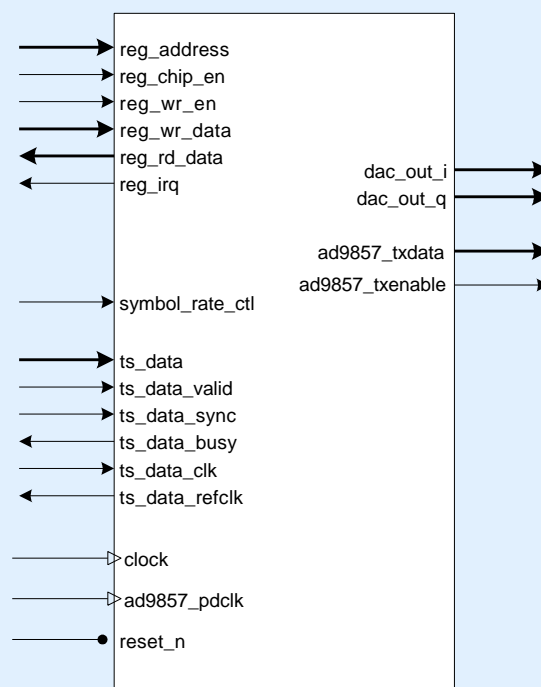


- Compliant with ATSC A/53 8-VSB
- Variable sample-rate interpolation provides ultra-flexible clocking strategy
- Integrated Reed Solomon/Convolutional channel coder
- Automatic insertion of Segment Sync, Field Sync and Pilot signals
- Extension core available for SPI/ASI interface with integrated PCR TS re-stamping.
- Extension core available for SMPTE 310M interface with DPLL timing synchronisation
- Flexible DAC interface compatible with baseband I/Q and IF DAC subsystems
- Optional interface to Analog Devices AD9857/AD9957 DDS DAC
- Modes that are not required may be removed with synthesis options to generate a compact, efficient design.
- Designed for very efficient FPGA implementation without compromise to the targeting of gate array or standard cell structures.
- Supplied as a protected bitstream or netlist (Megacore<sup>®</sup> also available for Altera<sup>®</sup> targets).

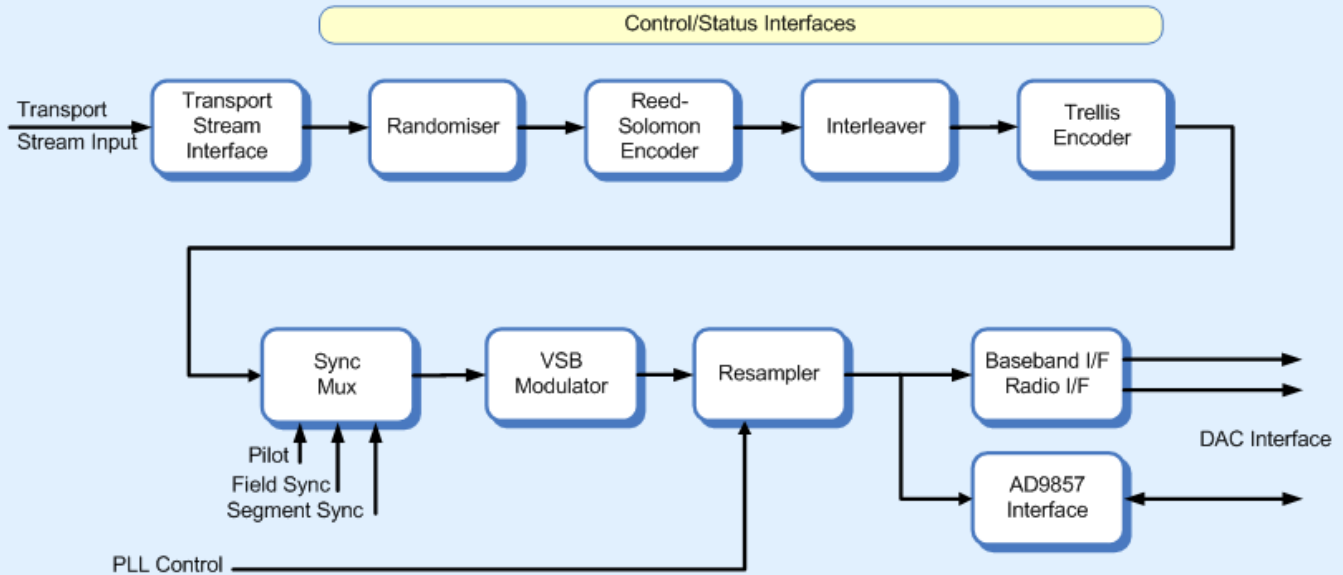


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## Block Diagram



## Detailed Description

The Commsonic CMS0033 ATSC 8-VSB Modulator with integrated Channel Coder has been designed specifically to implement the 8-VSB requirements of the ATSC Digital Television Standard (A/53).

The core provides all the necessary processing steps to modulate a single transport stream into a complex I/Q signal for input to a pair of DACs, or a DDS up-conversion DAC such as the AD9857 (or AD9957). Optionally, the output can be selected as an IF to supply a signal DAC.

The design has been optimised to provide excellent performance in FPGA devices.

A description of the processing steps follows:

**Randomiser.** This block performs energy dispersal by scrambling the incoming transport stream packets with a pseudo-random sequence.

**Reed-Solomon Encoder.** This block constructs 207-byte Reed Solomon codewords by applying a T=10 (207,187) code to the scrambled transport stream packets.

**Interleaver.** This block uses convolutional byte interleaving to disperse the Reed Solomon codewords over a period of approximately 4ms.

**Convolutional Encoder.** This block applies a rate 2/3 convolutional code to the interleaved data by means of a 4-state trellis encoder. The 3-bit encoder output symbols are mapped to 8-level 8-VSB constellation points.

**Sync Multiplexer.** This block inserts Field Sync and Segment Sync sequences into the transmitted symbol stream and adds a low-level Pilot signal. These signals are used for physical-layer synchronisation at the receiver.

**VSB Modulation.** This block performs vestigial sideband modulation of a locally-generated baseband carrier, driven by the composite output from the Sync Multiplexer.

## Detailed Description (cont'd)

**Rate Conversion.** This block re-samples the complex samples output from the VSB Modulation block at symbol-rate into complex samples at a sub-multiple of the DAC/core clock frequency.

A frequency control input is provided to allow the modulation symbol rate to be locked to the data rate on the transport stream interface. This would typically be driven by a PLL, for example when the SMPTE 310M interface option is selected.

**Baseband-to-IF.** This block provides the option to mix the signal up to a higher IF as defined by a software register. The block may be removed using synthesis options if it is not required.

**Radio Interface.** This block performs some final, register-selectable processing functions to optimise the output for the radio in the target application. For example, the data can be formatted to work

with either twos-complement or offset-binary DAC devices. In addition the data is formatted to suit the external device that could take separate I/Q, multiplexed I/Q or a single IF output.

Additional modes are provided to support the Analog Devices AD9857 device that provide up-conversion, SINC filtering and DAC functions in a single package. The AD9857 device requires that the I/Q data be multiplexed onto a single data bus. The *ad9857\_pdclk* input is provided to enable this feature and should be sourced from the AD9857 PDCLK output

**Control/Status Interface.** The Control/Status interface is provided by a synchronous, 32-bit register bank. Full details of the registers within the modulator core are contained within the full data sheet.

## Principle I/O Description

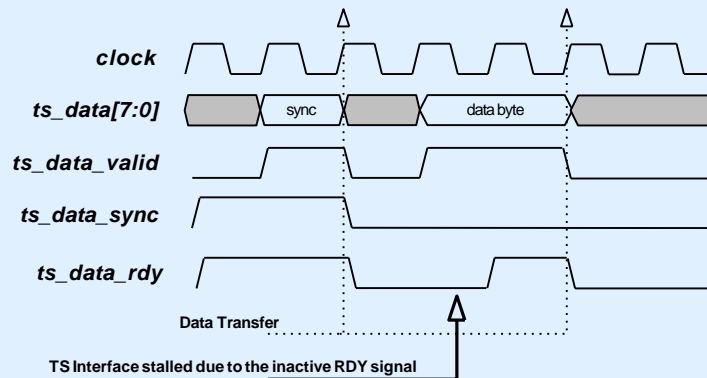
<b>Register Bus Interface</b>	
reg_address	Register address select input.
reg_chip_en	Block select input for the CMS0033 register bank.
reg_wr_en	Write Enable Input for block registers.
reg_wr_data	32-bit Write data input.
reg_rd_data	32-bit Read data output.
reg_irq	Core Interrupt.
<b>Transport Stream Interface</b>	
ts_data	8-bit Transport Stream data input
ts_data_valid	Transport Stream data valid input.
ts_data_sync	Transport Stream data sync input.
ts_data_busy	Transport Stream interface is busy. TS data should be stalled until the interface is available again.
ts_data_clk	Transport Stream clock input.
ts_data_refclk	Transport Stream reference clock output.
<b>Modulator Output Interface</b>	
dac_out_i	14-bit Transmit I complex output or IF output in IF mode.
dac_out_q	14-bit Transmit Q complex output.
ad9857_txdata	14-bit multiplexed data to the AD9857 if used.
ad9857_txenable	Controls the interface timing to the AD9857 if used.
<b>Others</b>	
clock	Clock input at greater than 4x 8-VSB symbol-rate (> 43.049MHz).
ad9857_pdclk	AD9857 Clock.
Symbol_rate_ctl	Symbol rate frequency control input. This input would typically be driven from a PLL when the modulation rate must be locked to the data rate on the transport stream interface.
reset_n	Asynchronous active-low reset input.

## Transport Stream (TS) Interface

### Standard TS interface:

The standard TS interface supplied uses a ready/valid handshake mechanism to allow data to be pulled through the modulator processing chain

based on the on-air symbol rate. This requires the TS data source to be stalled when the modulator core is busy.



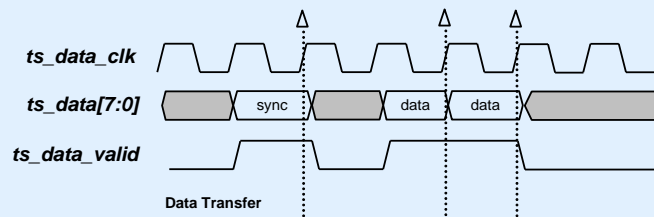
### PCR re-stamping TS interface:

Typically the input stream from the transport multiplexer is provided at a fixed rate that requires 'padding' to match the required on-air bitrate; consequently some form of traditional MPEG TS rate adaption is required. The TS PCR restamping extension core provides a simpler TS interface (compatible with SPI or ASI) to allow data to be input at an asynchronous rate.

packets as required and perform any PCR adjustment. An output signal, *ts\_data\_refclk* is provided that indicates the necessary 188-byte TS byte rate to satisfy the on-air requirements.

When the PCR restamping extension core is used, the core will pad the input TS stream with NULL TS

The core provides a symbol rate control input for applications that require a synchronous relationship between the modulation symbol rate and TS bit rate. This would normally be driven as part of a PLL controlling the fill state of an input TS FIFO.

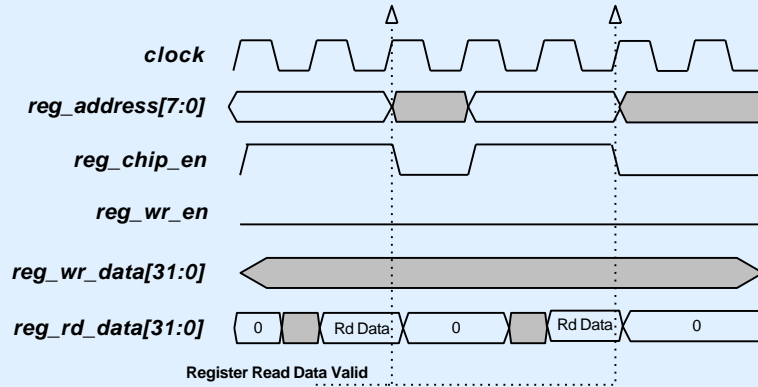


## Register Interface

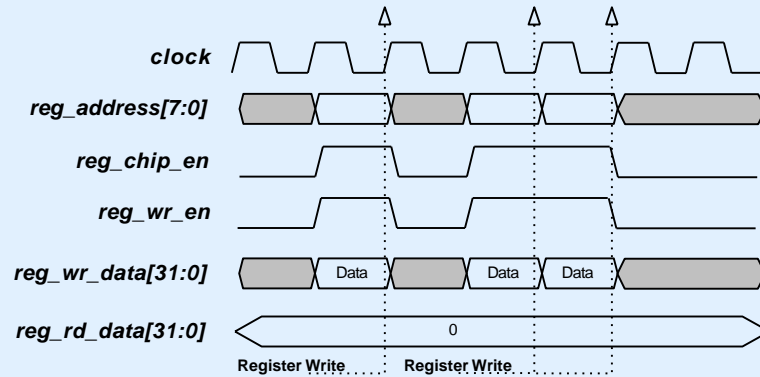
A simple 32-bit register-programming interface is provided. The register core is intended to be interfaced to whatever host interface is appropriate for the application (e.g. I<sup>2</sup>C, 8-bit, big-endian, little-

endian, etc). The register-core can be interface directly with the Altera SOPC builder via the Avalon bus using a zero wait-state configuration.

### Register read access:



### Register write access:

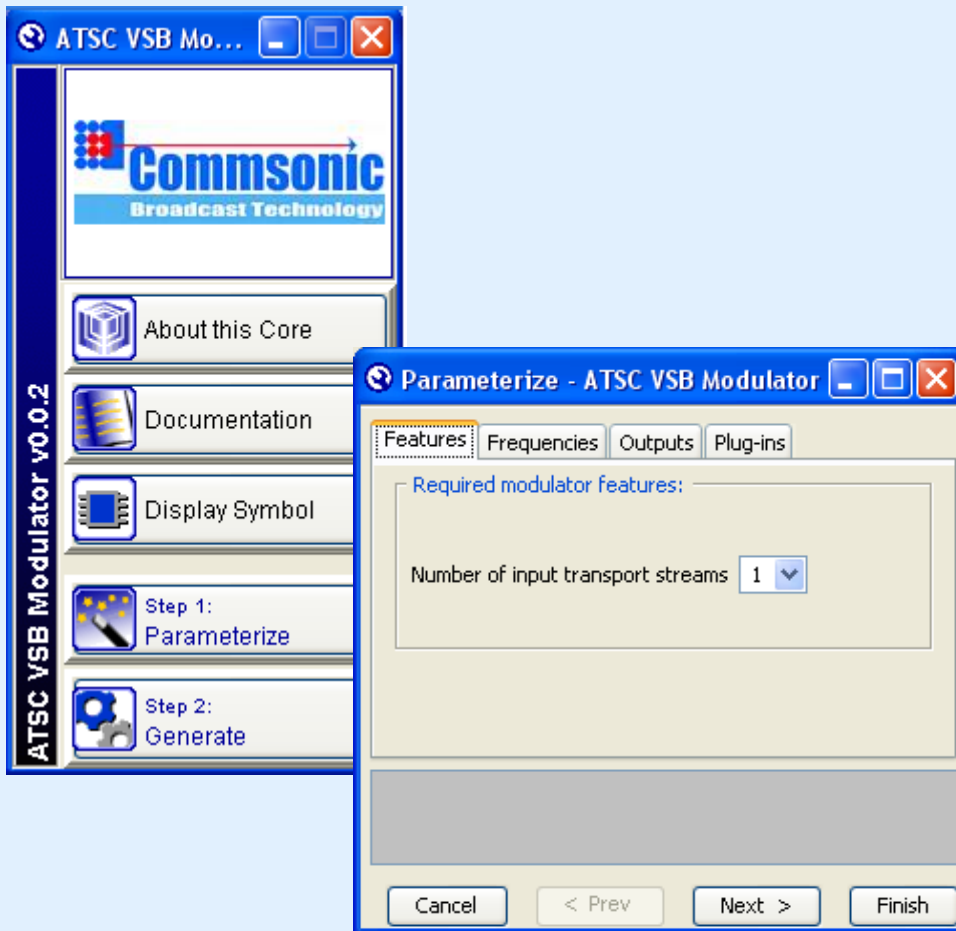


Altera® Megacore®



The ATSC 8-VSB Modulator core provides a number of parameters that can be modified to provide an optimal solution for the targeted technology and/or

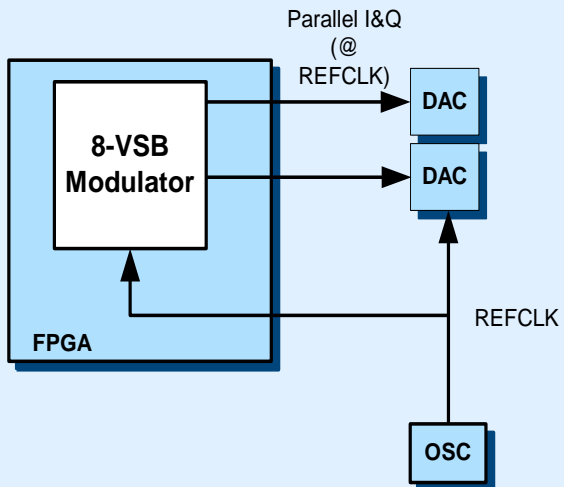
application. These parameters are available for synthesis time modification using the Megawizard tool within the Altera® Quartus® II software.



## EXAMPLE APPLICATIONS

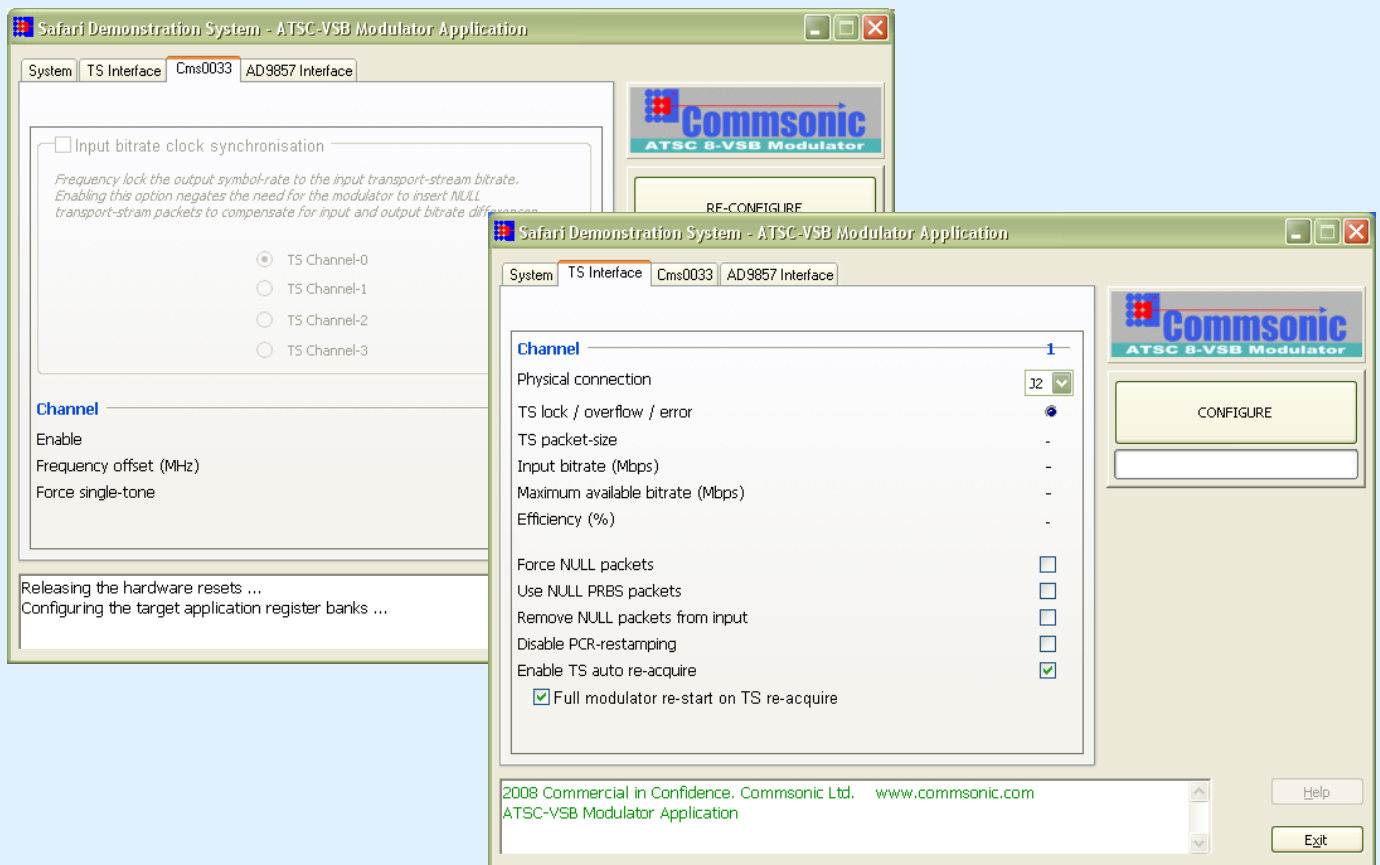
### Up-sampled output using internal interpolation & up-conversion:

This application uses the CMS0033 with internal interpolation and direct baseband I/Q interfacing to external DACs.





## EVALUATION



### About Commsonic:

Commsonic is an IP and design services company that specialises in the development of ASIC, FPGA, DSP and board-level sub-systems for applications in wireless and wireline communications.

Our expertise is primarily in the gate- and power-efficient implementation of physical-layer (PHY) functions such as modulation, demodulation and channel coding, but we have extensive experience with all of the major elements of a modern baseband 'core' including medium access control (MAC), voiceband DSP, mixed-signal interfaces and embedded CPU and software.

Our services are available on a turn-key basis but they are usually provided as part of a support package attached to members of our expanding family of licensable IP cores.

Commsonic's IP spans the major Standards for cable, satellite and terrestrial digital TV transmission and includes high-performance, adaptable, single-carrier (QAM) and multi-carrier (COFDM) modulator and demodulator solutions for DVB-S/DSNG/S2, ATSC-8VSB, DVB-C/J.83/A/B/C, DVB-T/H, DVB-T2 and ISDB-T.

Commsonic's customers are typically semiconductor vendors and manufacturers of broadband transceiver equipment that demand leading-edge Standards-based or proprietary PHY solutions but don't have the internal resources necessary to get their products to market soon enough.

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