



QAM Modulator IP Core Specification

Release Information

Name	QAM Modulator IP Core
Version	4.0
Build date	2014.09
Ordering code	ip-qam-modulator
Specification revision	r1244

Features

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

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

Deliverables

QAM Modulator IP Core includes:

- VQM/QXP/NGC/EDIF netlist for Altera Quartus II, Xilinx ISE, Lattice Diamond or Microsemi (Actel) Libero SoC;
- IP Core testbench scripts;
- Design examples for Altera, Xilinx, Lattice, and Microsemi (Actel) evaluation boards.

IP Core Structure

Figure 1 shows QAM Modulator IP Core block diagram.

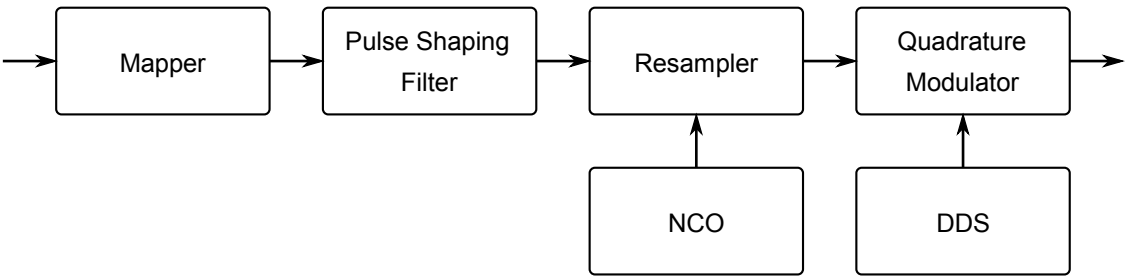


Figure 1. QAM Modulator IP Core block diagram

QAM modulator consists of constellation mapper (**Mapper**), RRC filter (**Pulse Shaping Filter**), fractional resampler/interpolator (**Resampler**), quadrature modulator (**Quadrature Modulator**), numerically controlled oscillator (**NCO**) and 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.

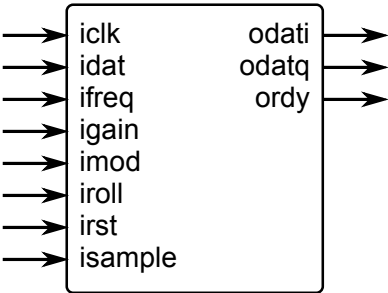


Figure 2. QAM Modulator port map

Table 1. 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 intermediate frequency
odatq	W_DAC	modulator output at baseband (Q channel)
ordy	1	ready to accept input data

IP Core
Parameters

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

Table 2. QAM Modulator IP Core parameters description	
Parameter	Description
W_DAC	Width of output DAC symbols (odati/odatq) Increasing the width of odati/odatq increases quality of waveform but also increases FPGA required resource
CONFIG	Set of mapping tables and QAM/PSK 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 Description

Quadrature Amplitude Modulation (QAM modulation) is the most 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

The values were obtained by automated characterization, using standard tool flow options and the floorplanning script delivered with the IP Core. Table 3 summarizes the QAM Modulator IP Core measurement results.

Table 3. 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 DAC connection diagram for baseband mode and Figure 4 shows timing diagram for this mode.

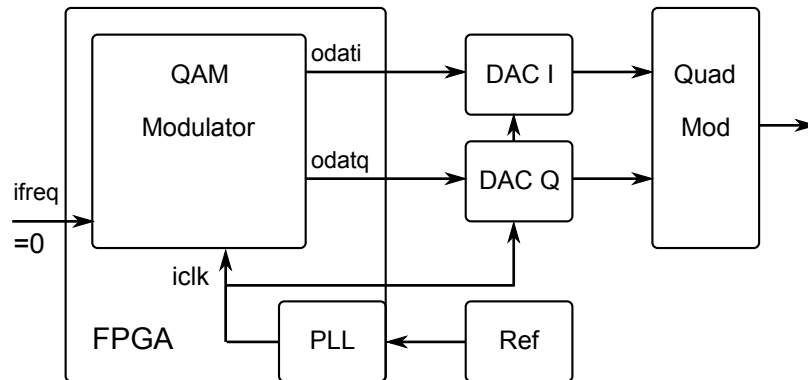


Figure 3. DAC connection diagram for baseband mode.

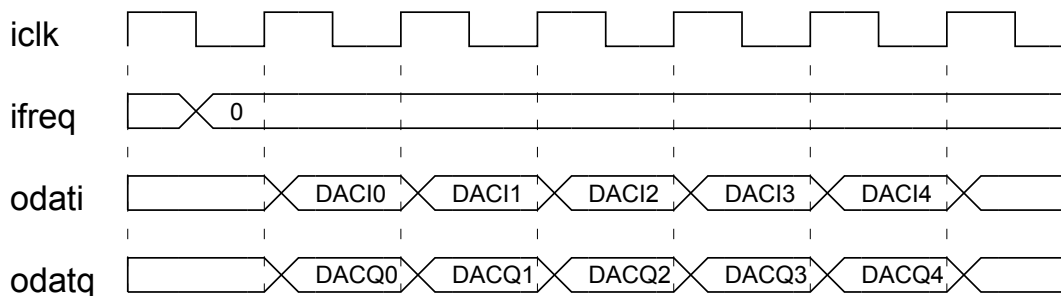


Figure 4. Timing diagram for baseband mode.

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

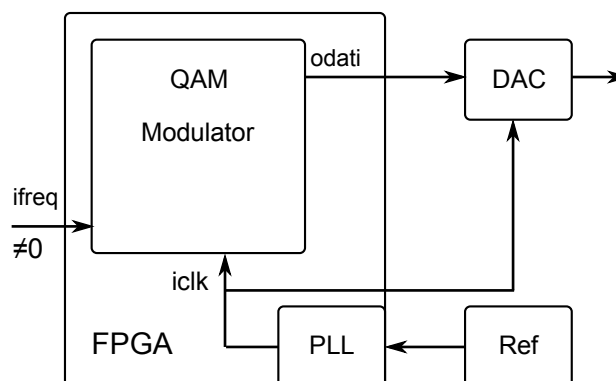


Figure 5. DAC connection diagram for IF mode.

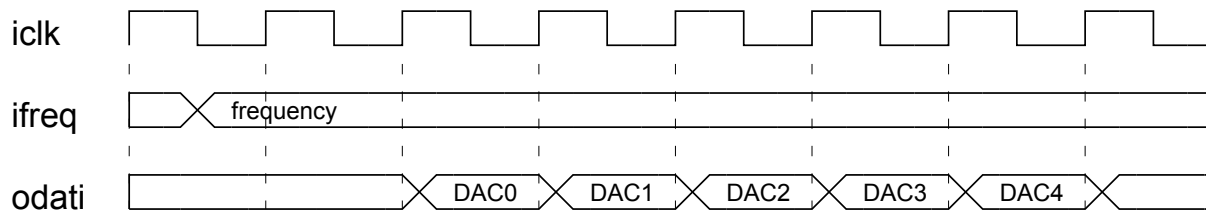


Figure 6. Timing diagram for IF mode.

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** equal to logical one ("1").

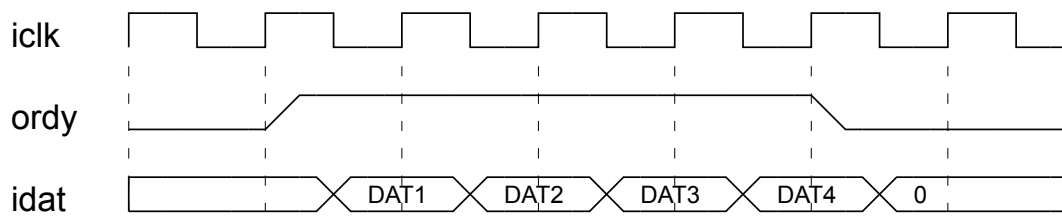


Figure 7. Timing diagram of the IP Core input interface.

Upgrade and Technical Support

Free technical support is provided for 1 year and includes consultation via phone, E-mail and Skype. The maximum term of processing a request for technical support - 1 business day.

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

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

Feedback

IPrium LLC

634029, Russia, Tomsk, Frunze ave, 20, office 427

Tel.: +7(952)7542219

E-mail: info@iprium.com

Skype: fpgahelp

website: <https://www.iprium.com/contacts/>

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