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## **Performance of DTT receivers following a mode change**

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## **Performance of DTT receivers following a mode change**

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### **Abstract**

Currently, all Digital Terrestrial Television (DTT) transmissions in the UK use a single transmission mode, which is often referred to as the "UK mode". However, the transmission specification allows for many possible variants. One issue that may become important at any time during preparations for digital switch-over, is the way in which existing receivers would respond if an operator chose to change transmission mode, or if an operator started a service using a different mode. BBC R&D conducted a study of this issue, and the results are presented in this paper.

18 DTT receivers were tested to determine the effects of using some alternative 2K transmission modes. In all cases, the receivers were able to receive the alternative modes, generally with little user intervention. There was one exception to this – in the case where two multiplexes were operated in a mixture of modes, but with the same programme stream on both multiplexes. In this case, most receivers only found one of the multiplexes.

**Key words:** digital terrestrial television; receiver; set-top box; integrated digital television

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## Performance of DTT receivers following a mode change

Chris Nokes, Tom Ellinor

### 1 Introduction

Currently, all Digital Terrestrial Television (DTT) transmissions in the UK use a single transmission mode, which is often referred to as the "UK mode". However, the transmission specification [1] allows for many possible variants. One issue that may become important at any time during preparations for digital switch-over, is the way in which existing receivers would respond if an operator chose to change transmission mode, or if an operator started a service using a different mode. BBC R&D conducted a study of this issue, and the results are presented in this paper.

Whilst these results are representative of receivers manufactured over the past 4 years, there are almost certainly a number of receivers, or particular variants of a given model, which have been deployed but were not represented in these tests. Therefore these results can be regarded only as representative, rather than fully comprehensive.

### 2 Description of the tests

BBC R&D has the capability within its laboratories to generate two full RF DTT multiplexes, operating in any transmission mode. This system was used to test a wide range of both set-top boxes (STB's) and integrated digital televisions (iDTV's) in a variety of transmission modes. The specific conditions of the tests were set to answer several questions as shown below, although time limitations meant that it was not possible to perform every test configuration with every receiver. Similarly, only a selection of modes was tested, the ones chosen representing the most likely candidate modes.

#### 2.1 Test conditions

Six different test conditions were examined, in an attempt to answer the following questions:

- a) Does the receiver operate in the mode under test?
- b) Does the receiver continue to operate if the signal feeding it is switched from the UK mode (64-QAM, rate 2/3, guard interval 1/32) to the mode under test?
- c) Can the receiver find two multiplexes operating in a mixture of modes, when both multiplexes contain the same programme streams and the UK mode comes first in the scan?
- d) Can the receiver find two multiplexes operating in a mixture of modes, when both multiplexes contain the same programme streams and the UK mode comes last in the scan?
- e) Can the receiver find two multiplexes operating in a mixture of modes, when the two multiplexes contain different programme streams and the UK mode comes first in the scan?
- f) Can the receiver find two multiplexes operating in a mixture of modes, when the two multiplexes contain different programme streams and the UK mode comes last in the scan?

## 2.2 Candidate modes

Four possible transmission modes were tested. However, no comment about the relative merit of these modes should be inferred. An FFT size of 2K, and a guard interval of 1/32 were used throughout the tests<sup>1</sup>.

The four modes tested were:

- a) 16-QAM, code rate 1/2
- b) 16-QAM, code rate 2/3
- c) 16-QAM, code rate 3/4
- d) 64-QAM, code rate 1/2

## 2.3 Receivers tested

9 STB's and 9 iDTV's were tested. For obvious commercial reasons the identity of the individual receivers has not been revealed. It should be noted that some of the receivers represent prototype models that have yet to be deployed.

## 3 Results

The full details of the results are given in the Appendices. A summary of these results is given here.

All of the receivers were able to receive all of the modes tested, generally with little intervention from the user. In most cases, no intervention was required at all. One of the STB's and two of the iDTV's required a "re-boot" to find the test mode, either by changing channel, selecting the menu or power cycling the receiver. A further two iDTV's required a rescan to find the new mode.

The only exception to the above was in the cases where two multiplexes were supplied, but with the same programme stream in both multiplexes. In this scenario, most receivers only listed one programme stream in their channel list, and so only one of the two services could be said to have been found. This could have implications if it was decided to have a transition scenario where services were simulcast for a short period. Further tests would be required to determine whether it would be possible to make some changes to the programme streams at the MPEG level (e.g. by changing the PID) which would allow the receivers to list both services in their channel lists, even though they might in effect be the same, as a workaround for this relatively minor problem.

## 4 Conclusions

18 DTT receivers have been tested to determine the effects of using transmission modes other than the one that has been used to date. In all cases, the receivers were able to receive the alternative modes tested and generally with little user intervention. There was one exception to this – in the case where two multiplexes were operated in a mixture of modes, but with the same programme stream on both multiplexes. In this case, most receivers only found one of the multiplexes.

## 5 References

1. 'Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television'. European Standard ETSI EN 300 744 V1.4.1 (2001-01).

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<sup>1</sup> A brief test was conducted with the 9 STB's changing from the UK mode to the equivalent 8K mode. None of the STB's was able to recognise the 8K variant. It is understood from some manufacturers that it may be possible to perform an over-air software upgrade to allow some STB's to work in 8K, but BBC R&D does not currently have the facility to simulate the over-air software upgrade. It is also believed that some STB's have been deployed with 2K only chip-sets, which could therefore never be upgraded.

### Appendix 1 Detailed results of STB tests; single multiplex

Key:										
<b>YES</b>	Received (no user action required)	<b>BT</b>	requires STB reboot to receive after mode change by changing channel, selecting menu or power cycling the STB							
<b>NO</b>	Could not be received									
		STB A	STB B	STB C	STB D	STB E	STB F	STB G	STB H	STB I
Receive in mode										
16QAM, 1/2 Gi 1/32		YES	YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 2/3 Gi 1/32		YES	YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 3/4 Gi 1/32		YES	YES	YES	YES	YES	YES	YES	YES	YES
64QAM, 1/2 Gi 1/32		YES	YES	YES	YES	YES	YES	YES	YES	YES
Change mode from 64QAM, 2/3 Gi 1/32 to:				Both services with same programme						
16QAM, 1/2 Gi 1/32		YES	YES	YES	YES	YES	YES	BT	YES	YES
16QAM, 2/3 Gi 1/32		YES	YES	YES	YES	YES	YES	BT	YES	YES
16QAM, 3/4 Gi 1/32		YES	YES	YES	YES	YES	YES	BT	YES	YES
64QAM, 1/2 Gi 1/32		YES	YES	YES	YES	YES	YES	BT	YES	YES

## Appendix 2 Detailed results of STB tests; two multiplexes with the same programme

Key:										
YES	Received (no user action required)	BT	requires STB reboot to receive after mode change by changing channel,selecting menu or power cycling the STB							
NO	Could not be received									
		STB A	STB B	STB C	STB D	STB E	STB F	STB G	STB H	STB I
Find channel in mixed mode band where 64QAM, 2/3 Gi 1/32 comes first in the scan :			Both services with same programme and the same signal amplitudes							
64QAM 2/3 & 16QAM 1/2										
64QAM, 2/3 Gi 1/32 found	NO	YES	YES	YES	YES	YES	NO	NO	NO	YES
16QAM, 1/2 Gi 1/32 found	YES	NO	NO	NO	NO	NO	YES	YES	YES	NO
64QAM 2/3 & 16QAM 2/3										
64QAM, 2/3 Gi 1/32 found	NO	YES	YES	YES	YES	YES	NO	NO	NO	YES
16QAM, 2/3 Gi 1/32 found	YES	NO	NO	NO	NO	NO	YES	YES	YES	NO
64QAM 2/3 & 16QAM 3/4										
64QAM, 2/3 Gi 1/32 found	NO	YES	YES	YES	YES	YES	NO	NO	NO	YES
16QAM, 3/4 Gi 1/32 found	YES	NO	NO	NO	NO	NO	YES	YES	YES	NO
64QAM 2/3 & 64QAM 1/2										
64QAM, 2/3 Gi 1/32 found	NO	YES	YES	YES	YES	YES	NO	NO	NO	YES
64QAM, 1/2 Gi 1/32 found	YES	NO	NO	NO	NO	NO	YES	YES	YES	NO
Find channel in mixed mode band where 64QAM, 2/3 Gi 1/32 comes last in the scan :			Both services with same programme							
16QAM 1/2 & 64QAM 2/3										
64QAM, 2/3 Gi 1/32 found	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES
16QAM, 1/2 Gi 1/32 found	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
16QAM 2/3 & 64QAM 2/3										
64QAM, 2/3 Gi 1/32 found	YES	NO	NO	NO	NO	NO	YES	YES	NO	YES
16QAM, 2/3 Gi 1/32 found	NO	YES	YES	YES	YES	YES	NO	NO	YES	YES
16QAM 3/4 & 64QAM 2/3										
64QAM, 2/3 Gi 1/32 found	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES
16QAM, 3/4 Gi 1/32 found	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
64QAM 2/3 & 64QAM 1/2										
64QAM, 2/3 Gi 1/32 found	NO	NO	NO	NO	NO	NO	YES	NO	NO	YES
64QAM, 1/2 Gi 1/32 found	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES

### Appendix 3 Detailed results of STB tests; two multiplexes with different programmes

Key:										
YES	Received (no user action required)	BT	requires STB reboot to receive after mode change by changing channel,selecting menu or power cycling the STB							
NO	Could not be received									
		STB A	STB B	STB C	STB D	STB E	STB F	STB G	STB H	STB I
Find channel in mixed mode band where 64QAM, 2/3 Gi 1/32 comes first in the scan :			Services with different programme streams							
64QAM 2/3 & 16QAM 1/2										
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 1/2 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
64QAM 2/3 & 16QAM 2/3										
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
64QAM 2/3 & 16QAM 3/4										
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 3/4 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
64QAM 2/3 & 64QAM 1/2										
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
64QAM, 1/2 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
Find channel in mixed mode band where 64QAM, 2/3 Gi 1/32 comes last in the scan :			Services with different programme streams							
16QAM 1/2 & 64QAM 2/3										
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 1/2 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
16QAM 2/3 & 64QAM 2/3										
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
16QAM 3/4 & 64QAM 2/3										
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 3/4 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
64QAM 2/3 & 64QAM 1/2										
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES
64QAM, 1/2 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES



### Appendix 4 Detailed results of iDTV tests; single multiplex

Key:										
<b>YES</b>	Received (no user action required)	<b>BT</b>	requires iDTV reboot to receive after mode change by changing channel, selecting menu or power cycling the iDTV							
<b>NO</b>	Could not be received	<b>SC</b>	requires rescan to find mode change							
		iDTV A	iDTV B	iDTV C	iDTV D	iDTV E	iDTV F	iDTV G	iDTV H	iDTV I
Receive in mode										
16QAM, 1/2 Gi 1/32		BT	YES	SC	YES	YES	YES	YES	YES	SC
16QAM, 2/3 Gi 1/32		BT	YES	SC	YES	YES	YES	YES	BT	SC
16QAM, 3/4 Gi 1/32		YES	YES	SC	YES	YES	YES	YES	YES	SC
64QAM, 1/2 Gi 1/32		YES	YES	YES	YES	YES	YES	YES	YES	YES
Both services with same programme										
Change mode without changing channel from 64QAM, 2/3 Gi 1/32 to:										
16QAM, 1/2 Gi 1/32		BT	YES	SC	YES	YES	YES	YES	YES	SC
16QAM, 2/3 Gi 1/32		BT	YES	SC	YES	YES	YES	YES	YES	SC
16QAM, 3/4 Gi 1/32		BT	YES	SC	YES	YES	YES	YES	YES	SC
64QAM, 1/2 Gi 1/32		YES	YES	SC	YES	YES	YES	YES	YES	SC

**Appendix 5 Detailed results of iDTV tests; two multiplexes with the same programme**

Key:																		
YES	Received (no user action required)	BT	requires iDTV reboot to receive after mode change by changing channel,selecting menu or power cycling the iDTV															
NO	Could not be received	SC	requires rescan to find mode change															
			iDTV A	iDTV B	iDTV C	iDTV D	iDTV E	iDTV F	iDTV G	iDTV H	iDTV I							
Find channel in mixed mode band where 64QAM, 2/3 Gi 1/32 comes first when the band is re-scanned :			Both services with same programme and the same signal amplitudes															
64QAM 2/3 & 16QAM 1/2			<b>NOT TESTED</b>															
64QAM, 2/3 Gi 1/32 found																		
16QAM, 1/2 Gi 1/32 found																		
64QAM 2/3 & 16QAM 2/3																		
64QAM, 2/3 Gi 1/32 found																		
16QAM, 2/3 Gi 1/32 found																		
64QAM 2/3 & 16QAM 3/4																		
64QAM, 2/3 Gi 1/32 found																		
16QAM, 3/4 Gi 1/32 found																		
64QAM 2/3 & 64QAM 1/2																		
64QAM, 2/3 Gi 1/32 found																		
64QAM, 1/2 Gi 1/32 found																		
Find channel in mixed mode band where 64QAM, 2/3 Gi 1/32 comes last when the band is re-scanned :										Both services with same programme								
16QAM 1/2 & 64QAM 2/3																		
64QAM, 2/3 Gi 1/32 found										YES	NO	YES	NO	NO	YES	NO	NO	YES
16QAM, 1/2 Gi 1/32 found										YES	YES	SC	YES	YES	YES	YES	YES	YES
16QAM 2/3 & 64QAM 2/3																		
64QAM, 2/3 Gi 1/32 found			YES	NO	YES	NO	NO	YES	NO	NO	YES							
16QAM, 2/3 Gi 1/32 found			YES	YES	SC	YES	YES	YES	YES	YES	YES							
16QAM 3/4 & 64QAM 2/3																		
64QAM, 2/3 Gi 1/32 found			YES	NO	YES	NO	NO	YES	NO	NO	YES							
16QAM, 3/4 Gi 1/32 found			YES	YES	SC	YES	YES	YES	YES	YES	YES							
64QAM 2/3 & 64QAM 1/2																		
64QAM, 2/3 Gi 1/32 found			YES	NO	YES	NO	NO	YES	NO	NO	YES							
64QAM, 1/2 Gi 1/32 found			YES	YES	SC	YES	YES	YES	YES	YES	YES							

## Appendix 6 Detailed results of iDTV tests; two multiplexes with different programmes

Key:											
YES	Received (no user action required)	BT	requires iDTV reboot to receive after mode change by changing channel,selecting menu or power cycling the iDTV								
NO	Could not be received	SC	requires rescan to find mode change								
			iDTV A	iDTV B	iDTV C	iDTV D	iDTV E	iDTV F	iDTV G	iDTV H	iDTV I
Find channel in mixed mode band where 64QAM, 2/3 Gi 1/32 comes first when the band is re-scanned :			Services with different programme streams								
64QAM 2/3 & 16QAM 1/2											
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 1/2 Gi 1/32 found			BT	YES	BT	YES	YES	YES	YES	YES	YES
64QAM 2/3 & 16QAM 2/3											
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 2/3 Gi 1/32 found			BT	YES	BT	YES	YES	YES	YES	YES	YES
64QAM 2/3 & 16QAM 3/4											
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 3/4 Gi 1/32 found			BT	YES	BT	YES	YES	YES	YES	YES	YES
64QAM 2/3 & 64QAM 1/2											
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES	YES
64QAM, 1/2 Gi 1/32 found			BT	YES	BT	YES	YES	YES	YES	YES	YES
Find channel in mixed mode band where 64QAM, 2/3 Gi 1/32 comes last when the band is re-scanned :			Services with different programme streams								
16QAM 1/2 & 64QAM 2/3											
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 1/2 Gi 1/32 found			BT	YES	BT	YES	YES	YES	YES	YES	YES
16QAM 2/3 & 64QAM 2/3											
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 2/3 Gi 1/32 found			BT	YES	BT	YES	YES	YES	YES	YES	YES
16QAM 3/4 & 64QAM 2/3											
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES	YES
16QAM, 3/4 Gi 1/32 found			BT	YES	BT	YES	YES	YES	YES	YES	YES
64QAM 2/3 & 64QAM 1/2											
64QAM, 2/3 Gi 1/32 found			YES	YES	YES	YES	YES	YES	YES	YES	YES
64QAM, 1/2 Gi 1/32 found			BT	YES	BT	YES	YES	YES	YES	YES	YES