

QAM Modulator IP Core Specification

Release
InformationNameQAM Modulator IP CoreVersion4.0Build date2014.09Ordering codeip-qam-modulatorSpecification revisionr1939

Features

The IP core implements the full-featured QAM modulation algorithm and is fully compatible with those standards:

- Digital Video Broadcasting (DVB-S, DVB-C, DVB-S2, DVB-S2X)
- Satellite Broadcasting
- ITU-T for point-to-point microwave communication systems

License

- License:
 - Netlist for One FPGA Family or Full Source Code (Verilog, SDC/XDC)
 - Perpetual
 - Without Quantitative Restrictions
 - Worldwide
 - Royalty-free
 - Free Remote Technical Support for 1 Year

Deliverables

The QAM Modulator IP Core includes:

- EDIF/NGC/QXP/VQM netlist for Xilinx Vivado/ISE, Intel (Altera)
- Quartus, Lattice Diamond or Microsemi (Actel) Libero SoC
- IP Core testbench scripts
- Design examples for Xilinx, Intel (Altera), Lattice, and Microsemi (Actel) evaluation boards
- **IP Core Structure** Figure 1 shows the QAM Modulator IP Core block diagram.



The QAM modulator consists of a constellation mapper (**Mapper**), a RRC filter (**Pulse Shaping Filter**), a fractional

resampler/interpolator (**Resampler**), a quadrature modulator (**Quadrature Modulator**), a numerically controlled oscillator (**NCO**) and a direct digital synthesis module (**Direct Digital Synthesis**).

Port Map Figure 2 shows a graphic symbol, and Table 1 describes the ports of the QAM Modulator IP Core.



Figure 2. The QAM Modulator port map

Table 1. The QAM Modulator port map description				
Port	Width	Description		
iclk	1	The main system clock. The IP Core operates on the rising edge of iclk.		
idat		input (information) data		
ifreq	32	output intermediate frequency		
igain	W_DAC	output gain control		
imod		modulation: specified before IP Core order		
iroll		RRC filter roll-off factor		
irst	1	The IP Core synchronously reset when irst is asserted high.		
isample	32	bandwidth control (symbol rate): 0.01% to 25% of iclk		
odati	W_DAC	modulator output at baseband (I channel) or at an intermediate frequency		
odatq	W_DAC	modulator output at baseband (Q channel)		
ordy	1	ready to accept input data		

IP Core Parameters

Table 2 describes the QAM Modulator IP Core parameters, which must be set before synthesis.

Table 2. The QAM Modulator IP Core parameters description			
Parameter	Description		
W_DAC	Width of output DAC symbols (odati/odatq) Increasing the width of odati/odatq, increases the quality of waveform but also increases FPGA required resource		
CONFIG	Set of mapping tables and QAM/APSK constellations. IP Core supports BPSK, QPSK, 8- PSK, 16-APSK, 32-APSK, 64-APSK, 128-APSK, 256-APSK, 16-QAM, 32- QAM, 64-QAM, 128-QAM, 256-QAM, 512-QAM, 1024-QAM modulations. For example, CONFIG="DVB-S2X" contains all DVB-S2 and DVB-S2X standard constellations.		
ROLL-OFF	Set of roll-off factors (alpha) for shaping filter (RRC). For example, ROLL-OFF = 0.35, 0.25, 0.20, 0.15, 0.10 Pë 0.05.		

IP Core Operation	Quadrature Amplitude Modulation (QAM modulation) is the most
Description	efficient in the use of spectrum by the transmission of information. QAM modulated signal is the sum of two orthogonal subcarriers, each of which is modulated in amplitude. Total oscillation is obtained simultaneously modulated both in amplitude and phase. The number of levels of amplitude modulation in each subcarrier is fixed and determines the type of modulated signal constellations. When the number of modulation levels, increases the amount of information carried by each symbol QAM signal.

Key features of the IP Core:

- Synchronous, high-speed algorithm for the formation BPSK/QPSK/QAM/APSK signals
- The output of the intermediate frequency range up to 40% of the system clock frequency
- Symbol rate to 1/4 of the system clock frequency
- Support for changing modulation schemes "on the fly"
- Parameterized shaping filter and fractional interpolator
- Fixed delay in the modulator

Performance and Resource Utilization

d The values were obtained by automated characterization, using standard tool flow options and the floorplanning script delivered with the IP Core. The IP Core fully supports all Xilinx and Altera FPGA families, including Spartan, Zynq, Artix, Kintex, Virtex, Cyclone, Arria, MAX, Stratix. Table 3 summarizes the QAM Modulator IP Core measurement results.

Table 3. The QAM Modulator performance						
IP Core parameters	FPGA type					
	Resource	Speed grade, maximal system frequency				
W_DAC=16 CONFIG="DVB- S2X" ROLL- OFF=0.35, 0.25, 0.20, 0.15, 0.10, 0.05	Altera Cyclone IV EP4CE75					
	15713 LEs 11 M9K RAM blocks 12 DSP (18x18)	-8, Fmax	-7, Fmax	-6, Fmax		
		104.0 MHz 26.0 Msymb/s	119.0 MHz 29.75 Msymb/s	135.0 MHz 33.75 Msymb/s		
W_DAC=16 CONFIG="DVB- S2X" ROLL- OFF=0.35, 0.25, 0.20, 0.15, 0.10, 0.05	Xilinx Virtex-6 XC6VLX240T					
	5125 Slices 10 18K RAM blocks 12 DSP (18x18)	-1, Fmax	-2, Fmax	-3, Fmax		
		144.0 MHz 36.0 Msymb/s	166.0 MHz 41.5 Msymb/s	184.0 MHz 46.0 Msymb/s		

IP Core Interface Description

IP core has two ways of forming the output spectrum:

- Baseband (using odati and odatq), ifreq equal 0
 - Intermediate frequency (using odati), ifreq not equal 0

Digital-to-analog converters must operate synchronously with the QAM Modulator IP core. Figure 3 shows the DAC connection diagram for baseband mode and Figure 4 shows the timing diagram for this mode.







Figure 4. The timing diagram for baseband mode.

Figure 5 shows the DAC connection diagram for IF mode and Figure 6 shows the timing diagram for this mode. The output intermediate frequency port **ifreq** sets the central frequency for **odati** modulator output port.



Figure 5. The DAC connection diagram for IF mode.



Figure 6. The timing diagram for IF mode.

Figure 7 shows an example of the waveform of the input interface. Handshake port **ordy** controls input dataflow. Input data is read from the input **idat** only when **ordy** is equal to logical one ("1").



Figure 7. The timing diagram of the IP Core input interface.

Upgrade and Technical Support Technical Support Free remote technical support is provided for 1 year and includes consultation via phone, E-mail and Skype. The maximum time for processing a request for technical support is 1 business day.

For up-to-date information on the IP Core visit this web page

https://www.iprium.com/ipcores/id/qam-modulator/

Feedback

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Revision history

Version	Date	Changes
4.0	2014.09.23	Added support for Xilinx Virtex-7, Kintex-7, Artix-7, Altera Stratix V, Arria V, Cyclone V, Lattice ECP5
3.0	2014.03.25	Added 128-APSK and 256-APSK modulation support
2.1	2010.10.12	Maintenance improvements
2.0	2009.08.18	Added 16-APSK/32-APSK/64- APSK modulation support
1.2	2008.10.10	Added 256-QAM/1024-QAM modulation support
1.1	2008.06.04	Added 64-QAM modulation support
1.0	2007.03.06	Official release