Y_1\,Y_3\,X_5\,X_7$
S_{OFDM}	$X_1\,Y_1$	$X_1\,Y_1\,Y_2\,X_3\,Y_3\,Y_4$	$X_1\,Y_1\,Y_2\,X_3$	$X_1\,Y_1\,Y_2\,X_3\,Y_4\,X_5$	$X_1\,Y_1\,Y_2\,Y_3\,Y_4\,X_5\,Y_6\,X_7$

Notes:
On lines *X* and *Y*, '0' denotes a suppressed bit, '1' denotes a transmitted bit. For terrestrial transmissions based on OFMD modulation, additional steps are required after the inner coding: serialization of the bitstream, inner interleaving and symbol mapping to adapt the bitstream format to the high number of carriers used (see Chapter 7). The last line of the table. S_{OFDM}, represents the serialized bitstream (obtained by alternating I and Q lines) applied to the inner interleaving circuit used in the case of terrestrial OFDM transmission.

Figure 5: DVB inner coding characteristics [1]

Figure 5 shows the puncturing.scheme and how the sequence is formed for the I and Q inputs of the QPSK modulator for the satellite transmission. The values of R_c are obtained by multiplying the pure convolutional rate (1/2) by the inverse of the puncturing ratio (input bits/output bits). The dfree stands for free distance and is the measure of the correction efficiency. X and Y are the outputs of the puncturing scheme and the The code rate chosen by the broadcaster is a trade-off between a useful bit-rate and the service area as the puncturing increases the capacity of the transmission channel at the expense of correction efficiency of the convolutional code.

2.2 THE VARIOUS TRANSMISSION STANDARDS OF DVB

In DVB-C and DVB-S different kinds of Quadrature Amplitude Modulation (QAM) schemes are used to increase the spectral efficiency of the modulation and a number of theoretical studies and practical tests have been performed for the cable as well as for the satellite. It has been found that Quadrature Phase Shift Keying (QPSK, 4-QAM) has the best spectral efficiency for the statellite transmission taking into account the signal-to-noise ratio on the receiving side.For the cable in which the signal-to-noise ratio is considerably higher the 64-QAM with its 6 bits/symbol rate compared to the 2 bits/symbol of QPSK has been found to be approximately three times more efficient of its spectral efficiency. Comparison of these modulation schemes is found in Figure 6.

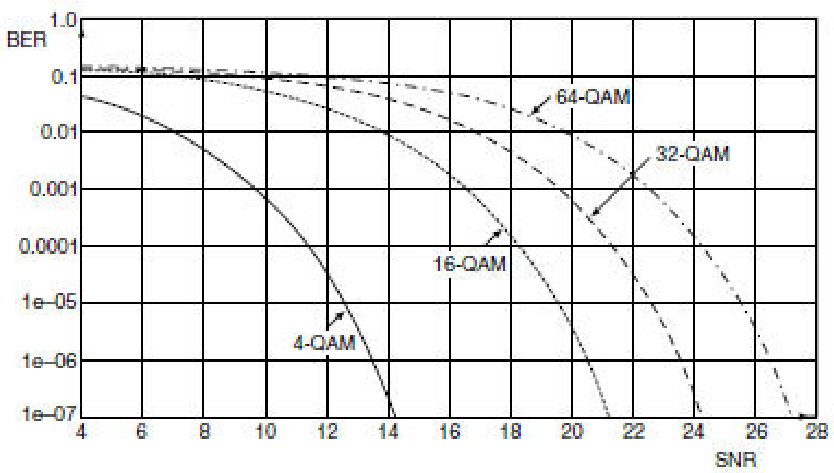

Figure 6: Bit error rate as a function of signal-to-noise ratio [1]

Figure 7 and Figure 8 illustrate the difference in bits per symbol and the number of possible states between QPSK and 64-QAM.

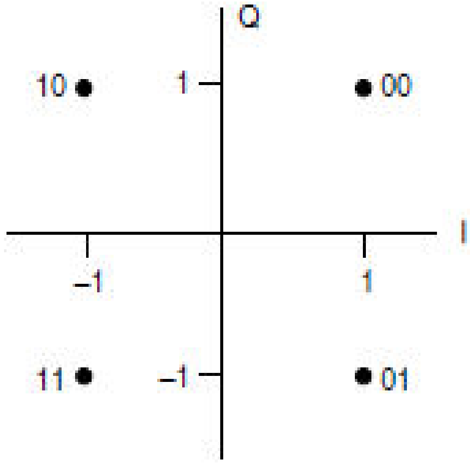

Figure 8: Constellation of a QPSK signal [1]

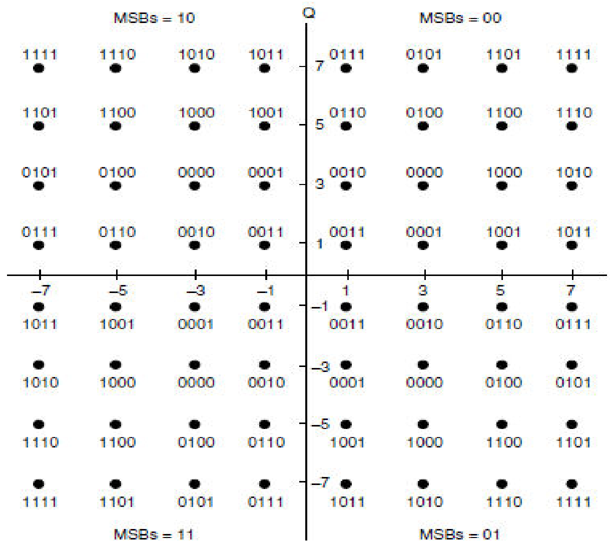

Figure 7: Constellation of a 64-QAM signal [1]

DVB-T has been designed to be compatible and to be able to coexist with the existing analog television transmissions and channelization and uses Orthogonal Frequency Division Multiplexing (OFDM) in DVB-T to carry the transmission over the error-prone air as the transport medium. The principle of this kind of modulation is to distribute a high bitrate stream over numerous orthogonal carriers.

.A detailed close up of the spectrum of OFDM is shown in the Figure 9 and Figure 10 specifically illustrates the virtually rectangular form of the spectrum when given enough of the carriers.

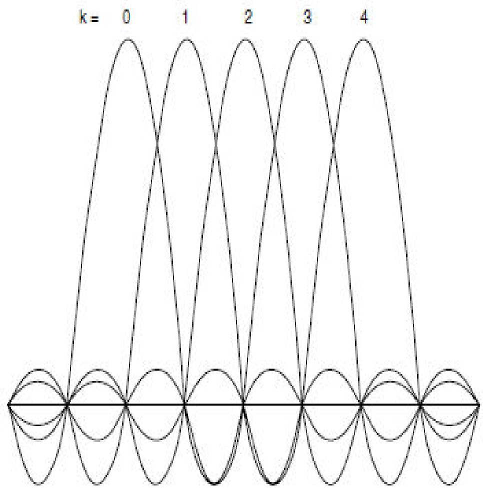

Figure 9: Spectrum of adjacent carriers with OFDM modulation [1]

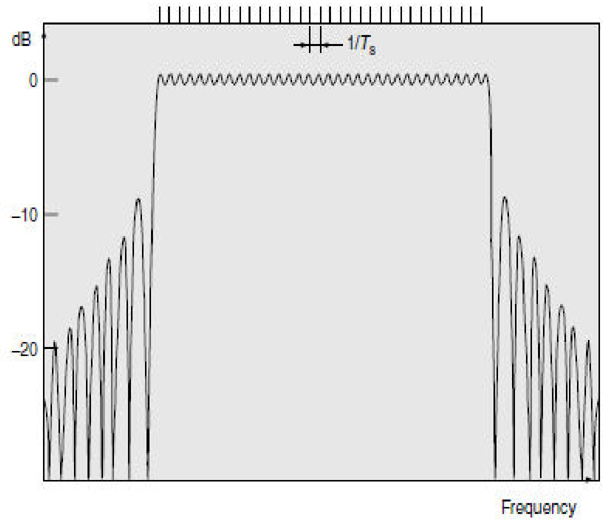

Figure 10: Spectrum of an OFDM signal with 32 carriers [1]

Each of these carriers on its own is of relatively low bitrate. The main advantage of this is that in the multipath reception the delay of the indirect paths becomes considerably smaller than the symbol period in the signal. A number of the carriers are used as pilot carriers with a fixed position and higher power level. A number of carriers are scattered and shifted by three positions at each new symbol. And yet some of the carriers are used for the Transmission Parameter Signalling (TPS). These continual pilot carriers are used by the receiver to synchonize and to evaluate the channel for the decoding and error correction of the channel coding. All of the TPS carriers transmit the same information bit simultaneously. Reception of the parameters is resistant to errors up to so great degree that the receivers are often able to obtain the characteristics of the transmission in considerably worse conditions than would be possible to even decode it.

In Figure 11 there is a visualisation of the frame structure and the pilot insertion pattern. It shows the placement of the pilot carriers as a function of time. Time is on the vertical axis.

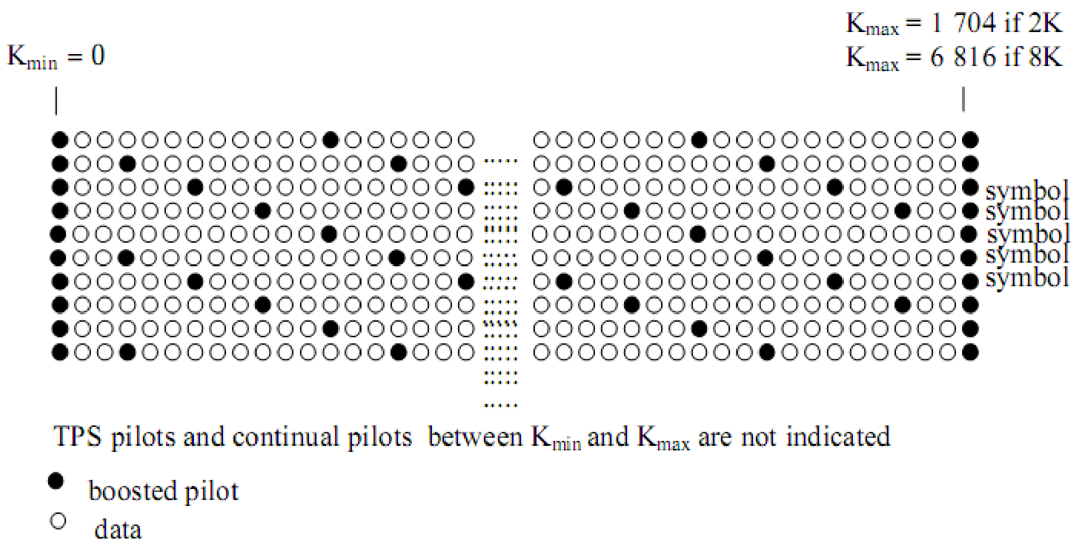

Figure 11: DVB-TH frame structure and pilot insertion pattern [3]

And finally, the complete transmission/reception chain is shown in Fig 12. On the top row of the picture is the transmission side and on the bottom row the receiving side.

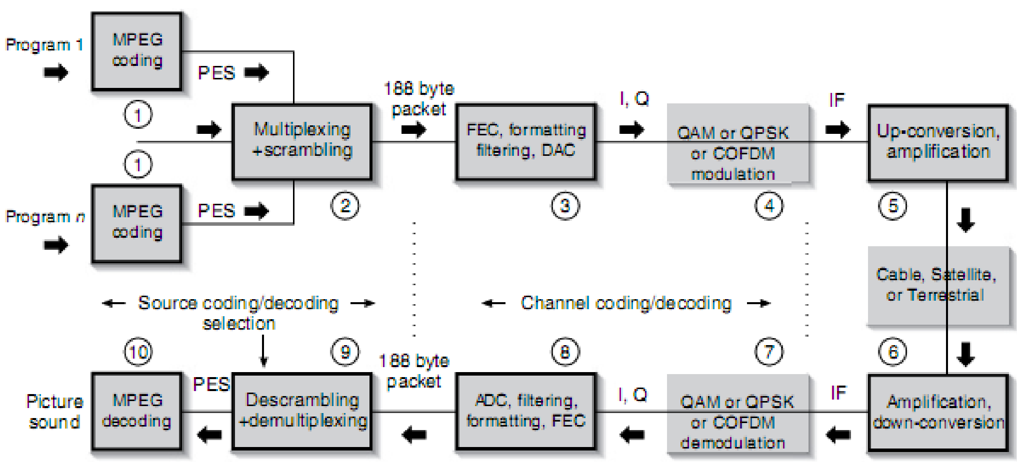

Figure 12: Simplified view of the complete DVB transmission - reception chain [1]

As a summary and overview of the phases of the transmission-reception chain, in the transmission phase the audio and video signals are fed through the MPEG-2 encoder, the PEs are multiplexed with the PSI and DVB-SI tables, the resulting data is encoded with the error correction, the signal is then modulated appropriately according to the transmission media, and finally amplified and up-converted in frequency. The signal is then transmitted over the transport media and the receiving phase follows. In the receiving side the signal is amplified and down-converted, demodulated according to the applicable modulation, fed through the error correction, and at last demultiplexed into PE which which the MPEG-2 decoder transforms finally into video and audio.

3 SEFRAM 7865 TV ANALYSER

This chapter introduces the equipment used in the study, namely the Sefram 7865 TV analyser.

Sefram 7865 is a portable instrument branded as field strength meter designed for maintenance and installation of television broadcast and reception systems of digital terrestrial and satellite systems as well as traditional analogue television systems.

The device allows the error rates of the streams introduced in the previous chapter to be measured but does not allow the user to observe in detail the content and the structure of the frames.

Depending of the DVB system used the equipment allows the error rates to be measured at several phases during the demodulation and decoding process.

For DVB-T/H as well as DVB-S it introduces the following measurements:

- CBER error rate before Viterbi algorithm
- VBER error rate after Viterbi algorithm
- UNC error rate after Reed-Solomon algorithm
- MER modulation error rate

These are defined as the ratio of erroneous bits to the number of the transmitted bits during the time of measurement excepting the UNC which is defined similarly but in the units of packets instead of bits.

For the DVB-S2 standard a different set of measurements is documented:

- LDPC error rate before Low-Density Parity Check
- BCH error rate after the LDPC
- PER error rate after BCH (lost packets)
- MER modulation error rate

The concatenation of the Viterbi and Reed-Solomon of the DVB-S is replaced in DVB-S2 by the concatenation of the LDPC and Bose-Chauhuri-Houquenohem algorithms instead.

The MER portrays all the occuring disturbing signal values and indicates the deviation from an ideal signal and is therefore a value depicting the total signal quality and hence can be compared to the signal-to-noise-ratio in analogue systems. It is in BER and MER the drop will occur when the guard interval is infringed.

Figure 13 shows once again the simplified phases of the receiving side for each of the different DVB broadcast standards.

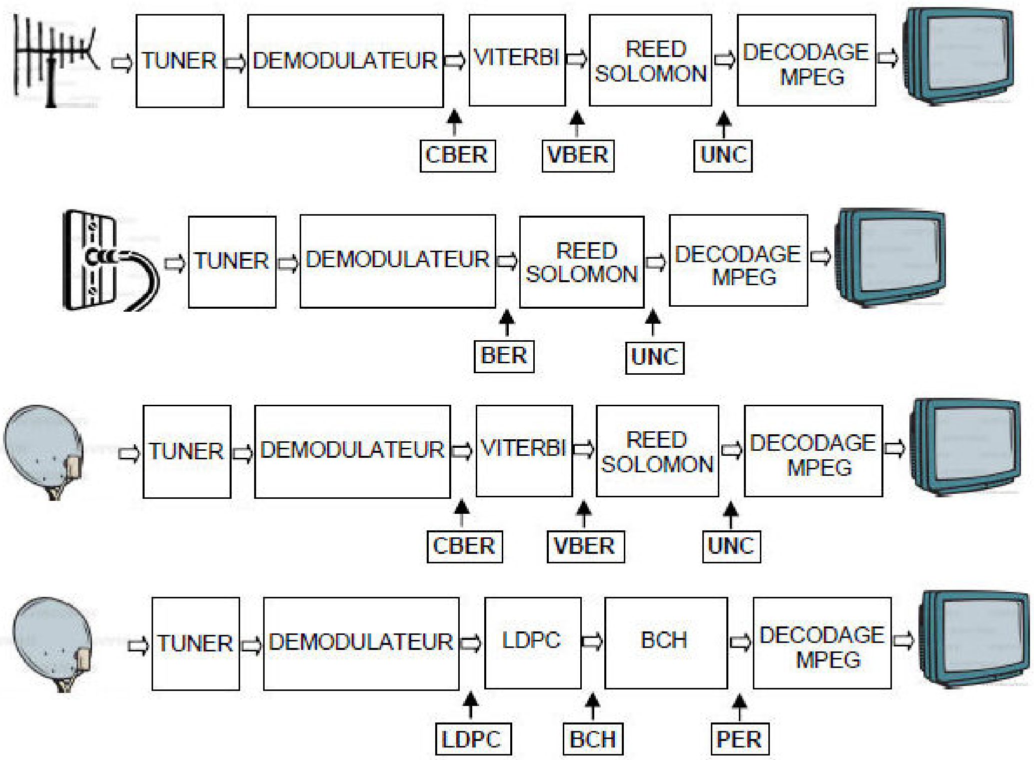

Figure 13: Block diagram of demodulation and decoding of DVB signal [2]

In both the DVB-T/H as well as in DVB-S the frame is considered erroneous if it contains more than 8 wrong bytes. In both of these standards the packet size is the same 204 bytes but the modulations differ.

The equipment allows the constellation graphs of the various modulations to be examined along with the error rates introduced earlier. The effect of the signal level becomes very apparent with the measurement of the constellation graph as will be shown in the laboratory exercise (cf. Appendix).

Figure 14 is the picture of the constellation display of Sefram 7865.

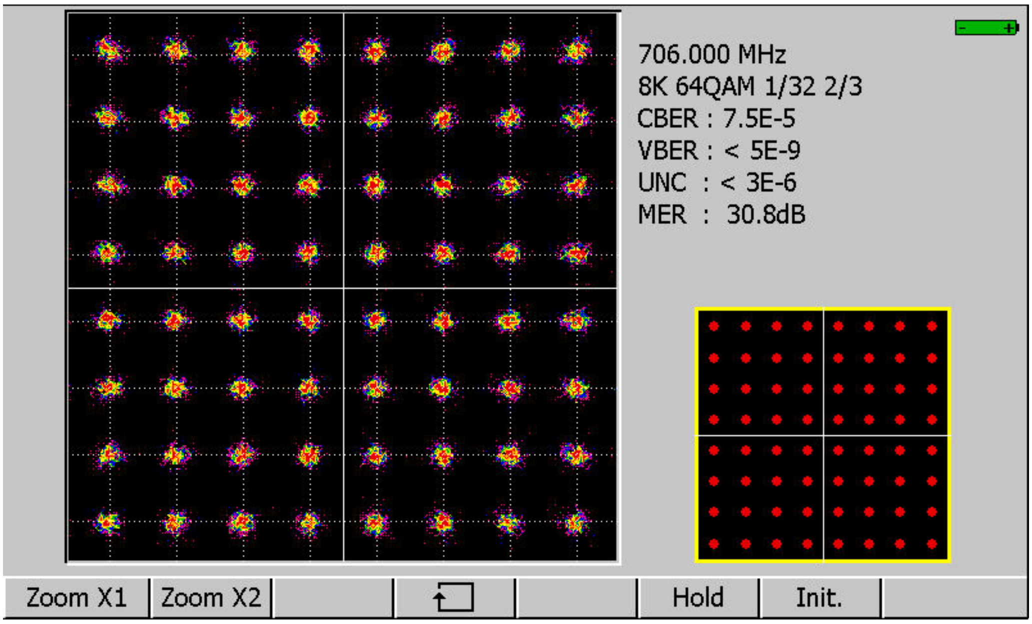

Figure 14: Constellation diagram [2]

The data transmission over the DVB-T/H is sent in frames and the first part of these frames is reserved for a guard interval of variable lenght with the possible lenghts 1/4, 1/8, 1/16, 1/32 of the ratio between the guard interval and the symbol time span.The potential guard time infringements can be seen in the outer points of the constellation diagram appearing larger and more spread than the inner ones.

As well as the constellation graph the equipment allows the Confidence-Frequency Response and the Impulse Response to be measured in DVB-T/H.

Figure 15 shows the Confidence-Frequency display of Sefram 7865.

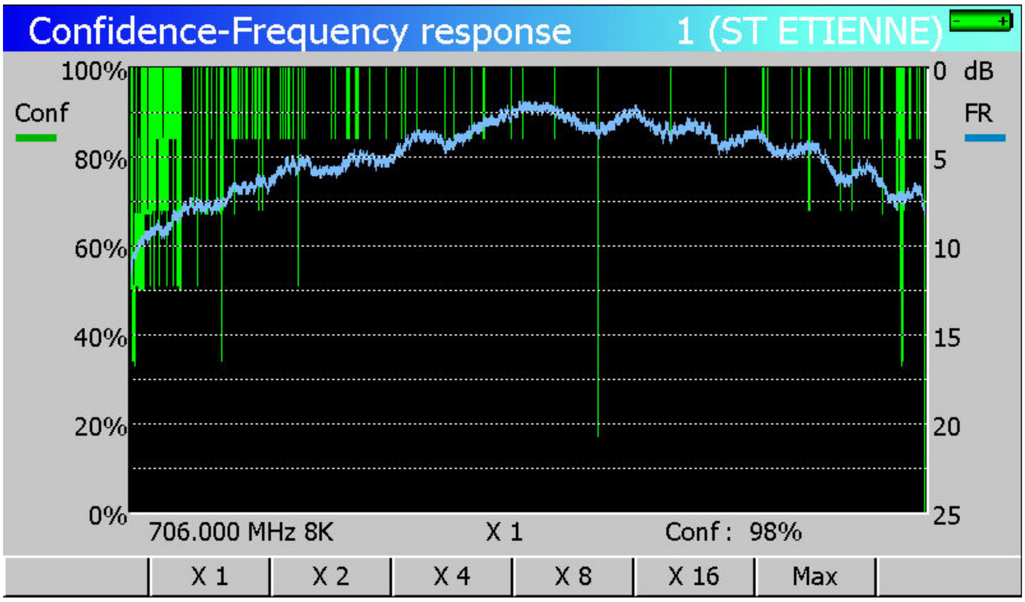

Figure 15: Confidence-Frequency display [2]

Confidence describes the perceived reliability of each of the received carriers by DVB-T/H modulator. The carriers with low enough confidence will be ignored as the data they carry can be retrieved using the error correction algorithms from the other carriers the streams is distributed on.

The frequency response, on the other hand, is the relative amplitude of reception for every carrier measured. The impulse response function allows the measurement of the echoes in the signal. Unlike in analogue TV in which the multipath reception of the signal causes echoes in the signal and affects the picture forming among other things the well known ghost outlines and contours the echoes in digital TV reception may turn out to be even beneficial. This depends on many factors but in practical consideration can be reduced to a concept of distance from the transmitter.

Figure 16 is the picture of the display of echo guard interval of Sefram 7685.

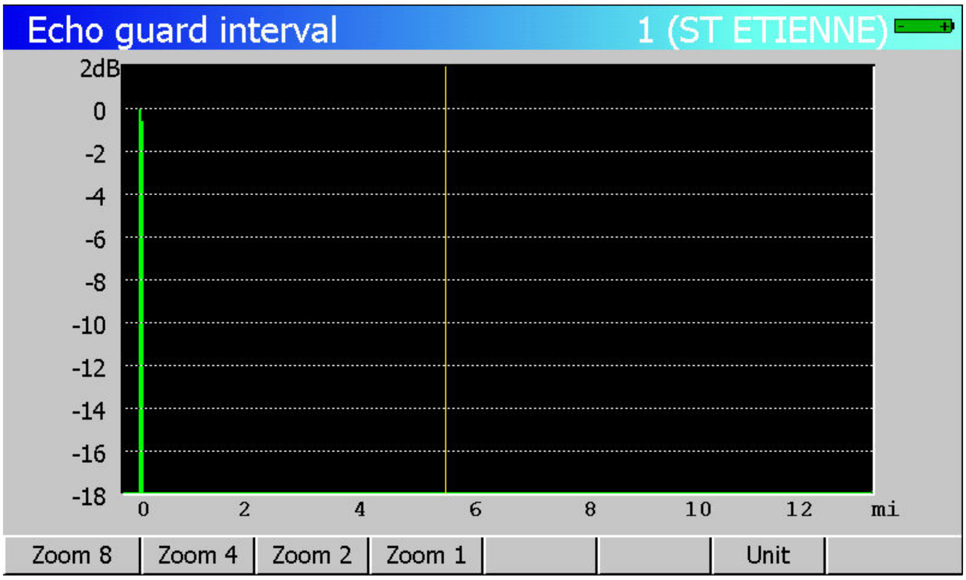

Figure 16: Display of echo guard interval [2]

The standard for the DVB-T defines a guard interval during which no signal is transmitted. When the delay of the symbol in transmission is less than the guard interval the signal is not affected and the signal can be received correctly, but when the delay is greater than the guard signal the reception is no longer possible without errors. The DVB standard defines the lenght of the guard intervals as 1/4, 1/8, 1/16 or 1/32 of the original block lenght for the DVB-T. A longer guard interval means that even signals received relatively late can be used but the useful data rate is naturally much lower.As an example of this in 8K mode (6817 carriers, 6048 available for useful data) in which the symbol time span is 896 μs an echo of 224 μs (1/4 guard) up to 67 km signal path differences are tolerated. In practise this means that if a Single Frequency Network is used the broadcast stations need to be within shorter distance of each other than the tolerated signal path difference. Code Rate is the ratio between the number of bits used and the total bit rate. Possible rates in descending order indicating the strongness of error correction are 1/2, 2/3, 3/4, 5/6, 7/8.

In Figure 17 is a table of available bitrates in different modulations according to the chosen coding rates and guard intervals.

Available bitrates (Mbit/s) for a DVB-T system in 8 MHz channels					
Modulation	Coding rate	Guard interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	4.976	5.529	5.855	6.032
	2/3	6.635	7.373	7.806	8.043
	3/4	7.465	8.294	8.782	9.048
	5/6	8.294	9.216	9.758	10.053
	7/8	8.709	9.676	10.246	10.556
16-QAM	1/2	9.953	11.059	11.709	12.064
	2/3	13.271	14.745	15.612	16.086
	3/4	14.929	16.588	17.564	18.096
	5/6	16.588	18.431	19.516	20.107
	7/8	17.418	19.353	20.491	21.112
64-QAM	1/2	14.929	16.588	17.564	18.096
	2/3	19.906	22.118	23.419	24.128
	3/4	22.394	24.882	26.346	27.144
	5/6	24.882	27.647	29.273	30.160
	7/8	26.126	29.029	30.737	31.668

Figure 17: Available bitrates in different DVB-T modulations. [3]

Figure 18 illustrates the multipath propagations of the DVB-T signal.

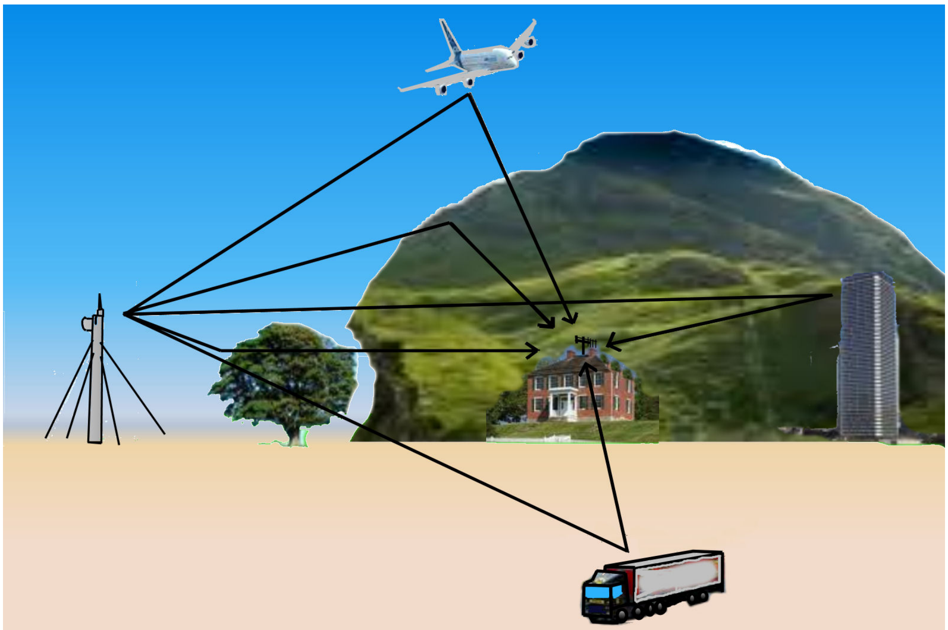

Figure 18: Illustration of multipath propagation

The most impressive function of the Sefram 7865 is the spectrum analyser. In addition to the automatic power and carrier-to-noise measurements the spectrum analyser display can be used for help in installation of the satellite dish antennas: For the identification of the satellites and adjusting the Low-Noise Block converter elements in the satellite dishes there is a completely separate function along with a supporting software installable onto a computer. This is one of the blatant shortcomings of the product as the supporting software seem to be only available for the Microsoft operating system(s).

Figure 19 shows examples of the spectrum display of Sefram 7685.

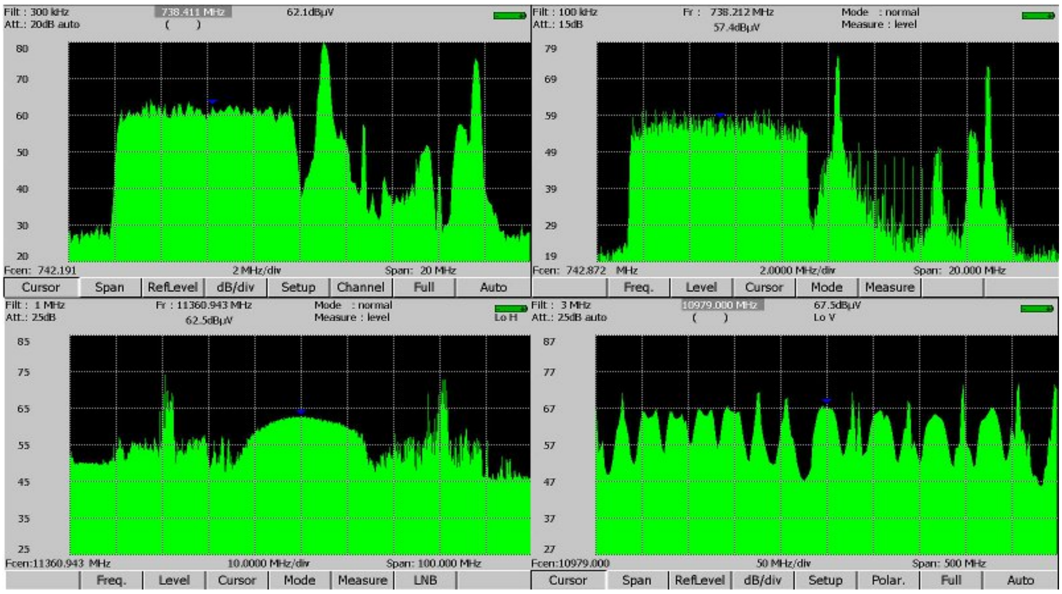

Figure 19: Spectrum diagram display [2]

The spectrum display provides two modes; Simple mode and Expert mode and depending of the mode offers various functions and parameters to be applied; sweep of frequency range specified by the minimum and maximum frequency and the central frequency, the reference level and the input attenuation, amplitude scale, search for peaks, and carrier-to-noise at the frequency indicated by the cursor to mention a few.

In this chapter we demonstrated the most generic functions and displays of the Sefram 7865.

4 RESULTS AND ANALYSIS

As the Sefram 7865 is described as a field strenght meter it is only meant for field measurements and is not capable of going deeper into the frame structure of DVB or more advanced analysis of it or at the very least the manufacturer has not included these options and functions in the built-in software that comes with the equipment. Thus it is mostly the various frame rates the user is able to acquire that would directly pertain to the DVB data streams. Apart from the the spectrum diagram the constellation display seem to be the most formidable tools the equipment has to offer.

The gist of this exercise is to use the function generator to produce a waveform to modulate the signal the signal generator is used to form. This modulated signal out of the RF output of the signal generator is then fed to the makeshift antenna made of a cable with a pair of short wires as in for instance in the connector with crocodile clips. Another one of these makeshift antennae is aligned with and placed approximately 10 cm away from the first one emitting the modulated signal. This second antenna is then connected to the antenna input of the Sefram equipment to act as the receiving antenna to the first one. As the student has first done the research work in order to be able to answer the preliminatory questions and is then asked to make a note of the frequency and the mode of the chosen channel bunch with the strongest signal the student is then asked to make use of the information of the channel separation in choosing the frequency for the signal produced by the function generator. As this very signal is used to modulate the signal produced by the signal generator on its RF output this in fact creates a rake of frequency spikes that as the amplitude is increased gradually block out the carriers. This can indeed be observed using the spectrum display of the Sefram equipment and is shown also on the constellation diagram as the plot drawn spreads and eventually the equipment loses syncronisation.

5 DISCUSSION AND CONCLUSIONS

The Sefram 7865 TV analyser was evaluated for its functions and usefulness. It is by all means not comparable to a good analyser which the user with the need for further and deeper analysis of the data stream and bit errors would need. Nevertheless, it is adequate tool for the maintenance and installation of television reception systems in the field environment. The equipment can be used for laboratory exercises comparable to and simulating situations and environment of the forementioned

In addition to the blatant shortcoming of the supporting software only being available for the Microsoft operating systems and while various configurations could be stored on and retrieved from a USB mass storage device at least at the time of evaluation the software was not able to transfer the measurements and results onto the computer. At this time and age one can only ask what good is an equipment whose data cannot be readily transferred onto a computer for further analysis and archiving but this is unfortunately often the case with the substandard proprietary solutions.

The laboratory exercise presented in the Appendix rose out of the need to create something that would be well within the capabilities of the Sefram equipment but at the same time sophisticated enough to hold the interest of the student and at the same time require for the student in fact to study and familiarise himself with the DVB technology to be able to use the equipment to find out the gist of the exercise and realise it on his own and hopefully get the eureka moment that so often accompanies the times when one is enlightened by something one has learned on his own.

Some of the most enlightening exercises could be created around the functions of the spectrum analyser as well as the constellation diagrams. These functions of the equipment visualise the effects in an especially comprehensive way and are easy to interpret and understand with the basic knowledge and yet display the data in diverse enough a way to captivate the interest of the students.

The laboratory exercise could be further developed including an oscilloscope to visualise first the waveform produced by the function generator on its own and secondly the signal output of the signal generator when it has been modulated by the output of function generator.

Furthermore, viewing and examining the signals either on the spectrum display of the equipment itself or on an external equipment before and after the introduction of the signal generated in the laboratory into the received DVB-T transmission. This would be especially good method for visualising and understanding what is done in the exercise.

REFERENCES

[1] Hervé Benoit: Digital Television, Focal Press 2008 3rd edition

[2] Sefram 7863-7865-7866 Field Strength Meter Manual, February 2009

[3] ETS 300 744 (ETSI/EBU) Framing structure channel coding and modulation for terrestrial services (DVB-T).

[4] ETS 300 421 (ETSI/EBU) Framing structure channel coding and modulation for satellite services.

[5] ETS 300 429 (ETSI/EBU) Framing structure channel coding and modulation for cable services.

[6] EN 300 468 (ETSI): Specification for Service Information (SI) in DVB systems.

[7] ETR 154 (ETSI/EBU) Implementation guidelines for the use of MPEG-2 systems, audio and video in satellite and cable broadcasting applications.

[8] ETR 162 (ETSI/EBU) Allocation of SI codes for DVB systems.

[9] TR 101 190 (ETSI) Measurement guidelines for DVB systems.

[10] TR 101 200 (ETSI) A guideline for the use of DVB specifications.

PRELIMINARY QUESTIONS

Explain the meaning of the terms:

- CBER
- VBER
- UNC
- MER
- C/B
- C/N

Explain the meaning of the modes 2K, 4K and 8K in DVB:

List modulation types used in DVB:

What are the frequencies used by the transmitters at Espoo and Perniö and what are these channel bundles they carry?

List the channel separations of DVB in MHz for 8K, 4K and 2K modes.

What is the amount of channels in various modes:

List the guard interval periods available in DVB:

EXERCISE

Requirements:

- Sefram 7865 Field Strength Meter
- Function generator (e.g. Agilent 33120A)
- Signal generator (e.g. HP 8656B)
- coaxial cables, connectors, alligator clips etc.

Use the Sefram equipment to find out the frequency of the channel bundle that has the most powerful signal received. Make a note of the frequency and the mode of the broadcast.

Connect the output of the function generator to the input of the signal generator with a coaxial cable with appropriate BNC connectors.

Adjust the function generator to produce frequency modulated square wave signal at the frequency of the channel separation of the mode of the chosen channel bundle.

On the signal generator choose the external input to be fed from the output of the function generator. Choose FM as the modulation of the input signal to signal generator.

Adjust the amplitude the function generator produces so that it is high enough for the signal generator but does not overdrive the input.

Choose a cable with BNC connector and at the other end e.g. alligator clips to form a short dipole antenna and connect the BNC end to the RF output of the signal generator.

Choose another similar cable and connect it as an antenna to the RF input of the Sefram 7865.

Align these ad-hoc antennae on the table at the distance of approximately 10 cm of each other.

Adjust the frequency on the signal generator to be equal to the center frequency of the channel bundle you made note of at the beginning.

Adjust the amplitude of the RF output on the signal generator to zero and start increasing the amplitude gradually.

Observe the results on various measurement displays of the Sefram equipment.

- Signal level display
- BER/MER display
- Constellation display
- Confidence-Frequency response display

Describe in detail what is happening in this exercise and explain in few words what roles do each of the equipment play in the setting?

Draw and copy on paper the changes at each phase of the graphical representation on the signal level display of Sefram equipment when the RF output of the signal generator is step by step increased by 5 dB.

At which point does the Sefram start to lose synchronisation?

When will the reception of the DVB payload become impossible?

When is the DVB payload signal apparently completely drowned into the RF signal produced by the signal generator?

Why are the effects so intensive considering the redundancy in the DVB transmission?

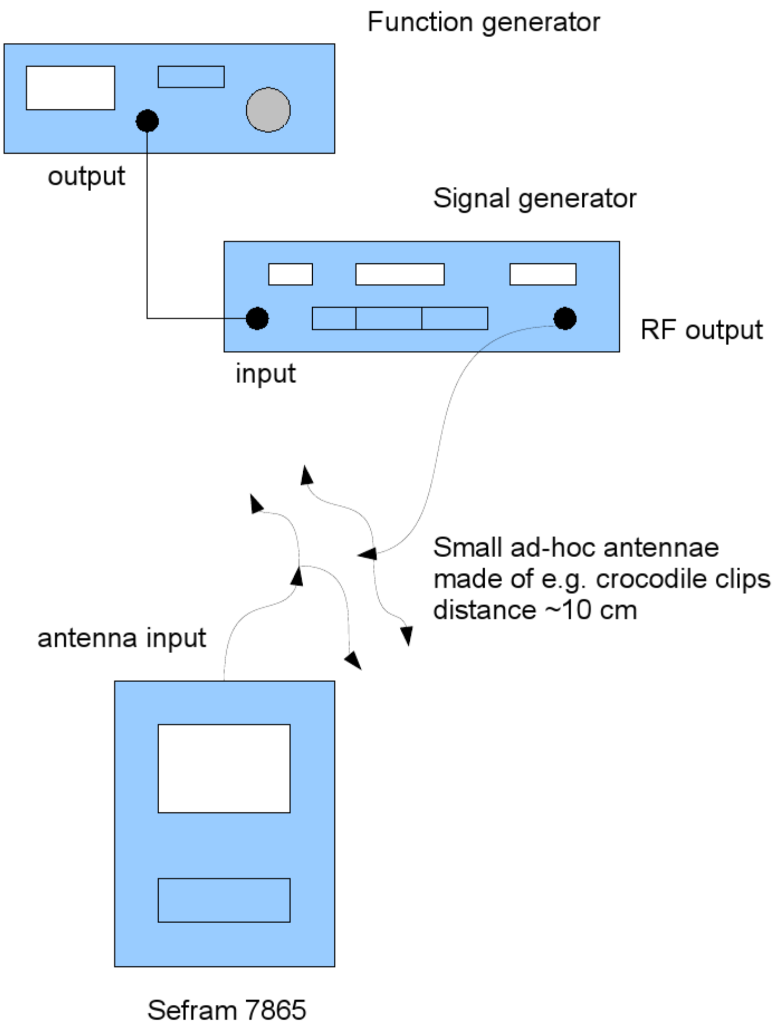

Figure 20: Illustration of the laboratory setting