SystemView
BY ELANIX

Digital Video Broadcast Library
(DVB)

Conforming to European Telecommunications Standard
ETS 300 744
(March 1997)
## Table of Contents

1.0 Introduction ........................................................................................................... 5

2.0 General Information ............................................................................................. 7

3.0 Token Parameter Definitions ................................................................................ 9

4.0 Data Rates ............................................................................................................ 15

5.0 Example Files ...................................................................................................... 17

6.0 DVB Library Tokens ......................................................................................... 19

<table>
<thead>
<tr>
<th>Token Name</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit Deinterleaver</td>
<td>BitDint</td>
</tr>
<tr>
<td>Bit Demux</td>
<td>BitDemux</td>
</tr>
<tr>
<td>Bit Interleaver QPSK</td>
<td>BitIntQPSK</td>
</tr>
<tr>
<td>Bit Interleaver 16QAM</td>
<td>BitInt16</td>
</tr>
<tr>
<td>Bit Interleaver 64QAM</td>
<td>BitInt64</td>
</tr>
<tr>
<td>Bit Mux QPSK</td>
<td>BMuxQPSK</td>
</tr>
<tr>
<td>Bit Mux 16QAM</td>
<td>BMXQAM16</td>
</tr>
<tr>
<td>Bit Mux 64QAM</td>
<td>BMXQAM64</td>
</tr>
<tr>
<td>Depuncture</td>
<td>Depunct</td>
</tr>
<tr>
<td>DVB Detector</td>
<td>Detector</td>
</tr>
<tr>
<td>DVB Demodulator</td>
<td>DVBDMod</td>
</tr>
<tr>
<td>DVB Modulator</td>
<td>DVBMOD</td>
</tr>
<tr>
<td>OFDM Demodulator</td>
<td>OFDMDMod</td>
</tr>
<tr>
<td>OFDM Modulator</td>
<td>OFDMOD</td>
</tr>
<tr>
<td>PRBS Data</td>
<td>PRBS</td>
</tr>
<tr>
<td>Puncture</td>
<td>Punct</td>
</tr>
<tr>
<td>Symbol Deinterleaver</td>
<td>SymDint</td>
</tr>
<tr>
<td>Symbol Demapper</td>
<td>Demap</td>
</tr>
<tr>
<td>Symbol Interleaver</td>
<td>SymInt</td>
</tr>
<tr>
<td>Symbol Mapper</td>
<td>SymMap</td>
</tr>
</tbody>
</table>

SystemView DVB Library
1.0 Introduction

The SystemView DVB Library contains a comprehensive set of tools to aid in the design and simulation of systems that are based on the European Telecommunications Standard, ETS 300 744. A complete set of models representing the various stages in signal generation and demodulation are presented, in addition to single tokens representing complete modulators and demodulators.

The Eagleware-Elanix DVB library contains a complete set of SystemView Tokens, that are necessary for the complete modulation, demodulation and formatting of data. The tokens are organized into two groups:

1) Components that perform one single function are:

- Convolutional Code Puncture and Depuncture
- Bit Multiplexing and Bit Demultiplexing
- Bit Interleaving and Bit Deinterleaving
- Symbol Detection
- Symbol Interleaving and Symbol Deinterleaving
- Symbol Mapping and Symbol Demapping
- OFDM (Orthogonal Frequency Division Multiplexing) Modulation and Demodulation

2) Two composite tokens, the DVB Modulator and the DVB Demodulator.

With the exception of the code puncture operation, the DVB modulator incorporates the modulation functions described above. The DVB Demodulator inverts the modulation process and contains the complementary demodulator chain functions.
All DVB Library tokens are input and output compatible with the European Standard ETS 300 744, and can interface with tokens from other SystemView libraries. As an option, a SystemView simulation can mix tokens from either of the two groups described above, and also incorporate generic tokens from other SystemView libraries (Convolutional and Reed Solomon Encoders/Decoders, Interleavers/DeInterleavers etc.).
2.0 General Information

To access the DVB library, Click and drag a Custom library token to the SystemView window. Right click on the token and select Library. The libraries licensed to the user are displayed in the Custom Libraries window.

The main elements of the DVB system are shown in Figure 1:

- [204, 188, 8] shortened Reed Solomon code.
- [17, 12] convolutional interleaver.
- Rate $\frac{1}{2}$ k= 7 punctured convolutional encoder, code polynomial (133, 171) octal.
- DVB modulator (Figure 2) consisting of:
  1. Demux
  2. Bit Interleaver
  3. Symbol Interleaver
  4. Symbol Mapper
  5. OFDM Modulator

To recover the modulated signal of the DVB, there is a DVB demodulation chain token for each of the above functions that invert the operation of the matching modulator part.
Figure 1: End-to-End DVB system

a) QPSK

b) 16QAM

c) 64QAM

Figure 2: DVB Data Modulator

SystemView DVB Library
3.0 Token Parameter Definitions

- **Alpha Hierarchy Mode**

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>1,2,4</td>
</tr>
<tr>
<td>Default Value</td>
<td>1</td>
</tr>
<tr>
<td>Definition</td>
<td>The Alpha (α) Hierarchy Mode is used to shape the 16QAM and 64QAM constellations. A value of α=1 describes an equally spaced constellation.</td>
</tr>
</tbody>
</table>

- **Modulation Type**

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>QPSK, 16QAM, 64QAM</td>
</tr>
<tr>
<td>Default Value</td>
<td>QPSK</td>
</tr>
<tr>
<td>Definition</td>
<td>The three types of modulation supported are QPSK, 16QAM, and 64QAM</td>
</tr>
</tbody>
</table>
**Frame Type 2K/8K**

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>2K, 8K</td>
</tr>
<tr>
<td>Default Value</td>
<td>2K</td>
</tr>
<tr>
<td>Definition</td>
<td>The frame type specifies one of two modes of OFDM modulation. In the 2K modes there are 1512 useful carriers modulated with data. With the addition of the pilot and other synchronization data, the total is 1704 modulated carriers. Efficient generation of the OFDM signal employs an FFT algorithm with the next power of two or 2048, hence the designation 2K. In the same way, the 8K mode has 6048 useful carriers and a total of 6816 carriers. An 8192 (8K) point FFT generates the modulated signal.</td>
</tr>
</tbody>
</table>
### Threshold (v)

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>Any</td>
</tr>
<tr>
<td>Default Value</td>
<td>0</td>
</tr>
</tbody>
</table>
| Definition          | This parameter distinguishes a logical 1 from a logical 0 for input to the Bit Demux, and PBRS Data, tokens.  
                      $\text{Input } \geq \text{threshold output } = 1$  
                      $\text{Input } < \text{threshold output } = 0$ |

### Input Delay (sec)

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>No Negative Value</td>
</tr>
<tr>
<td>Default Value</td>
<td>0</td>
</tr>
<tr>
<td>Definition</td>
<td>This value tells the token the start time of the valid information. It is used, to account for the group delay in the system between the OFDM modulator and the demodulator.</td>
</tr>
</tbody>
</table>
• Guard Interval Type

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>$1 = 1, 2, 3, 4$</td>
</tr>
<tr>
<td>Default Value</td>
<td>1</td>
</tr>
</tbody>
</table>

**Definition**

The OFDM signal, allows for the time spread of the fading signal, after the FFT is extended in time by a guard interval. A transmitted signal time interval $T_s$, is related to the useful signal time interval $T_u$, and the guard interval $\Delta$ via the simple relation:

$$T_s = T_u + \Delta$$

The parameterizations of $\Delta$ are expressed as a fraction of the time $T_u$.

<table>
<thead>
<tr>
<th>Input Parameter</th>
<th>$\Delta/T_u$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1/4$</td>
</tr>
<tr>
<td>2</td>
<td>$1/8$</td>
</tr>
<tr>
<td>3</td>
<td>$1/16$</td>
</tr>
<tr>
<td>4</td>
<td>$1/32$</td>
</tr>
</tbody>
</table>
• **Code Rate**

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>0,1,2,3,4</td>
</tr>
<tr>
<td>Default Value</td>
<td>0</td>
</tr>
<tr>
<td>Definition</td>
<td>This entry specifies the net code rate of the convolutional encoder taking into account the puncture operation:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input Parameter</th>
<th>Code Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1/2</td>
</tr>
<tr>
<td>1</td>
<td>2/3</td>
</tr>
<tr>
<td>2</td>
<td>3/4</td>
</tr>
<tr>
<td>3</td>
<td>5/6</td>
</tr>
<tr>
<td>4</td>
<td>7/8</td>
</tr>
</tbody>
</table>

• **Clock Threshold (v)**

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>Any</td>
</tr>
<tr>
<td>Default Value</td>
<td>0</td>
</tr>
<tr>
<td>Definition</td>
<td>The value that separates a logical 1 from a logical 0, for the input clock signal that drives the PRBS token. This token is located in the SystemView Communications Library.</td>
</tr>
</tbody>
</table>
### Logic 1 Output

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>Any</td>
</tr>
<tr>
<td>Default Value</td>
<td>1</td>
</tr>
<tr>
<td>Definition</td>
<td>The numeric value that represents a logic 1 in the PRBS sequence.</td>
</tr>
</tbody>
</table>

### Logic 0 Output

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Inputs</td>
<td>Any</td>
</tr>
<tr>
<td>Default Value</td>
<td>0</td>
</tr>
<tr>
<td>Definition</td>
<td>The numeric value that represents a logic 0 in the PRBS sequence.</td>
</tr>
</tbody>
</table>


4.0 Data Rates

This section describes the procedure for determining the DVB Modulator input data rates. Table 19 in the ETS 300 744 specification, gives a complete listing of the useful data rates. Two examples of how the numbers are determined are presented here.

Since the modulated OFDM symbol has a multiplexed guard interval, only part of the symbol contains the modulated (useful) input data. The time period of OFDM useful data is \( T_u \). As defined in Table 4 of ETS 300 744, the value of \( T_u \), for the 8K and 2K modes, are 896 and 224 microseconds respectively.

The starting point is the definition of the useful data symbol time interval. \( T_u \) in terms of the parameter \( T \) is defined as follows:

\[
T_u = 896 \text{ µsec} = 8192T \quad \text{........ 8K mode} \\
T_u = 224 \text{ µsec} = 2048T \quad \text{........ 2K mode}
\]

In either case, compute \( T = 0.109375 \text{ µsec} \). The value \( R = 1/T = 9.1428 \text{MHz} \) is the sample or data rate used by the FFT modulator to generate the OFDM signal.

The 2K mode has 1512 useful carriers (\( K_{useful} \)), and the 8K mode has 6048 useful carriers. This data is transmitted over an OFDM symbol time of \( T_s \). Therefore the symbol time into the OFDM modulator is:

\[
T_{sym} = T_s/K_{useful}
\]

Example: for a 2K mode with a guard time of \( 1/4 \), \( T_s = 280 \text{µsec} \) from which \( T_{sym} = 280 \text{µsec}/1512 = 0.1852 \text{µsec} \). The corresponding rate \( R_{sym} = 1/T_{sym} = 5.4 \text{Msym/sec} \). Similar calculations apply for the 8K mode and the other guard interval times. Note that this data rate applies to both the I and Q parts of the symbol.
The number of bits associated with each symbol depends on the modulation type, as shown:

<table>
<thead>
<tr>
<th>Modulation Type</th>
<th>Bits/Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPSK</td>
<td>2</td>
</tr>
<tr>
<td>16QAM</td>
<td>4</td>
</tr>
<tr>
<td>64QAM</td>
<td>6</td>
</tr>
</tbody>
</table>

The input bit rate for QPSK modulation is 10.8 Mbps. This is the data rate of the serial data, out of the puncture token and convolutional encoder. The rate into the convolutional encoder is this rate, times the rate of the coder/puncture combination. For a code rate of ½ (i.e. no puncturing), the data rate into the convolutional encoder is 5.4 Mbps. The useful data rate into the whole system, is the rate into the convolutional encoder divided by the rate of the Reed Solomon encoder, or:

\[ R_{data} = \frac{5.4 \text{ Mbps}}{204/188} = 4.976 \text{ Mbps} \]

This is the entry given in Table 19 of the ETS 300 744 Specification for this case.

If the correct input rates are maintained, the DVB tokens will automatically adjust the output data rates to conform to the DVB standard.
5.0 Example Files

The eight example files listed in Table 1 indicate the various DVB system configurations. In each example there are two parallel systems as shown in the example of figure 3.

Figure 3: DVB simulation Block by Block vs. Single token

For the 16qam_2K_1_4.svu example, each path corresponds to the modulator, from the output of the convolutional encoder/puncture operation, to the output of the OFDM modulator. A delay is added to simulate the channel group delay, from the OFDM modulator to the OFDM demodulator. The inverse steps used by the modulator recover the input data. In one path each element of the process is explicitly used in its proper position. The second path uses the DVB Modulator and DVB Demodulator tokens that replace the combination of the individual elements. In both cases the output should agree with the input data.
### Table 1: Example File Parameters

<table>
<thead>
<tr>
<th>File name</th>
<th>Modulation Type</th>
<th>Mode (2K, 8K)</th>
<th>Alpha</th>
<th>Guard Interval</th>
<th>Time Offset usec</th>
</tr>
</thead>
<tbody>
<tr>
<td>16qam_2K_1_4.svu</td>
<td>16QAM</td>
<td>2K</td>
<td>1</td>
<td>¼</td>
<td>4.08</td>
</tr>
<tr>
<td>16qam_8K_1_4.svu</td>
<td>16QAM</td>
<td>8K</td>
<td>1</td>
<td>¼</td>
<td>4.08</td>
</tr>
<tr>
<td>16qam_8K_2_4.svu</td>
<td>16QAM</td>
<td>8K</td>
<td>2</td>
<td>¼</td>
<td>3.14</td>
</tr>
<tr>
<td>16qam_8K_4_4.svu</td>
<td>16QAM</td>
<td>8K</td>
<td>4</td>
<td>¼</td>
<td>3.14</td>
</tr>
<tr>
<td>64qam_8K_1_4.svu</td>
<td>64QAM</td>
<td>8K</td>
<td>1</td>
<td>¼</td>
<td>0.50</td>
</tr>
<tr>
<td>64qam_8K_2_4.svu</td>
<td>64QAM</td>
<td>8K</td>
<td>2</td>
<td>¼</td>
<td>0.50</td>
</tr>
<tr>
<td>qpsk_2K_1_4.svu</td>
<td>QPSK</td>
<td>2K</td>
<td>1</td>
<td>¼</td>
<td>3.14</td>
</tr>
<tr>
<td>qpsk_8K_1_4.svu</td>
<td>QPSK</td>
<td>8K</td>
<td>1</td>
<td>¼</td>
<td>3.14</td>
</tr>
</tbody>
</table>

The example in Figure 1 is a complete end-to-end system simulation. It starts with the basic input data and continues through the Reed-Solomon (RS) encoder, the convolutional interleaver, the convolutional encoders and the DVB modulator token. The OFDM signal is the output of the DVB modulator, and is the input to the channel. The demodulation process recovers the signal step by step by performing the inverse operations in the appropriate order.
# 6.0 DVB Library Tokens

This section contains the descriptions and usage instructions for all tokens in the DVB library.

## INDEX

<table>
<thead>
<tr>
<th>Token Name</th>
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<tbody>
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<td>Bit Deinterleaver</td>
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<td>BitDemux</td>
</tr>
<tr>
<td>Bit Interleaver QPSK</td>
<td>BitInt</td>
</tr>
<tr>
<td>Bit Interleaver 16QAM</td>
<td>BitInt16</td>
</tr>
<tr>
<td>Bit Interleaver 64QAM</td>
<td>BitInt64</td>
</tr>
<tr>
<td>Bit Mux QPSK</td>
<td>BMuxQPSK</td>
</tr>
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<td>BMXQAM16</td>
</tr>
<tr>
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<td>BMXQAM64</td>
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</tr>
<tr>
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<td>SymInt</td>
</tr>
<tr>
<td>Symbol Mapper</td>
<td>SymMap</td>
</tr>
</tbody>
</table>
**Token Name:** Bit Deinterleaver  
**Abbreviation:** BitDint

**Synopsis:**  
This token performs the inverse operation of the bit interleaver as described in the specification.

For a detailed description of this operation, consult the ETS 300 744 Specification.

**Specification References:**  
ETS 300 744 .........................4.3.4.1

**See Also:**  
Bit interleaver

**Parameters:**  
Refer to Section 3.0 for a detailed description of each parameter.

- Modulation Type
- Input Delay (sec)
- Guard Interval Type
- Frame Type

**Token Inputs:**  
The token input is the output from the Bit Demapper token.

**Token Outputs:**  
The 2, 4, or 6 parallel outputs to the appropriate Bit Mux token.
**Token Name:** Bit Demux  
**Abbreviation:** BitDemux

**Synopsis:**  
This token takes the serial (punctured) output of the convolutional encoder and splits it, into 2(QPSK), 4(16QAM), or 6(64QAM) parallel paths depending on the modulation type. These parallel paths serve as the input to the Bit Interleaver token. Each of the parallel bit streams becomes one of the elements making up the symbol, that is input to the symbol interleaver.

For a detailed description of this operation, consult the ETS 300 744 Specification.

**Specification References:**  
ETS 300 744 .........................4.3.4

**See Also:**  
Bit Mux

**Parameters:**  
Refer to Section 3.0 for a detailed description of each parameter.

- Modulation Type
- Alpha Hierarchy Mode
- Threshold (v)

**Token Inputs:**  
The token input is the output from the (punctured) convolutional encoder.

**Token Outputs:**  
The 2, 4, or 6 parallel outputs to the Bit Interleaver token.
Synopsis:
This token takes the two outputs of the Demux token and performs the QPSK bit interleaving operation. After performing the interleaver operation, the parallel bit streams are merged into a single serial bit stream. This serial bit stream (Multilevel Out) of symbols is used in the Symbol Interleaver token.

For detailed description of operation, consult ETS 300 744 Specification.

Specification References:
ETS 300 744 .........................4.3.4.1

See Also:
Bit Demux, Bit Interleaver 16 QAM, Bit Interleaver 64 QAM

Parameters:
Refer to Section 3.0 for a detailed description of each parameter.

None

Token Inputs:
The 2 parallel outputs from the Bit Demux token.

Token Outputs:
1) I Channel bit stream
2) Q Channel bit stream
3) Multilevel Out
**Token Name:** Bit Interleaver 16QAM  
**Abbreviation:** BitInt16

**Synopsis:**
This token takes the four outputs of the Demux token and performs the 16QAM bit interleaving operation. After the operation, the parallel bit streams are merged into a single, 16 level serial bit stream of symbols for input to the Symbol Interleaver token. Four output streams are also available that are the binary representation of the 16 level serial stream.

For a detailed description of this operation, see the ETS 300 744 Specification.

**Specification References:**
ETS 300 744 .........................4.3.4.1

**See Also:**
Bit Demux, Bit Interleaver QPSK, Bit Interleaver 64QAM

**Parameters:**
Refer to Section 3.0 for a detailed description of each parameter.

Alpha Hierarchy Mode

**Token Inputs:**
The 4 parallel outputs from the Bit Demux token.

**Token Outputs:**
1) The serial multilevel (16) bit interleaved data, for input to the Symbol Interleaver token.
2) The six serial streams that represent the binary equivalent of the multilevel stream described above.
**Token Name:** Bit Interleaver 64QAM  
**Abbreviation:** BitInt64

**Synopsis:**  
This token takes the six outputs of the Bit Demux token and performs the 64QAM bit interleaving operation. After the operation, the parallel bit streams are merged into a single 64 level serial bit stream of symbols, for the Symbol Interleaver token. Six output streams are also available that are the binary representation of the 64 level serial stream.

For detailed description of the operation, see ETS 300 744 Specification.

**Specification References:**  
ETS 300 744 .........................4.3.4.1

**See Also:**  
Bit Demux, Bit Interleaver QPSK, Bit Interleaver 16QAM

**Parameters:**  
Refer to Section 3.0 for a detailed description of each parameter.

Alpha Hierarchy Mode

**Token Inputs:**  
The 6 parallel outputs from the Demux token.

**Token Outputs:**  
1) The serial bit interleaved data for input to the Symbol Interleaver token.  
2) The six parallel streams that represent the binary equivalent of the multilevel stream described above.
Token Name: Bit Mux QPSK
Abbreviation: BMuxQPSK

Synopsis:
This token performs the inverse operation of the QPSK Bit Demux token.
For a detailed description of this operation, consult the ETS 300 744 Specification.

Specification References:
ETS 300 744 .........................4.3.4

See Also:
Bit Demux, Bit Mux 16QAM, Bit Mux 64QAM

Parameters:
Refer to Section 3.0 for a detailed description of each parameter.

- Input Delay (sec)
- Guard Interval Type
- Frame Type 2K/8K

Token Inputs:
The 2 parallel outputs from the Bit Deinterleaver token.

Token Outputs:
The multiplexed data for input to the (punctured) convolutional encoder.
**Synopsis:**
This token performs the inverse operation of the Bit Demux 16QAM token.

For a detailed description of this operation, consult the ETS 300 744 Specification.

**Specification References:**
ETS 300 744 .........................4.3.4

**See Also:**
Bit Mux QPSK, Bit Mux 64QAM

**Parameters:**
Refer to Section 3.0 for a detailed description of each parameter.

- Alpha Hierarchy Mode
- Input Delay (sec)
- Guard Interval Type
- Frame Type 2K/8K

**Token Inputs:**
The 4 parallel outputs from the Bit Mux token.

**Token Outputs:**
The multiplexed data stream, for input to the (punctured) convolutional decoder.
**Token Name:** Bit Mux 64QAM  
**Abbreviation:** BMXQAM64

**Synopsis:**  
This token performs the inverse operation of the Bit Demux 64QAM token.

For a detailed description of this operation, consult the ETS 300 744 Specification.

**Specification References:**  
ETS 300 744 .........................4.3.4

**See Also:**  
Bit Mux QPSK, Bit Mux 16QAM

**Parameters:**  
Refer to Section 3.0 for a detailed description of each parameter.

Alpha Hierarchy Mode  
Input Delay (sec)  
Guard Interval Type  
Frame Type 2K/8K

**Token Inputs:**  
The 6 parallel outputs from the Bit Mux token.

**Token Outputs:**  
The multiplexed data stream, for input to the (punctured) convolutional decoder.
**Token Name:** Depuncture  
**Abbreviation:** Depunct

**Synopsis:**  
This token performs the inverse operation of the Puncture token. It reinserts null data into the data stream positions where the Puncture token removed the data.

For a detailed description of this operation, consult the ETS 300 744 Specification.

**Specification References:**  
ETS 300 744 .........................4.3.3

**See Also:**  
Puncture

**Parameters:**  
Refer to Section 3.0 for a detailed description of each parameter.

- Code Constraint Length  
- Puncture Code Rate  
- Start Offset (sec)

**Token Inputs:**  
The token input is the output signal from the Bit Mux token.

**Token Outputs:**  
The depunctured data stream, for input to the convolutional decoder.
Token Name: DVB Detector
Abbreviation: Detector

Synopsis:
This token takes the output of the channel demodulator and makes hard decisions, thus recovering the specified signal constellation. Note: it is mandatory for the net gain to be 0 dB, from the output of the OFDM modulator, to the input of this token.

Specification References:
ETS 300 744 .........................4.4

See Also:

Parameters:
Refer to Section 3.0 for a detailed description of each parameter.

Modulation type
Alpha Hierarchy Mode

Token Inputs:
1) The raw I channel useful data, out of the OFDM demodulator token.
2) The raw Q channel useful data, out of the OFDM demodulator token.

Token Outputs:
1) The hard decision I channel data, for input to the Symbol Demapper token.
2) The hard decision data from the Q channel, for input to the Symbol Demapper token.
Token Name: DVB Demodulator
Abbreviation: DVBDMod

Synopsis:
This token is a complete demodulator. It encompasses all operations, from the input to the OFDM demodulator through all of the Demapping and De-interleaving operations, producing a data stream to the Depuncture token.

Specification References:
ETS 300 744 ..........................4.4, and Appendix D

See Also:
DVB Modulator

Parameters:
Refer to Section 3.0 for a detailed description of each parameter.

Guard Interval Type
Input Delay (sec)
Code Rate
Modulation Type
Frame Type 2K/8K

Token Inputs:
1) The raw I channel signal from the channel.
2) The raw Q channel signal from the channel.

Token Outputs:
Convolutional encoded data for input to the Depuncture token.
**Synopsis:**
This token performs all of the modulation operations, from the output of the Puncture token, to the output of the OFDM modulator.

**Specification References:**
ETS 300 744 ..........................4.4, Appendix D

**See Also:**
DVB Demodulator

**Parameters:**
Refer to Section 3.0 for a detailed description of each parameter.

- Guard Interval Type
- Modulation Type
- Frame Type 2K/8K
- Alpha Hierarchy Mode
- Threshold (v)

**Token Inputs:**
The token input is the output, from the Puncture token.

**Token Outputs:**
1) The I channel of the OFDM modulated signal.
2) The Q channel of the OFDM modulated signal.
3) PRBS Reference.
**Token Name:** OFDM Demodulator

**Abbreviation:** OFDMDMod

**Synopsis:**
This token performs the inverse operation of the OFDM modulator. The FFT operation is used to recover the data symbols.

**Specification References:**
ETS 300 744 .........................4.4

**See Also:**
OFDM Modulator

**Parameters:**
Refer to Section 3.0 for a detailed description of each parameter.

- Guard Interval Type
- Input Delay (sec)
- Modulation Type
- Frame Type 2K/8K
- Alpha Hierarchy Mode

**Token Inputs:**
1) OFDM modulated I data from the channel.
2) OFDM modulated Q data from the channel.
Token Outputs:
1. I useful data. The undetected I channel OFDM demodulated data for input to the symbol detector. Boosted Pilots and Sync data have been extracted.

2. Q useful data. The undetected Q channel OFDM demodulated data for input to the symbol detector. Boosted Pilots and Sync data have been extracted.

3. Recovered TPS data.


5. I Demod. In phase OFDM demodulated data, which contains the useful data Boosted Pilots and TPS sync data.

6. Q Demod. Quadriphase OFDM demodulated data, which contains the useful data Boosted Pilots and TPS sync data.
**Token Name:** OFDM Modulator  
**Abbreviation:** OFDMMod

**Synopsis:**
This token takes the output of the signal mapper and uses the FFT operation to produce the OFDM modulated signal. The modulator operation is described by the equation:

\[
\begin{align*}
  s(t) &= \text{Re}\{e^{2\pi \jmath f_c t} \sum_{m=0}^{\infty} \sum_{l=0}^{\ell_{\text{max}}} \sum_{k=0}^{\ell_{\text{max}}} C_{mlk} \Psi_{mlk}(t)\} \\

  \Psi_{mlk}(t) &= e^{2\pi \jmath k' \left(t - \Delta f T_s - 68m T_s\right)/T_u} \phantom{{}^2} (l + 68m)T_s \leq t \leq (l + 68m + 1)T_s \\
  &= 0 \quad \text{otherwise}
\end{align*}
\]

Where:

- \( k \) Denotes the carrier number
- \( l \) Denotes the OFDM symbol number
- \( m \) Denotes the frame number
- \( K \) is the number of transmitted carriers
- \( T_s \) is the symbol duration
- \( T_u \) is the inverse of the carrier spacing
- \( f_c \) is the central RF carrier frequency
- \( k' \) is the carrier index relative to center frequency.
- \( c_{mlk} \) Denotes the symbol information

**Specification References:**
ETS 300 744 ..........................4.4
See Also:
OFDM Demodulator

Parameters:
Refer to Section 3.0 for a detailed description of each parameter.

Guard Interval Type
Modulation Type
Convolution Code Rates
Frame Type 2K/8K
Alpha Hierarchy Mode

Token Inputs:
1) The I channel output of the Symbol Mapper token.
2) The Q channel output of the Symbol Mapper token.

Token Outputs:
1) The I channel of the OFDM modulated signal.
2) The Q channel of the OFDM modulated signal.
3) PRBS Reference.
Token Name: PRBS Data
Abbreviation: PRBS

Synopsis:
This token will implement the pseudo random feedback operation used to generate the Pseudo Random Bit Stream (PRBS) signal. The data from this generator is used to calculate the position of the random pilot tones.

For a detailed description of this operation, consult the ETS 300 744 specification.

Specification References:
ETS 300 744 .........................4.5.2

See Also:

Parameters:
Refer to Section 3.0 for a detailed description of each parameter.

Clock Threshold (v)
Logic 1 Out
Logic 0 Out

Token Inputs:
The clock signal that drives the PN sequence generator.

Token Outputs:
The token output is PRBS data, at 1 sample per bit.
**Synopsis:**
This token performs the puncture operation. This operation removes bits from the convolutional coded data in order to reduce the signal bandwidth. The table below describes the puncture operation:

<table>
<thead>
<tr>
<th>Code rates r</th>
<th>Puncturing Pattern</th>
<th>Transmitted Sequence (After parallel-serial conversion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>X: 1</td>
<td>X1Y1</td>
</tr>
<tr>
<td></td>
<td>Y: 1</td>
<td></td>
</tr>
<tr>
<td>2/3</td>
<td>X: 10</td>
<td>X1Y1Y2</td>
</tr>
<tr>
<td></td>
<td>Y: 11</td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>X: 101</td>
<td>X1Y1Y2X3</td>
</tr>
<tr>
<td></td>
<td>Y: 110</td>
<td></td>
</tr>
<tr>
<td>5/6</td>
<td>X: 10101</td>
<td>X1Y1Y2X3Y4X5</td>
</tr>
<tr>
<td></td>
<td>Y: 11010</td>
<td></td>
</tr>
<tr>
<td>7/8</td>
<td>X: 1000101</td>
<td>X1Y1Y2Y3Y4X5Y6X7</td>
</tr>
<tr>
<td></td>
<td>Y: 1111010</td>
<td></td>
</tr>
</tbody>
</table>

1 = transmit, 0 = puncture

**Specification References:**
ETS 300 744 .........................4.3.3

**See Also:**
Depuncture
**Parameters** (Refer to Section 3.0 “Token Parameter Definitions” for a detailed description of each parameter.):

- Constraint Length
- Code Rate
- Start Offset (sec)

**Token Inputs:**
The token input is the output of the convolutional encoder.

**Token Outputs:**
The token output is punctured convolutional encoded signal, for Bit Demux token input.
**Token Name:** Symbol Deinterleaver  
**Abbreviation:** SymDint

**Synopsis:**  
This token performs the inverse of the Symbol Interleaver token.

For a detailed description of this operation, consult the ETS 300 744 Specification.

**Specification References:**  
ETS 300 744 .........................4.3.4.2

**See Also:**  
Symbol Interleaver

**Parameters:**  
Refer to Section 3.0 for a detailed description of each parameter.

- Input Delay (sec)  
- Guard Interval Type  
- Frame Type 2K/8K

**Token Inputs:**  
The token input is the output of the Bit Deinterleaver token.

**Token Outputs:**  
The symbol deinterleaved data for input to the Bit Deinterleaver token.
**Token Name:** Symbol Demapper  
**Abbreviation:** Demap

**Synopsis:** This function performs the opposite operation of the Symbol Mapper token. It removes the alpha hierarchy bias.

For a detailed description of this operation, consult the ETS 300 744 Specification.

**Specification References:**
ETS 300 744 .........................4.3.5

**See Also:**  
Symbol Mapper

**Parameters:**  
Refer to Section 3.0 for a detailed description of each parameter.

- Modulation Type
- Alpha Hierarchy Mode

**Token Inputs:**
1) The I channel signal out of the DVB Detector token.  
2) The Q channel signal out of the DVB Detector token.

**Token Outputs:**
A multilevel demapped signal for input to the Symbol Deinterleaver token.
Synopsis:
The symbol interleaver takes the output group of 2, 4, or 6 bits out of the bit interleavers and permutes their order in the OFDM symbol.

For a detailed description of this operation, consult the ETS 300 744 Specification.

Specification References:
ETS 300 744 .........................4.3.4.2

See Also:
Symbol Deinterleaver

Parameters:
Refer to Section 3.0 for a detailed description of each parameter.

Frame Type 2K/8K

Token Inputs:
The token input is bit data out of the Bit Interleaver token.

Token Outputs:
This token output is the interleaved data for input to the Symbol Mapper token.
This token outputs a binary data stream representing the permuted address of the symbol.
**Token Name:** Symbol Mapper  
**Abbreviation:** SymMap

**Synopsis:**  
The symbol mapper takes the 2, 4, or 6 bit output of the symbol interleaver and assigns a [I, Q] pair of numbers that represent the complex information used by the OFDM modulator. This mapping produces symbol groups such that nearest neighbors differ in only one bit position (i.e. Gray encoding).

For a detailed description of this operation, consult the ETS 300 744 Specification.

**Specification References:**  
ETS 300 744 .........................4.3.5

**See Also:**  
Symbol Demapper

**Parameters:**  
Refer to Section 3.0 for a detailed description of each parameter.

- Modulation Type
- Alpha Hierarchy Mode

**Token Inputs:**  
The token input is interleaved data from the Symbol Interleaver token.

**Token Outputs:**  
1) The I channel symbol data, for input to the OFDM Modulator token.  
2) The Q channel symbol data, for input to the OFDM Modulator token.