

# Symbol Interleaver/Deinterleaver MegaCore Function

Solution Brief 42

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## Target Applications:

Digital Communications

## Family:

APEX™ 20K & FLEX® 10K

## Ordering Code:

PLSM-INLV

## Vendor:



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## Features

- Offers high-speed data rates: 120 million samples per second (MSPS)
- Supports convolutional interleaving algorithm
- Supports block interleaving algorithm
- Contains a burst error distribution analyzer

## General Description

Interleaving is a standard digital signal processing (DSP) function used in many communications systems. Applications that store or transmit data use symbol interleaver/deinterleavers to reduce spurious noise that can corrupt data. The Altera® symbol interleaver/deinterleaver MegaCore® function supports both a continuous mode and a discrete mode, making it compatible with any type of Reed-Solomon function. Also, the symbol interleaver/deinterleaver improves the efficiency of Reed-Solomon encoders/decoders by spreading the errors across several codewords.

The symbol interleaver/deinterleaver MegaCore function has been optimized for Altera APEX™ 20K and FLEX® 10K devices. The MegaWizard® Plug-In reduces design and simulation cycles from weeks to minutes, optimizing memory configurations based on user-defined parameters. For block interleaving, the MegaWizard Plug-In uses single-port RAM; for convolutional interleaving, the interleaver/deinterleaver function utilizes embedded array block (EAB) and embedded system block (ESB) dual-port RAM capability. Flexible programmable logic combined with the symbol interleaver/deinterleaver MegaWizard Plug-In allows you to build real-time systems that analyze and improve custom parameter values.

## Functional Description

Interleavers arrange the symbols into a group of transmitted codewords so that adjacent symbols in the data stream are not from the same codeword. Deinterleavers reassemble the codewords when the deinterleaver processes the data stream. This process of interleaving and deinterleaving data reduces the effects of burst errors (multiple errors in a row) as it rearranges codeword symbols and spreads the errors among multiple codewords.

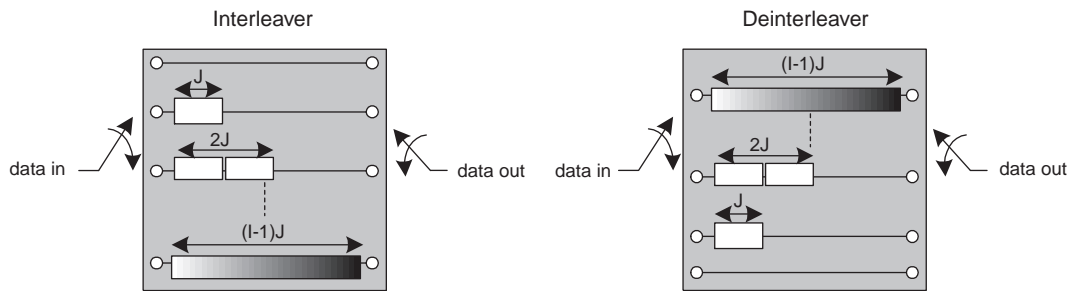
The interleaving/deinterleaving process introduces a constant delay between the interleaver input data and the deinterleaver output data. When a symbol enters a branch of the interleaver or deinterleaver, it exits the branch via the output commutator after a variable delay that depends on the branch index. The symbol interleaver/deinterleaver supports two algorithms: convolutional and block.

### *Convolutional Interleavers/Deinterleavers*

Convolutional interleavers/deinterleavers process data in a continuous stream, making them ideal for high-speed applications that require burst error correction (e.g., digital video broadcasting). Compared to block interleavers/deinterleavers, convolutional interleavers/deinterleavers provide reduced delay and lower memory usage for the same distribution of errors.

Figure 1 shows the structure of the convolutional interleaver/deinterleaver.

**Figure 1. Convolutional Interleaver/Deinterleaver Structure**

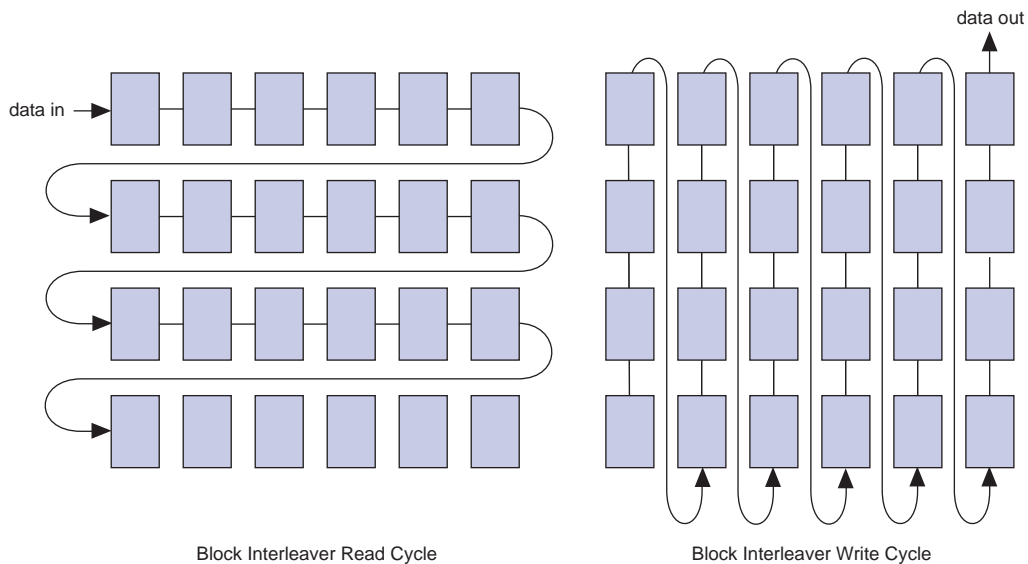


**Block Interleaver/Deinterleaver**

Block interleavers/deinterleavers use single-port RAM memory configured as a matrix of  $n$  rows by  $m$  columns to interleave data. Symbol transmission consists of an alternating sequence of write and read cycles. During the write cycle, input symbols are written column-by-column; during the read cycle, output symbols are read row-by-row. Each cycle delay is equal to the buffer size (block length  $\times$  by span delay).

Figure 2 shows the block structure for a six-symbol codeword during each cycle.

**Figure 2. Block Interleaver/Deinterleaver Structure for a Six-Symbol Codeword**



**MegaWizard Plug-In**

The MegaWizard Plug-In Manager, which you can use within the Quartus™ or MAX+PLUS® II software or as a standalone application, lets you create or modify design files for the interleaver/deinterleaver MegaCore function. When you run the symbol interleaver/deinterleaver, the MegaWizard Plug-In Manager creates AHDL (.tdf), VHDL (.vhd), and Verilog (.v) files that you can instantiate in your system design, as well as MAX+PLUS II vector files (.vec) and symbol files (.sym) that allow you to view the design waveform.

Table 1 shows the MegaWizard options available for block and convolutional functions.

<b>Option</b>	<b>Function</b>	<b>Description</b>
Number of columns	Block	Specifies the total length of the codeword (data and checksum symbols)
Number of branches	Convolutional	Specifies the number of branches used by the interleaver
Direction	Block or convolutional	Specifies whether you wish to create an interleaver or a deinterleaver
Memory type	Block or convolutional	Indicates whether you wish to use internal or external memory
Number of rows	Block	Specifies the maximum number of codewords in the block interleaver/deinterleaver memory
Unit delay element	Convolutional	Specifies the unit delay for each branch of the interleaver/deinterleaver
Symbol width	Block or convolutional	Specifies the width of the input symbol
Type	Block or convolutional	Indicates whether you wish to create a block or convolutional interleaver/deinterleaver

## Performance & Implementation

This section provides an overview of the steps that create and implement a custom interleaver/deinterleaver function. The MegaWizard Plug-In Manager lets you create or modify design files that contain custom megafunction variations. You can then simulate your design with the Quartus or MAX+PLUS II Simulator to verify compatibility and instantiate the custom megafunction in your design file.

### *Design Entry*

Start the MegaWizard Plug-In Manager by choosing the **MegaWizard Plug-In Manager** command (File menu) in the Quartus or MAX+PLUS II software, or type the command `megawiz` at a command or UNIX prompt. Choose the type of file you wish to create from the **Available Megafunctions** dialog box on the second page of the MegaWizard Plug-In Manager. Select the type of algorithm (convolutional or block) and the direction (interleaver or deinterleaver). Once you specify the characteristic options of the function, you can use the Manager to view and analyze burst error distribution.

### *Simulation*

You can simulate your design after you have compiled it with the Quartus or MAX+PLUS II software. The vector file created by the MegaWizard Plug-In Manager is loaded automatically when you begin the simulation. Once the simulation is complete, you can choose the **OPEN SCF** button on the MegaWizard Plug-In Manager screen to view the design waveform. Verify the function compatibility with your design requirements, then insert the function into your system-level design.

Table 2 shows the interleaver/deinterleaver function's performance as calculated using the MAX+PLUS II version 9.2 software.

<b>Table 2. Symbol Interleaver/Deinterleaver Performance</b>						
<b>Function</b>	<b>Parameters</b>	<b>Device</b>	<b>Speed Grade</b>	<b>Logic Elements Used</b>	<b>EABs Used</b>	<b>f<sub>MAX</sub> (MHz)</b>
Convolutional interleaver using FLEX <sup>®</sup> 10KE EABs	Depth = 12 Unit Delay = 17 Symbol width = 8 bits (digital video broadcast settings)	FLEX 10KE	1	392	8	110
Block interleaver using single-port RAM	Block length = 36 Span delay = 20 Data Width =8 (UTRA) ITU-R RTT	FLEX 10KE	-1	40	4	120



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