



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	r1383

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

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.

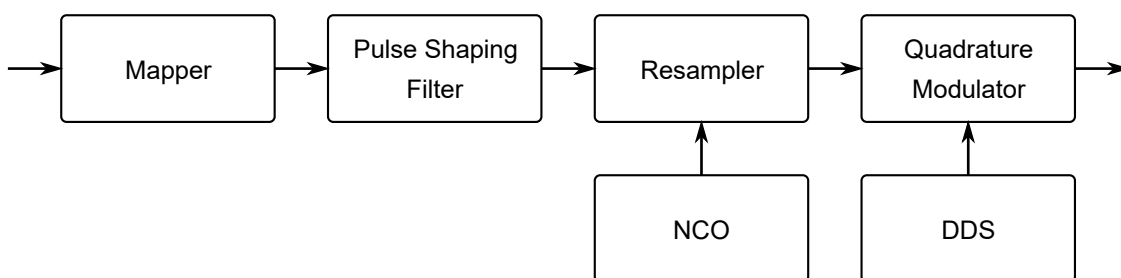


Figure 1. The QAM Modulator IP Core block diagram

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.

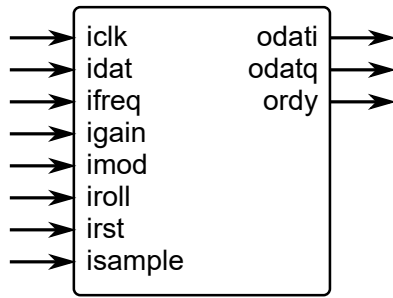


Figure 2. The QAM Modulator port map

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

<b>W_DAC</b>	<p>Width of output DAC symbols (<b>odati/odatq</b>)</p> <p>Increasing the width of odati/odatq, increases the quality of waveform but also increases FPGA required resource</p>
<b>CONFIG</b>	<p>Set of mapping tables and QAM/PSK constellations.</p> <p>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.</p> <p>For example, CONFIG="DVB-S2X" contains all DVB-S2 and DVB-S2X standard constellations.</p>
<b>ROLL-OFF</b>	<p>Set of roll-off factors (alpha) for shaping filter (RRC).</p> <p>For example, ROLL-OFF = 0.35, 0.25, 0.20, 0.15, 0.10 Pë 0.05.</p>

### 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/PSK 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. 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.

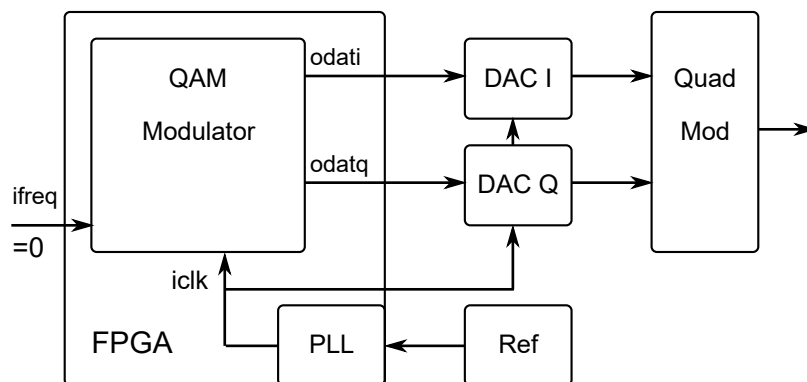
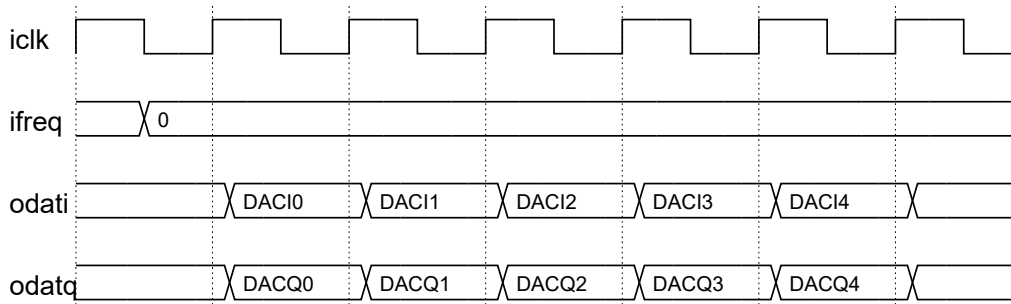
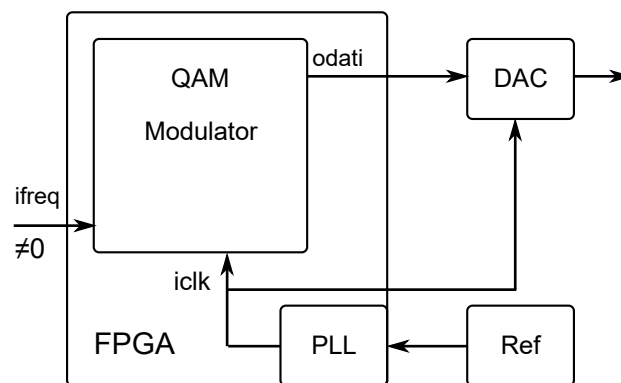


Figure 3. The DAC connection diagram for baseband mode.

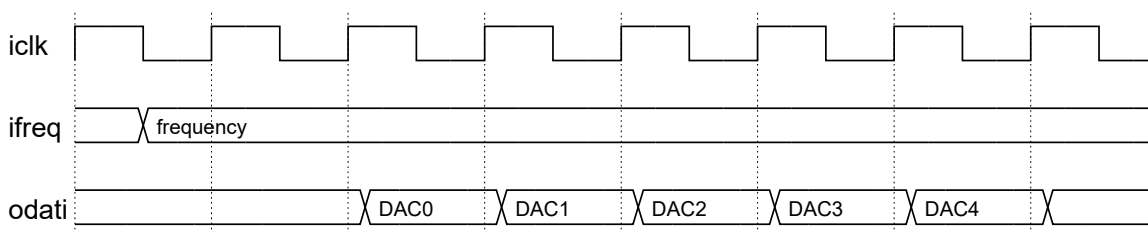


**Figure 4. The timing diagram for baseband mode.**

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.

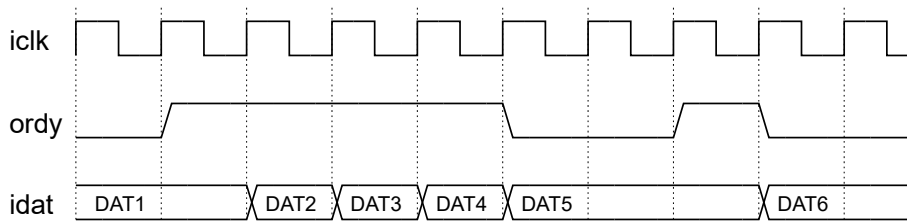


**Figure 5. The DAC connection diagram for IF mode.**



**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

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