DESIGNING A MOBILE TV SERVICE TO COVER A TYPICAL URBAN REGION IN AFRICA

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Abstract: Over the years, there has been an increase in demand for digital TV. To design a Digital Video Broadcasting-Terrestrial (DVB-T) transmitter network for a digital transmission or data broadcasting to mobile receivers, the first thing to put in mind is the network coverage (urban region in Africa) and the coverage criteria have to be known. In this paper we try to suggest important parameter and the suitable values that need to be put into consideration when setting up a DVB-T network.

Objectives:

- ***To develop DVB-T system for fixed and portable services.***
- ***To develop a system that the choice of one parameter does not affect the operation of other parameter. E.g. Choice of transmission bandwidth does not affect forward error correction and guard interval or vice versa.***
- ***To make sure that the DVB-T transmissions we are developing is compatible with the present equipments***
- ***To develop a system with increase in capacity and robustness when compared with existing transmission system.***
- ***To develop a system that flexible, i.e. when a parameter is changed, it has minimal no negative impact on the system.***
- ***To make sure that during the implementation of this project the transmission cost is minimized by reducing the peak to average power ration. And this can be done by selecting parameters with considerations.***

Keywords: Digital Video Broadcasting-Terrestrial (DVB-T), Digital TV, Transmitter, Mobile services, Network Coverage, DVB-T network, Bandwidth, Transmission bandwidth, Quadratic Phase Shift keying (QPSK), orthogonal frequency-division multiplexing (OFDM), Terrestrial broadcasting, Cables, Optical-fibre, Satellite.

I. INTRODUCTION

The development of DVB-T was due to the increase in demand for digital terrestrial transportation system for video, pictures and sound. This paper gives an overview of parameter selection when considering setting up a DVB-T transmission station.

In telecommunication and recording industries of today, an upgrade is taking place i.e. moving from analogue to digital technology for the transmission of signals both in cables and air channels. In the distribution of broadcast signals, digital coding and modulation can be fused together to realize different aims. And some of the aims are mentioned below:

- To produce rugged signals this in turn gives a more consistent reception in any unfavourable (weather) condition.
- To transmit more programme services within a given bandwidth, this in turn yields more resourceful utilization of spectrum.
- In order to produce a picture of high quality and multichannel sound.
- To have a low transmission cost per program service.
- To improve the communication between different equipments, this includes terrestrial broadcasting, cables, optical-fibre, and satellite.

In DVB-T standards, there are series of options both in modulation and inner code rate. Quadratic Phase Shift keying (QPSK), 16-QAM, and 64 QAM are the data carriers in orthogonal frequency-division multiplexing (OFDM). While inner code rate could be ½, 2/3, ¾, 5/6 and 7/8 with guard intervals of 1/32, 1/16, 1/8 and ¼, this makes a total of 60 options. Also, the structure of OFDM consists of 68 symbols. For example 2K mode consists of 1705 carriers while 8K mode consists of 6817 carriers. In this project all these parameters will be carefully chosen in other to get the best output of the equipment.

II. THE SYSTEM

The figures 1 & 2 represent the setup of a Digital video broadcast Terrestrials. Any of the system below can be implemented, both figures comprises of the same component. Both are given just to have different set up of DVB-T.

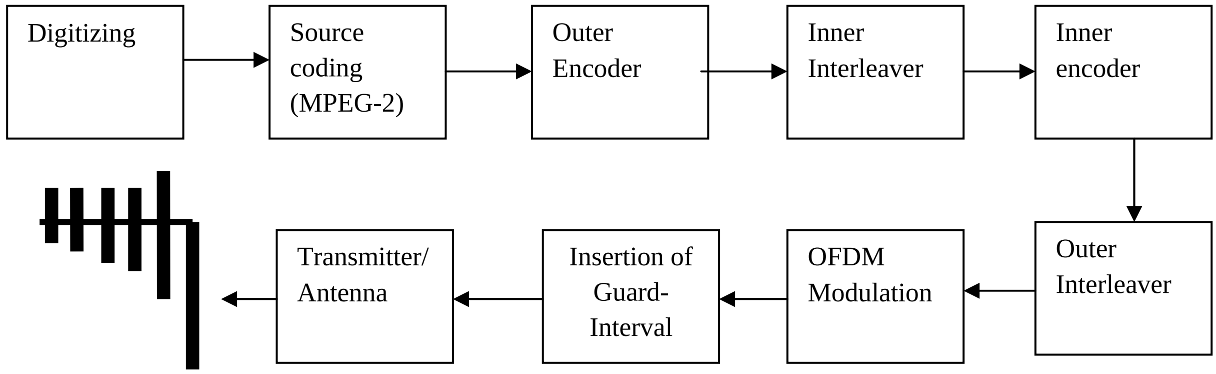


Figure 1: Block diagram of the DVB-T system 1

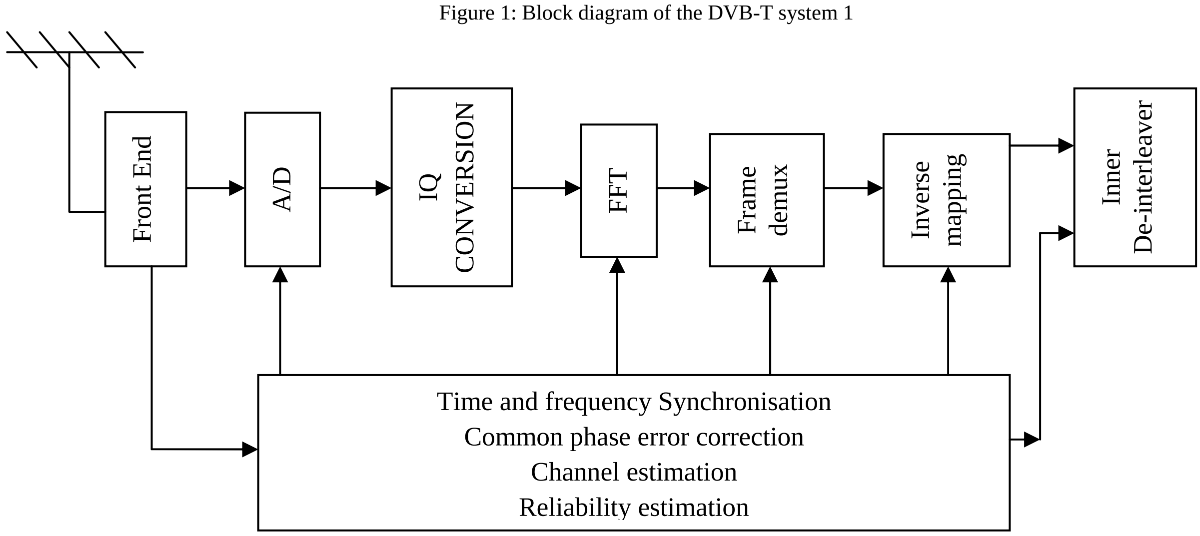


Figure 2: Block diagram of the DVB-T system 2 [1]

A. *OFDM Modulation*

The sequence of blocks is modulated based on the OFDM technique, using 1705 or 6817 carriers (2k or 8k mode, respectively). Increase in the number of carriers does not change the payload bit rate.

B. ***External encoder***

A first level of error correction is applied to the transmitted data, using a non-binary block code, a Reed-Solomon RS (204, 188) code, allowing the correction of up to a maximum of 8 wrong bytes for each 188-byte packet [2].

C. ***Internal interleaver***

At the internal interleaver, data sequence is rearranged which is aimed at reducing the effect of burst errors. This time, a block interleaving technique is adopted; with a pseudo-random assignment scheme (this is really done by two separate interleaving processes, one operating on bits and another one operating on groups of bits).

D. ***External interleaver***

Convolutional interleaving is used to reorganize the transmitted data sequence, for it becomes stronger to long sequences of errors.

E. Internal encoder

A second level of error correction is given by a punctured convolutional code, which is often denoted in STBs menus as FEC (Forward error correction). There are 5 applicable coding rates viz: 1/2, 2/3, 3/4, 5/6, and 7/8.

F. Guard interval insertion

In order to reduce receiver complexity, all OFDM block is broadened, copying in front of its own end (cyclic prefix). The width of such guard interval can be 1/32, 1/16, 1/8, or 1/4 that of the original block length. Cyclic prefix is required to operate single frequency networks, where there may exist an in eliminable interference coming from several sites transmitting the same program on the same carrier frequency [2].

G. Channel Bandwidth

The channel of the transmitter can be chosen between 6MHz, 7MHz and 8MHz as shown in Figure 3.

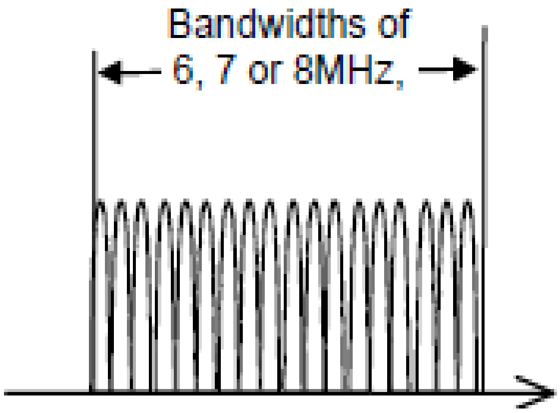


Figure 3: Transmission Bandwidth [3].

For this project we can decide to choose 7MHz as the bandwidth. We do not need to choose a lower bandwidth because the higher the bandwidth, the higher the payload data rate (Bandwidth is directly proportional to payload data-rate). On the other hand, the higher the bandwidth, the lower the transmitter maximum cell size (Bandwidth is inversely proportional to the transmitter maximum cell size), invariably this mean that more cost will be incurred on erecting transmitters by increasing the bandwidth.

H. Number of Carrier (i.e. FFT size)

For a terrestrial channel using 7MHz like this project, and for a channel that are liable to be affected by multi-path and channel interference, “a digital bit rate of about 20Mbit/s must be available” [1]. And because of this reason DVB-T have chosen a complex modulation system, orthogonal frequency-division multiplexing (OFDM). When compared with other modulation systems, OFDM can be used to transmit data at a higher rate, by modulating many carriers of low data rate simultaneously.

OFDM consists of 68 symbols and the type of OFDM will determine the numbers of carrier that will be available for use. For example, if you decide to choose 2K mode you get 1705 carriers and if you choose 8K mode you get 6917 carriers.

For the start of this project, 2k standard will be appropriate. When using 2k FFT size, the accompanied number of carrier is 1075. Consideration must be given to the size of the area that must be covered. If it’s a developing area like small towns and cities, then 2k mode will be better. But if it’s a larger area, 8k mode with 6917 carrier will suffice. But as time goes on, there will be a need to change from 2K mode to 8K mode.

I. Carrier Modulation

For this project, QAM-16 is chosen because it accommodates more bits into symbol rate than its QPSK counterpart. Though QPSK do not transmit data as fast as the modulation format QAM-16, but it can receive better when the signal strength is weak. Since we are particular about transmission end, QAM-16 will be better off.

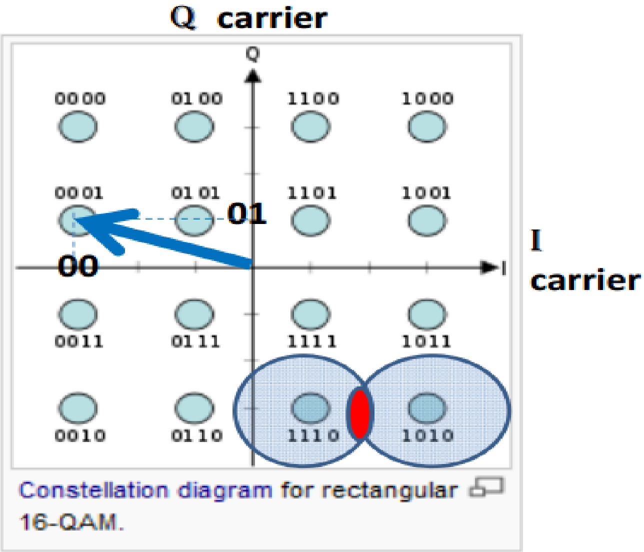


Figure 4: Diagram of 16-QAM [4]

The only disadvantage of QAM-16 is that, the received signal is susceptible to noise and interference. As shown in the diagram in figure 4, when a signal is received, due to noise and interference the carrier will be unstable because there will be phase and amplitude distortions and this forms an area on each carrier [4]. Things will be alright in an instance when the area on each carrier does not overlap, but there will be problem when there is an increase in distortion and area on the carriers begin to overlap as shown in the figure 4. Then error begins to surface in the transmitted signal. In order to correct this error, we then use error correcting circuitry [4].

In summary;

- Quadratic Phase Shift keying (QPSK) can be used for a robust data transfer, but it is characterised with a low data rate.
- 16-QAM (Quadrature amplitude modulation) can be used for transferring data at a considerable higher rate and it is good for portable devices.

So 16 QAM will be good for this project.

J. Guard Interval

Digital signals are prone to various type of distortions (propagation delay, echoes and reflections), and one of the ways to protect digital signal is to introduce guard interval. In coded orthogonal frequency division multiplexing (COFDM), at the beginning of each symbol, guard interval is introduced. For the purpose of this project, a guard interval of ¼ will be better with Duration of Guard Interval = 64µSec, Guarded Symbol Duration = 320µSec. Because when we use a longer guard interval period, this reduces the channel efficiency and it gives minimal protection from long echoes and the heist data rate. And another thing that is worthy of note is that, when choosing the value of guard interval, it must be greater than the signals relative delay because this add constructively, but when the guard interval is less that the signals relative delay this interact destructively [5].

K. Error code rate

The best code rate for this project is ¾. Because reduction in code rate will cause reduction in useful bit rate and robustness of mobile, pedestrian and portable systems, putting into consideration all other selected parameter. Though, reducing code rate increases the maximum speed of cars, but this should not be used as a trade-off for the useful bit rate considering those that will be using fixed antenna for home use.

L. Maximum Cell size

Inputting all the selected values above, the transmitter maximum cell size is 19km. That means the maximum distance between two transmitters is 19km. Though when the size of FFT is increased from 2K to 8K and keeping other values constant, the TX maximum cell size increases (from 19km to 77km), which means the cost of erecting transmitter will be minimal, but there is drastic reduction in the speed of receiver in moving vehicles. So it is better to stick to the 19km, which is better.

M. Useful bit rate

13.06Mbps is the useful bit rate when all parameters in the report are used. This is better instead of using QPSK.

N. *Robustness*

25.0db is the maximum robustness for this system using 16QAM as shown in figure 4. One of the factors that affect the robustness of the type of modulation is use. Though, robustness can be increased when we choose QPSK as shown in figure 5. The reason is that the carrier to noise ratio is very low. But the useful bit rate will be reduced drastically. And robustness shouldn't be selected over useful bit rate for us to deliver good and quality picture to our customer. Also QPSK do not transmit data as fast as the modulation format QAM-16.

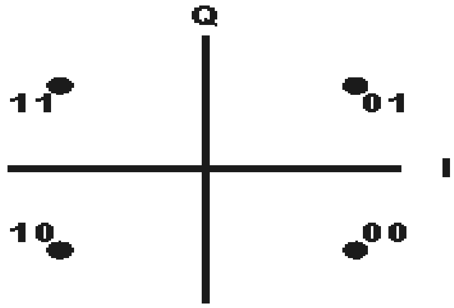


Figure 5: Diagram of QPSK

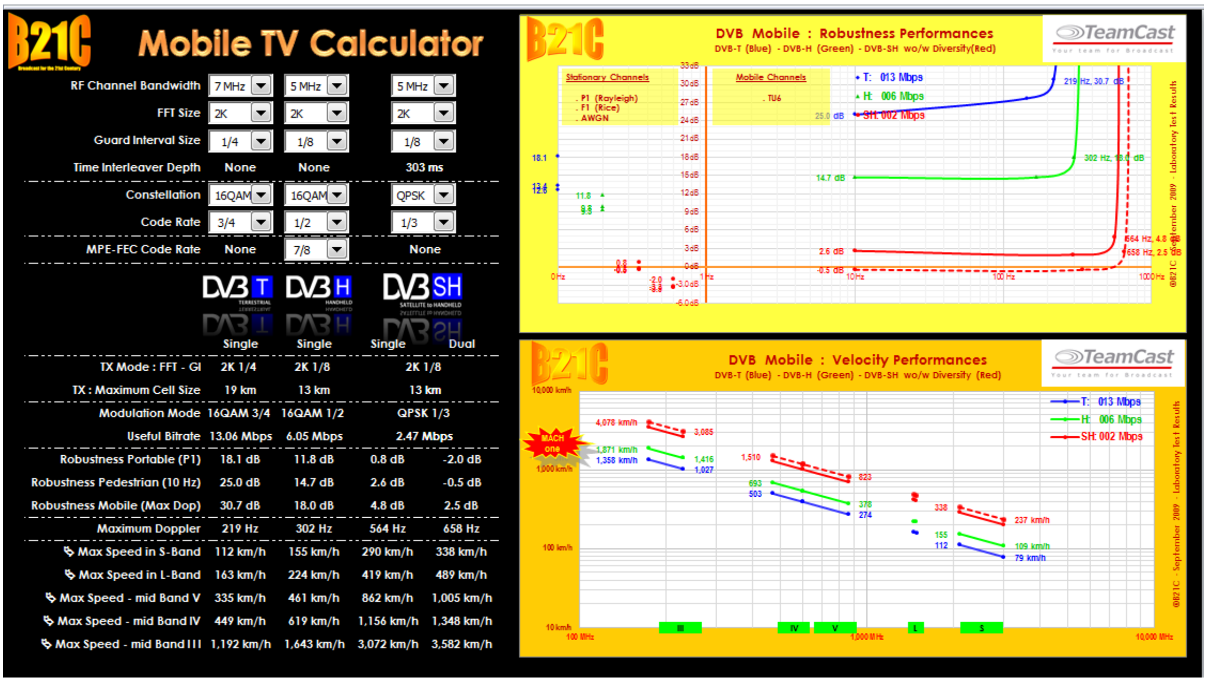
Maximum Allowable Speed for Vehicular Use

FFT Size	2K	8K
	Maximum Speed in S-band 112km/h	Maximum Speed in S-band 28km/h
	Maximum Speed in L-band 163km/h	Maximum Speed in L-band 41km/h
	Maximum Speed in mid-band V 335km/h	Maximum Speed in mid-band V 84km/h
	Maximum Speed in mid-band IV 449km/h	Maximum Speed in mid-band IV 112km/h
	Maximum Speed in mid-band III 1192km/h	Maximum Speed in mid-band III 298km/h

As shown in the table above, increasing the Carrier from 2K to 8K reduces the maximum allowable speed for vehicular use. So going for 2K FFT size will be better when considering the speed of vehicle.

III. CONCLUSION

It is obvious that the future of television is going digital. Digital transmission offers range of advantages which transmission engineers cannot overlook. With DVB-T a high data, video and audio broadcasting is possible with great investment on transmitter and network terminals. This paper presented the most cost effective plan for a DVB-T transmission station. Investment into erecting of transmitter is one of the aspects of digital transmission that must be look into with care. This paper has suggested the maximum cell size (19km) for the effectiveness of this project. As the distance reduces so the number and the cost of providing transmitter increases.



The table below is the values that can be used in determining the useful bit rate for different bandwidth, corresponding code error rate and Modulation.

Table 1: Net-Data-Rate for a Chosen RF Bandwidth and Modulation Scheme [6].

Modulation	FEC Coderate	Channel bandwidth/Kanalbandbreite (MBit/sec)															
		8 MHz				7 MHz				6 MHz				5 MHz			
		Schutzintervall/Guard				Schutzintervall/Guard				Schutzintervall/Guard				Schutzintervall/Guard			
		1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32
QPSK	1/2	4,98	5,53	5,85	6,03	4,36	4,84	5,12	5,28	3,74	4,15	4,39	4,52	3,11	3,46	3,66	3,77
	2/3	6,64	7,37	7,81	8,04	5,81	6,45	6,83	7,04	4,98	5,53	5,86	6,03	4,15	4,61	4,88	5,03
	3/4	7,46	8,29	8,78	9,05	6,53	7,25	7,68	7,92	5,60	6,22	6,59	6,79	4,66	5,18	5,49	5,66
	5/6	8,29	9,22	9,76	10,05	7,25	8,07	8,54	8,79	6,22	6,92	7,32	7,54	5,18	5,76	6,10	6,28
	7/8	8,71	9,68	10,25	10,56	7,62	8,47	8,97	9,24	6,53	7,26	7,69	7,92	5,44	6,05	6,41	6,60
16-QAM	1/2	9,95	11,06	11,71	12,06	8,71	9,68	10,25	10,55	7,46	8,30	8,78	9,05	6,22	6,91	7,32	7,54
	2/3	13,27	14,75	15,61	16,09	11,61	12,91	13,66	14,08	9,95	11,06	11,71	12,07	8,29	9,22	9,76	10,06
	3/4	14,93	16,59	17,56	18,10	13,06	14,52	15,37	15,84	11,20	12,44	13,17	13,58	9,33	10,37	10,98	11,31
	5/6	16,59	18,43	19,52	20,11	14,52	16,13	17,08	17,60	12,44	13,82	14,64	15,08	10,37	11,52	12,20	12,57
	7/8	17,42	19,35	20,49	21,11	15,24	16,93	17,93	18,47	13,07	14,51	15,37	15,83	10,89	12,09	12,81	13,19
64-QAM	1/2	14,93	16,59	17,56	18,10	13,06	14,52	15,37	15,84	11,20	12,44	13,17	13,58	9,33	10,37	10,98	11,31
	2/3	19,91	22,12	23,42	24,13	17,42	19,36	20,49	21,11	14,93	16,59	17,57	18,10	12,44	13,83	14,64	15,08
	3/4	22,39	24,88	26,35	27,14	19,59	21,77	23,06	23,75	16,79	18,66	19,76	20,36	13,99	15,55	16,47	19,96
	5/6	24,88	27,65	29,27	30,16	21,77	24,19	25,61	26,39	18,66	20,74	21,95	22,62	15,55	17,28	18,29	18,85
	7/8	26,13	29,03	30,74	31,67	22,86	25,40	26,90	27,71	19,60	21,77	23,06	23,75	16,33	18,14	19,21	19,79

REFERENCES

[1] Fraidoon Mazda. Telecommunications engineering's Reference Book, 2nd edition. Focal press 1998

[2] http://en.wikipedia.org/wiki/DVB-T

[3] Okubo. A. Presentation 1. Digital TV Broadcasting in Japan. 28th February – 1st March, 2007. Pp9.

[4] Crawford D. Transmission System. CE702 note. University of Essex

[5] Nasr et al, Performance of an Echo Canceller and Channel Estimator for On-Channel Repeaters in DVB-T/H Networks, IEEE TRANSACTIONS ON BROADCASTING, VOL. 53, NO. 3, SEPTEMBER 2007

[6] RF Newsletter Orange County Amateur Radio Club www.W6ZE.org. June 2010. Page 12