TMS320DM646x DMSoC VLYNQ Port

User's Guide

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Contents

List of Figures

List of Tables

Read This First

About This Document

This document describes the VLYNQ™ communications interface port in the TMS320DM646x Digital Media System-on-Chip (DMSoC).

Notational Conventions

This document uses the following conventions.

- Hexadecimal numbers are shown with the suffix h. For example, the following number is 40 hexadecimal (decimal 64): 40h.
- Registers in this document are shown in figures and described in tables.
  - Each register figure shows a rectangle divided into fields that represent the fields of the register. Each field is labeled with its bit name, its beginning and ending bit numbers above, and its read/write properties below. A legend explains the notation used for the properties.
  - Reserved bits in a register figure designate a bit that is used for future device expansion.

Related Documentation From Texas Instruments

The following documents describe the TMS320DM646x Digital Media System-on-Chip (DMSoC). Copies of these documents are available on the Internet at www.ti.com. *Tip:* Enter the literature number in the search box provided at www.ti.com.

The current documentation that describes the DM646x DMSoC, related peripherals, and other technical collateral, is available in the C6000 DSP product folder at: www.ti.com/c6000.

SPRUEP8 — ***TMS320DM646x DMSoC DSP Subsystem Reference Guide.*** Describes the digital signal processor (DSP) subsystem in the TMS320DM646x Digital Media System-on-Chip (DMSoC).

SPRUEP9 — ***TMS320DM646x DMSoC ARM Subsystem Reference Guide.*** Describes the ARM subsystem in the TMS320DM646x Digital Media System-on-Chip (DMSoC). The ARM subsystem is designed to give the ARM926EJ-S (ARM9) master control of the device. In general, the ARM is responsible for configuration and control of the device; including the DSP subsystem and a majority of the peripherals and external memories.

SPRUEQ0 — ***TMS320DM646x DMSoC Peripherals Overview Reference Guide.*** Provides an overview and briefly describes the peripherals available on the TMS320DM646x Digital Media System-on-Chip (DMSoC).

SPRAA84 — ***TMS320C64x to TMS320C64x+ CPU Migration Guide.*** Describes migrating from the Texas Instruments TMS320C64x digital signal processor (DSP) to the TMS320C64x+ DSP. The objective of this document is to indicate differences between the two cores. Functionality in the devices that is identical is not included.

SPRU732 — ***TMS320C64x/C64x+ DSP CPU and Instruction Set Reference Guide.*** Describes the CPU architecture, pipeline, instruction set, and interrupts for the TMS320C64x and TMS320C64x+ digital signal processors (DSPs) of the TMS320C6000 DSP family. The C64x/C64x+ DSP generation comprises fixed-point devices in the C6000 DSP platform. The C64x+ DSP is an enhancement of the C64x DSP with added functionality and an expanded instruction set.

SPRU871 — ***TMS320C64x+ DSP Megamodule Reference Guide.*** Describes the TMS320C64x+ digital signal processor (DSP) megamodule. Included is a discussion on the internal direct memory access (IDMA) controller, the interrupt controller, the power-down controller, memory protection, bandwidth management, and the memory and cache.

Trademarks

VLYNQ is a trademark of Texas Instruments.

VLYNQ Port

1 Introduction

1.1 Purpose of the Peripheral

The VLYNQ™ communications interface port is a serial interface with a low pin count, high-speed point-to-point serial interface in the TMS320DM646x Digital Media System-on-Chip (DMSoC) for connecting to host processors and other VLYNQ compatible devices. The VLYNQ port is a full-duplex serial bus where transmit and receive operations occur separately and simultaneously without interference.

VLYNQ enables the extension of an internal bus segment to one or more external physical devices. The external devices are mapped to local physical address space and appear as if they are on the internal bus of the DM646x DMSoC. The external devices must also have a VLYNQ interface.

VLYNQ uses a simple block code (8b/10b) packet format and supports in-band flow control so that no extra terminals are needed to indicate that overflow conditions might occur.

The VLYNQ module on the DM646x DMSoC serializes a write transaction to the remote/external device and transfers the write via the VLYNQ port (TX pins). The remote VLYNQ module deserializes the transaction on the other side.

The read transactions to the remote/external device follow the same process, but the remote device's VLYNQ module serializes the read return data and transfers it to the VLYNQ port (RX pins). The read return data is finally deserialized and released to the device internal bus.

The external device can also initiate read and write transactions.

1.2 Features

The general features of the VLYNQ port are:

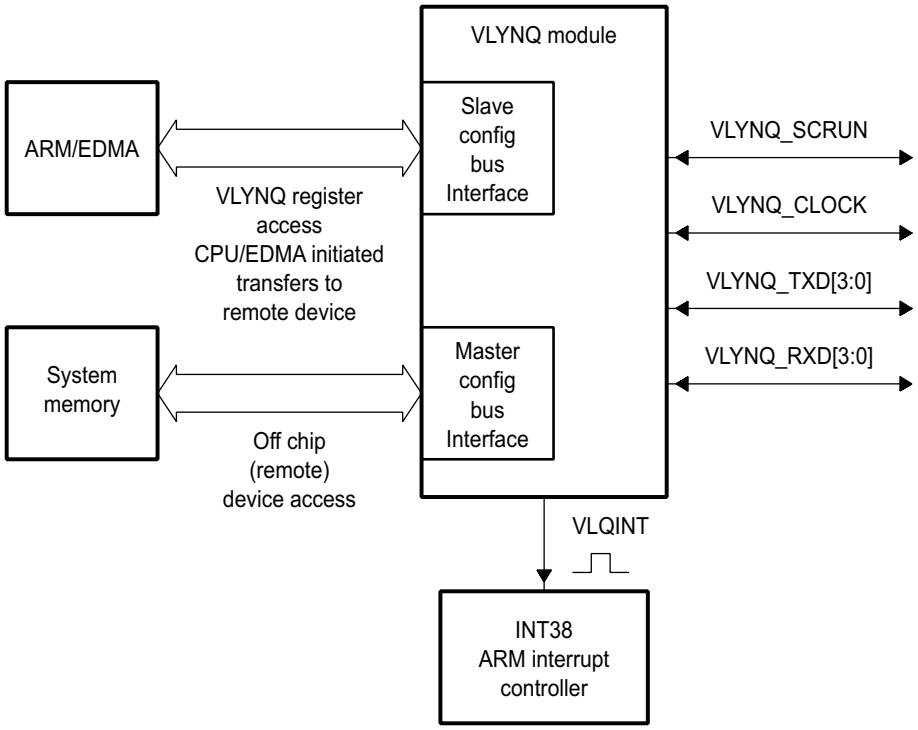
- Low pin count (10 pin interface, scalable to as low as 3 pins)
- No tri-state signals
  - All signals are dedicated and driven by only one device
  - Necessary to allow support for high-speed PHYs
- Scalable Performance
  - Programmable frequency and 1 to 4 bits for TX and RX data
  - Performance increases linearly as the data port width increases
- Simple packet-based transfer protocol for memory-mapped access
  - Write request/data packet
  - Read request packet
  - Read response data packet
  - Interrupt request packet
- Auto width negotiation

- Symmetric Operations
  - Transmit (TX) pins on the first device connect to the receive (RX) pins on the second device and vice-versa.
  - Data pin widths are automatically detected after reset
  - Re-request packets, response packets, and flow control information are all multiplexed and sent across the same physical pins.
  - Supports both host/peripheral and peer-to-peer communication models
- Simple block code packet formatting (8b/10b)
- Supports in-band and flow control
  - No extra pins are needed
  - Allows the receiver to momentarily throttle the transmitter back when overflow is about to occur
  - Uses the special built-in block code capability to interleave flow control information seamlessly with user data
- Automatic packet formatting optimizations
- Internal loopback modes are provided

1.3 Functional Block Diagram

Figure 1 shows a functional block diagram of the VLYNQ port.

Figure 1. VLYNQ Port Functional Block Diagram



1.4 Industry Standard(s) Compliance Statement

VLYNQ is an interface defined by Texas Instruments and does not conform to any other industry standard.

2 Architecture

This section discusses the architecture and basic functions of the VLYNQ peripheral.

2.1 Clock Control

The VLYNQ internal system clock is derived from SYSCLK3, which is the PLL0 clock divided by 4. For detailed information on the PLLs and clock distribution on the processor, see the *TMS320DM646x DMSoC ARM Subsystem Reference Guide* (SPRUEP9). The module's serial clock direction and frequency are software configurable through the CLKDIR and CLKDIV bits in the VLYNQ control register (CTRL). The VLYNQ serial clock can be sourced from the internal system clock (CLKDIR = 1) or by an external clock source (CLKDIR = 0) for its serial operations.

The CLKDIV bit can divide the serial clock (1/1 to 1/8) down when the internal clock is selected as the source. The serial clock is not affected by the CLKDIV bit values if the serial clock is externally sourced. For the maximum serial clock the VLYNQ supports, see the device-specific data manual.

The reset value of the CLKDIR bit is 0 (external clock source).

The external clock source is shown in Figure 2. The internal clock source is shown in Figure 3.

Figure 2. External Clock Block Diagram

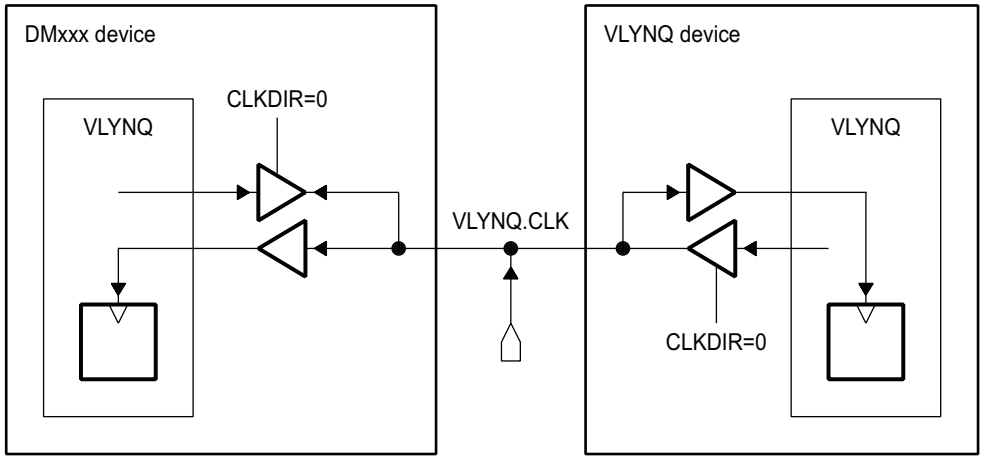
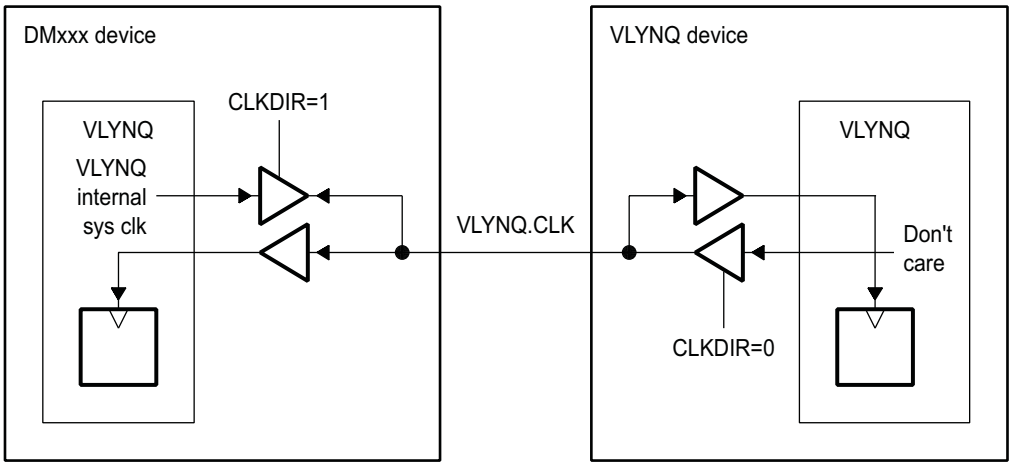


Figure 3. Internal Clock Block Diagram



2.2 Signal Descriptions

The VLYNQ module on the DM646x device is configurable for a 1 to 4 bit-wide RX/TX.

If the configured width does not match the number of transmit/receive lines that are available on the remote device, negotiation between the two VLYNQ devices automatically configures the width (see Section 2.6).

The VLYNQ interface signals are shown in Table 1.

Table 1. VLYNQ Port Pins

Pin Name	Signal Name	I/O	Description
VLYNQ_CLOCK	VLYNQ serial clock	I/O	The VLYNQ reference clock supports the internally or externally generated clock.
VLYNQ_SCRUN	VLYNQ serial clock run request (Active low)	I/O	The VLYNQ serial clock run request allows remote requests for the VLYNQ serial clock to be turned off for system power management. Low: The request VLYNQ serial clock is active. High: The VLYNQ serial clock is requested to be high when all transactions are complete.
VLYNQ_RXD[0:3]	VLYNQ receive data	I	VLYNQ receive data is synchronous with the VLYNQ serial clock.
VLYNQ_TXD[0:3]	VLYNQ transmit data	O	VLYNQ transmit data is synchronous with the VLYNQ serial clock.

2.3 Protocol Description

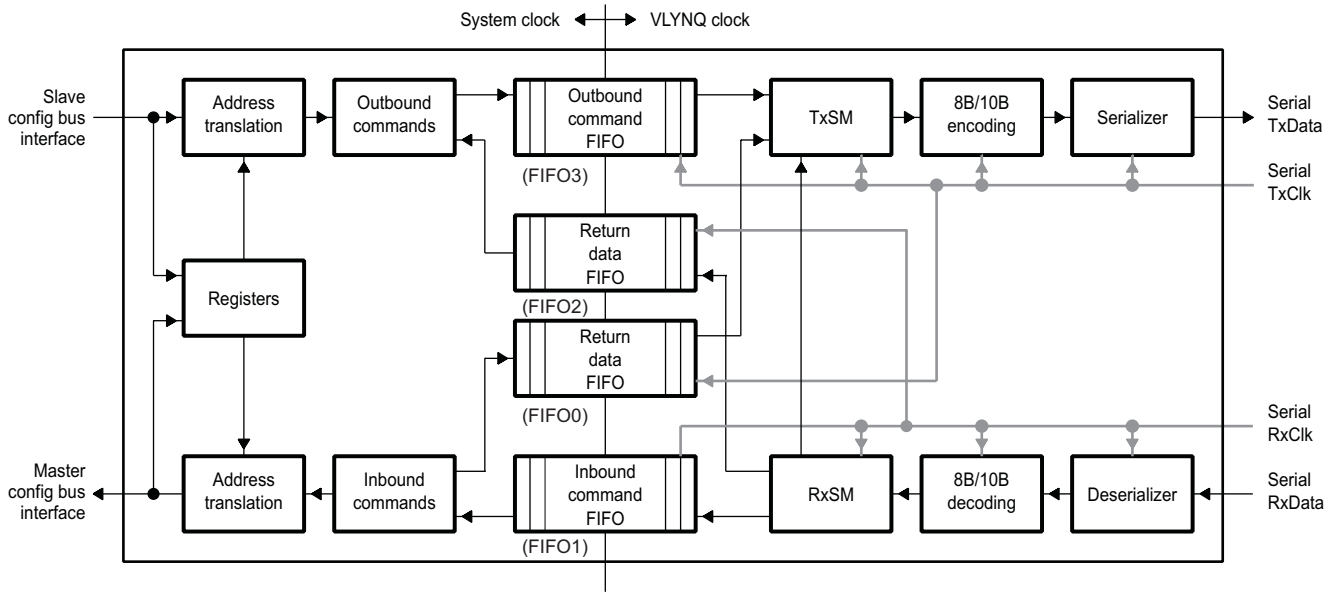
VLYNQ relies on 8b/10b block coding to minimize the number of serial pins and allows for in-band packet delineation and control.

Appendix A provides general information on 8b/10b coding definitions and their implementation within the VLYNQ module in the DM646x device.

2.4 VLYNQ Functional Description

The VLYNQ core supports both host-to-peripheral and peer-to-peer communication models and is symmetrical. The VLYNQ module structure is shown in Figure 4.

Figure 4. VLYNQ Module Structure



The VLYNQ core module implements two 32-bit configuration bus interfaces. Transmit operations and control register access require the slave configuration bus interface. The master configuration bus interface is required for receive operations. Converting to and from the 32-bit bus to the external serial interface requires serializer and deserializer blocks.

8b/10b block coding encodes data on the serial interface. Frame delineation, initialization, and flow control use special overhead code groups.

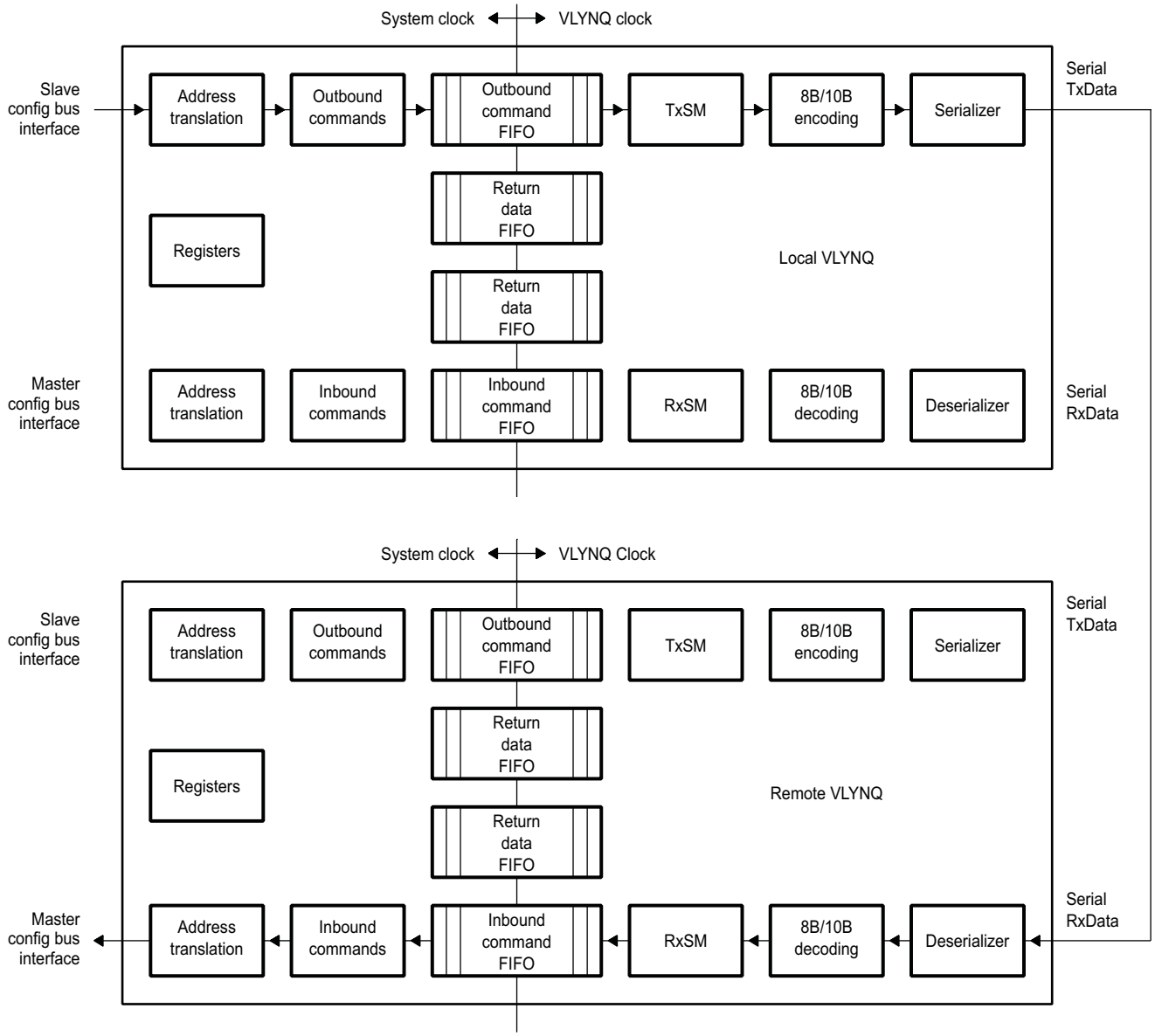
FIFOs buffer the entire burst on the bus for maximum performance, thus minimizing bus latency. Using write operations of each VLYNQ module interfaced is typically recommended to ensure the best performance on both directions of the link.

2.4.1 Write Operations

Write requests that initiate from the slave configuration bus interface of the local device write to the outbound command (CMD) FIFO. Data is subsequently read from the FIFO and encapsulated in a write request packet. The address is translated, and the packet is encoded and serialized before being transmitted to remote device. The remote device subsequently deserializes and decodes the receive data and writes it into the inbound CMD FIFO. A write operation initiates on the remote device's master configuration bus interface after reading the address and data from the FIFO.

The data flow between two VLYNQs that are connected is shown in Figure 5. In the example shown in Figure 5, the write originates from the DM646x device.

Figure 5. Write Operations

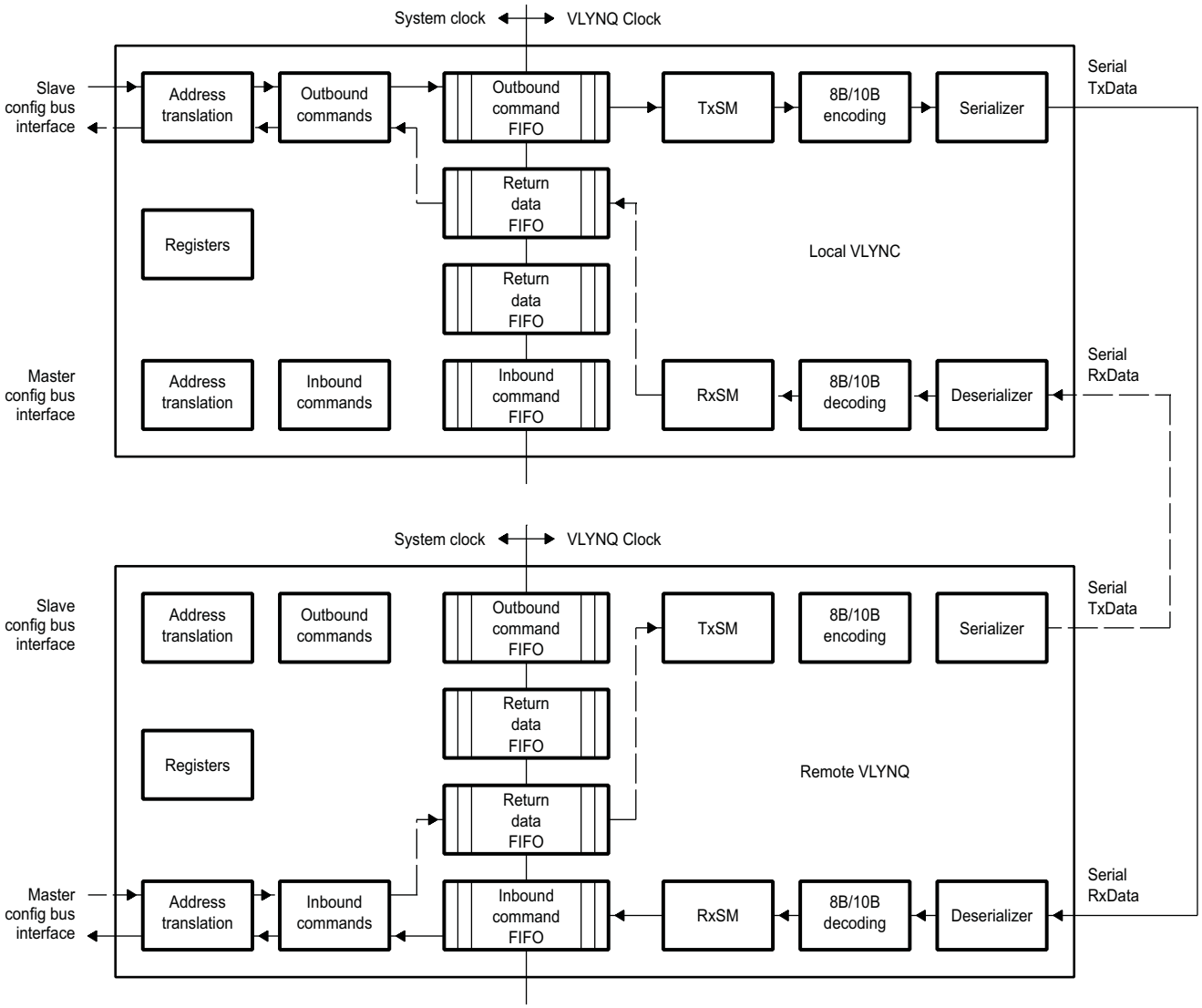


2.4.2 Read Operations

Read requests from the slave configuration bus interface are written to the outbound CMD FIFO (similar to the write requests). Data is subsequently read from the FIFO and encapsulated into a read request packet. The packet is encoded and serialized before it is transmitted to the remote device. Next, the remote device deserializes, decodes the receive data, and writes the receive data to the inbound CMD FIFO. After reading the address from the FIFO, a master configuration bus interface read operation initiates in the remote device. When the remote master configuration bus interface receives the read data, the data is written to the return data FIFO before it is encoded and serialized. When the receive data reaches the local VLYNQ module, it is deserialized, decoded, and written to the return data FIFO (local device). Finally, the read data is transferred on the local device's slave configuration interface.

The data flow between two connected VLYNQ devices with read requests that originate from the DM646x device is shown in Figure 6. The remote VLYNQ device returns the read data. Read data is shown with dotted arrows.

Figure 6. Read Operations



Note: Not servicing read operations results in deadlock. The only way to recover from a deadlock situation is to perform a hard reset. Read operations are typically not serviced due to read requests that are issued to a non-existent remote VLYNQ device or they are not serviced due to trying to perform reads on the VLYNQ memory-map prior to establishing the link.

Generally, you should not use read operations to transfer data packets since the serial nature of the interface could potentially result in longer latencies.

2.5 Initialization

Since VLYNQ devices can be controlled solely over the serial interface (that is, no local CPU exists), an automatic reliable initialization sequence (without user configuration) establishes a connection between two VLYNQ devices, just after a VLYNQ module is enabled and auto-negotiation occurs. Auto-negotiation is defined in Section 2.6. The same sequence is used to recover from error conditions.

Bit 0 in the VLYNQ status register (LINK bit) is set to 1 when a link is established.

A link pulse timer generates a periodic link code every 2048 serial clock cycles. The link is lost when time expires and no link code has been detected during a period of 4096 serial clock cycles.

2.6 Auto Negotiation

Auto-negotiation occurs after reset. It involves placing a negotiation protocol in the outbound data and processing the inbound data to establish connection information. The width of the data pins on the serial interface is automatically determined at reset as a part of the initialization sequence. For a connection between two VLYNQ devices of version 2.0 and later (VLYNQ on DM646x device is version 2.6), the negotiation protocol using the available serial pins is used to convey the maximum width capability of each device. The TXD data pins are not required to have the same width as the RXD data pins.

The auto width negotiation does not occur until after completion of the VLYNQ 1.x legacy width configuration, which involves a period of 2000 VLYNQ 1.x system clock cycles for connection to VLYNQ 1.x devices. After the VLYNQ 1.x has determined its width, it receives the VLYNQ2.x auto width negotiation protocol. The VLYNQ 1.x device does not recognize this protocol and transmits error codes over the serial interface. The received error codes allow the VLYNQ 2.x devices to determine how many serial pins are valid on the connected VLYNQ 1.x device.

Once the width is established, VLYNQ further identifies the version (version 1.x or version 2.x) of the remote VLYNQ. This better determines the capabilities of the connected VLYNQ device. This is software readable via the VLYNQ auto-negotiation register (AUTNGO), bit 16 (0 = Ver 1.x , 1 = Ver 2.x), after the link has been established.

2.7 Address Translation

Once a link is established, remote VLYNQ device(s) are memory mapped into the local (host) device's address space, similar to any other on chip peripherals. Part of the initialization sequence is to enumerate the VLYNQ devices (single or multiple) into a coherent memory map for accessing each device.

After the enumeration, the host (local) device can access the remote device address map using local device addresses. The VLYNQ module in the host device manages the address translation of the local address to the remote address. A remote VLYNQ device is mapped to the local device’s address via the address map registers (TX address map, RX address map size *n*, RX address map offset *n*, where *n* = 1 to 4). The transmit side has a contiguous map; the size of the map is the same as the remote device map. Figure 7 illustrates this mapping.

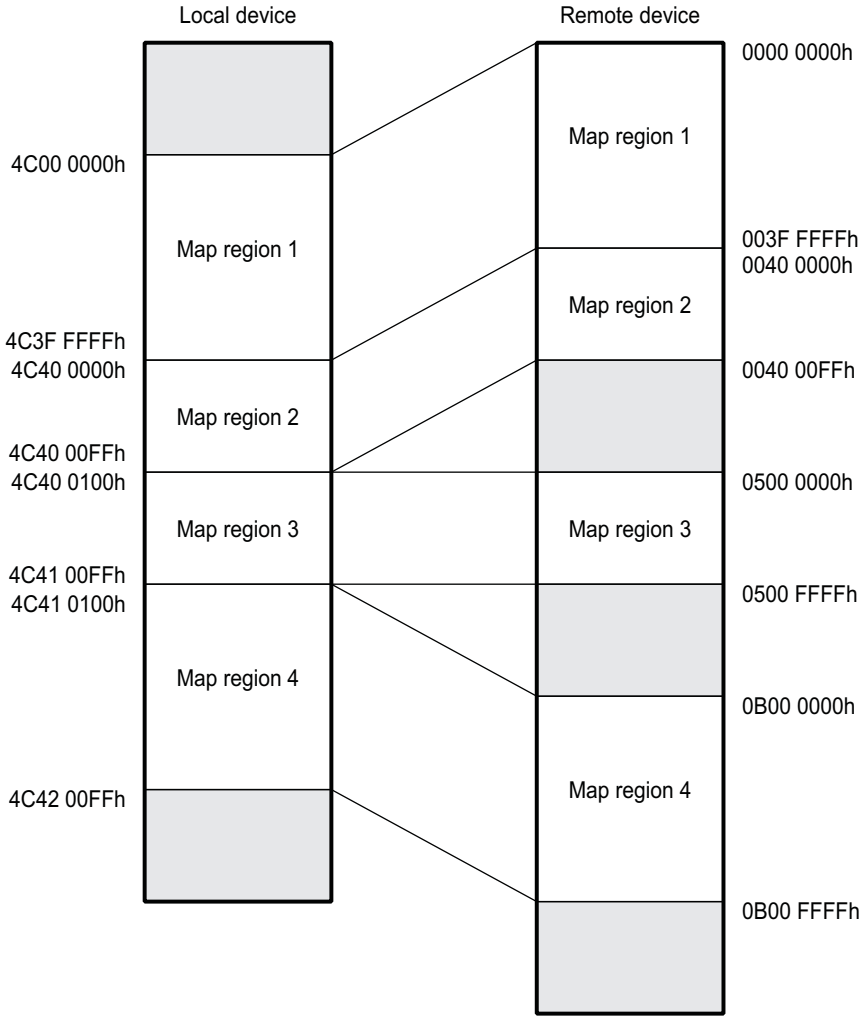
In the local device, the address of the VLYNQ Remote Memory Map in the local configuration space will be the transmit address accessing remote device's over the serial interface and is programmed in the TX Address Map (XAM) register. When the local device transmits, it first strips off the transmit address offset in local device memory map. Then sends the data with an address offset from the transmit address.

VLYNQ allows each receive packet address to be translated into one of the four mapped regions. The size and offset of each memory region must be aligned to 32-bit words. No restriction is placed on programming the size or on the offset of each mapped region, as long as the total memory that is mapped into these one to four regions is not more then 64 MBytes.

Note: Care should be taken while programming the receive address map size register (RAMS*n*) and the receive address map offset register (RAMO*n*) values. These registers should be programmed with valid address locations and memory size to match the device specifications. See the Memory Map Summary and the System Interconnect sections in your device-specific data manual to identify the valid memory regions that can be accessed by an off-chip peer device through the VLYNQ interface.

At the remote device, the transmitted address is used to determine, which remote mapped region is being accessed. This is achieved by summing each memory size sequentially until the memory size is larger than the transmitted address. The last memory size added is the region targeted. The remote map is specified by a memory size and an offset, programmed in the RX Address Map Size (RAMS*n*) register and RX Address Map Offset (RAMO*n*) in the remote device. Figure 7 illustrates one possible memory map.

Figure 7. Example Address Memory Map



The following section shows an example illustrating the address translation used in each VLYNQ module.

Table 2 illustrates address map register configuration when the DM646x device is transmitting data to the remote device.

Table 2. Address Translation Example (Single Mapped Region)

Register	DM646x VLYNQ Module	Remote VLYNQ Module
TX Address Map	4C00 0000h	Do not care
RX Address Map Size 1	Do not care	0000 0100h
RX Address Map Offset 1	Do not care	0800 0000h

DM646x VLYNQ Module:

	4C00 0054h	Initial address at the slave configuration bus
subtract	4C00 0000h	TX Address Map Register (no need to change the reset value for DM646x , for this register)
	0000 0054h	Translated address to remote device via serial interface

Remote VLYNQ Module:

	0000 0054h	Initial address from the RX serial interface
compare	0000 0100h	RX address map size 1 register
	0000 0054h	
add	0800 0000h	RX address map offset 1 register
	0800 0054h	Translated address to remote device

The local address 4C00 0054h was translated to 0800 0054h on the remote VLYNQ device in Table 3.

Table 3 illustrates the address map register configuration when the DM646x device is receiving data from the remote device.

Table 3. Address Translation Example (Single Mapped Region)

Register	DM646x VLYNQ Module	Remote VLYNQ Module
TX Address Map	Do not care	0400 0000h
RX Address Map Size 1	0000 0100h	Do not care
RX Address Map Offset 1	0200 0000h	Do not care
RX Address Map Size 2	0000 0100h	Do not care
RX Address Map Offset 2	8200 0000h	Do not care

Remote VLYNQ Module:

	0400 0154h	Initial address at the slave configuration bus of the remote device
subtract	0400 0000h	TX address map register
	0000 0154h	Translated address to remote device via serial interface

DM646x VLYNQ Module:

	0000 0154h	Initial address from the RX serial interface
compare	0000 0100h	RX address map size 1 register
	0000 0154h	The RX packet address is greater than the value in the RX address map size 1 register
compare	0000 0200h	RX address map size 1 register + RX address map size 2
		Since the RX packet address < the RX address map size 1 register + RX address map size 2 register
add	8200 0000h	RX address map offset 2 register
subtract	0000 0100h	RX address map size 1 register
	8200 0054h	Translated address to DM646x device

Example 1. Address Translation Example

The remote address 0400 0154h (or 0000 0054h) was translated to 8200 0054h on the DM646x (local) device.

The translated address for packets received on the serial interface is determined as follows:

```
If (RX Packet Address < RX Address Map Size 1 Register) {
  Translated Address = RX Packet Address +
                       RX Address Map Offset 1 Register

} else if (RX Packet Address < (RX Address Map Size 1 Register +
            RX Address Map Size 2 Register)) {
  Translated Address = RX Packet Address +
                       RX Address Map Offset 2 Register -
                       RX Address Map Size 1 Register
} else if (RX Packet Address < (RX Address Map Size 1 Register +
                                RX Address Map Size 2 Register +
                                RX Address Map Size 3 Register)) {
  Translated Address = RX Packet Address +
   RX Address Map Offset 3 Register -
                       RX Address Map Size 1 Register -
                       RX Address Map Size 2 Register

} else if (RX Packet Address < (RX Address Map Size 1 Register +
                                RX Address Map Size 2 Register +
                                RX Address Map Size 3 Register +
                                 RX Address Map Size 4 Register)) {
  Translated Address = RX Packet Address +
   RX Address Map Offset 4 Register -
                       RX Address Map Size 1 Register -
                       RX Address Map Size 2 Register -
                       RX Address Map Size 3 Register
} else {
  Translated Address = 0x0

}
```

Multiple VLYNQ modules may be included on any device so that VLYNQ serial interfaces are daisy-chained effectively. The only requirement is that the address translation registers are configured to include the outbound VLYNQ module of the remote device.

2.8 Flow Control

The VLYNQ module includes flow control features. The VLYNQ module automatically generates flow control enable requests, /P/, when the RX/inbound FIFOs (FIFO1 and FIFO2) resources are consumed. The FIFOs can take up to 16 32-bit words.

The remote device will begin transmitting idles, /I/, starting on the first byte boundary following reception of the request. When sufficient RX FIFO resources have been made available, a flow control disable request, /C/, is transmitted to the remote device. In response, the remote device will resume transmission of data. See Appendix A.

2.9 Reset Considerations

2.9.1 Software Reset Considerations

Peripheral clock and reset control is done through the power and sleep controller (PSC) module that is included with the device. For more information, refer to the power management section (Section 2.12). Additionally, there is a software reset (the reset bit in the VLYNQ control register, CTRL) within the peripheral itself. Writing a 1 to the reset bit resets all of the internal state machines of the VLYNQ module, the serial interface is disabled, and the link is lost. The VLYNQ module remains in reset until the software clears the bit.

Note: When setting the reset bit, the VLYNQ status register (STAT) value is the only value that is set to the default value. All of the other VLYNQ memory-mapped registers retain their values prior to the software reset.

2.9.2 Hardware Reset Considerations

When a hardware reset occurs, the VLYNQ peripheral resets its register values to the default values and the serial interface is disabled. After a hardware reset, the VLYNQ memory mapped registers and any chip-level registers that are associated with VLYNQ (for example, pin multiplexing registers) must be configured appropriately before data transmission can resume.

CAUTION

Be cautious when only resetting one of the VLYNQ devices after two or more VLYNQ devices have established a link. If only one of the VLYNQ devices is in reset, then no data activity can occur across the serial interface during the time of reset.

2.10 Interrupt Support

2.10.1 Interrupt Events and Requests

The VLYNQ module has a single interrupt source (Table 4) mapped to the ARM interrupt controller (AINTC). For more information on the ARM interrupt controller (AINTC), see the *TMS320DM646x DMSoC ARM Subsystem Reference Guide* (SPRUEP9).

Table 4. VLYNQ Interrupt

ARM Event	Acronym	Source
38	VLQINT	VLYNQ

Interrupts generate when bits are set in the VLYNQ interrupt pending/set register (INTPENDSET). Bits are set in the INTPENDSET register when any of the following occur:

- Writing directly to the INTPENDSET
- Remote interrupt (via the serial interrupt packet)
- Serial bus error

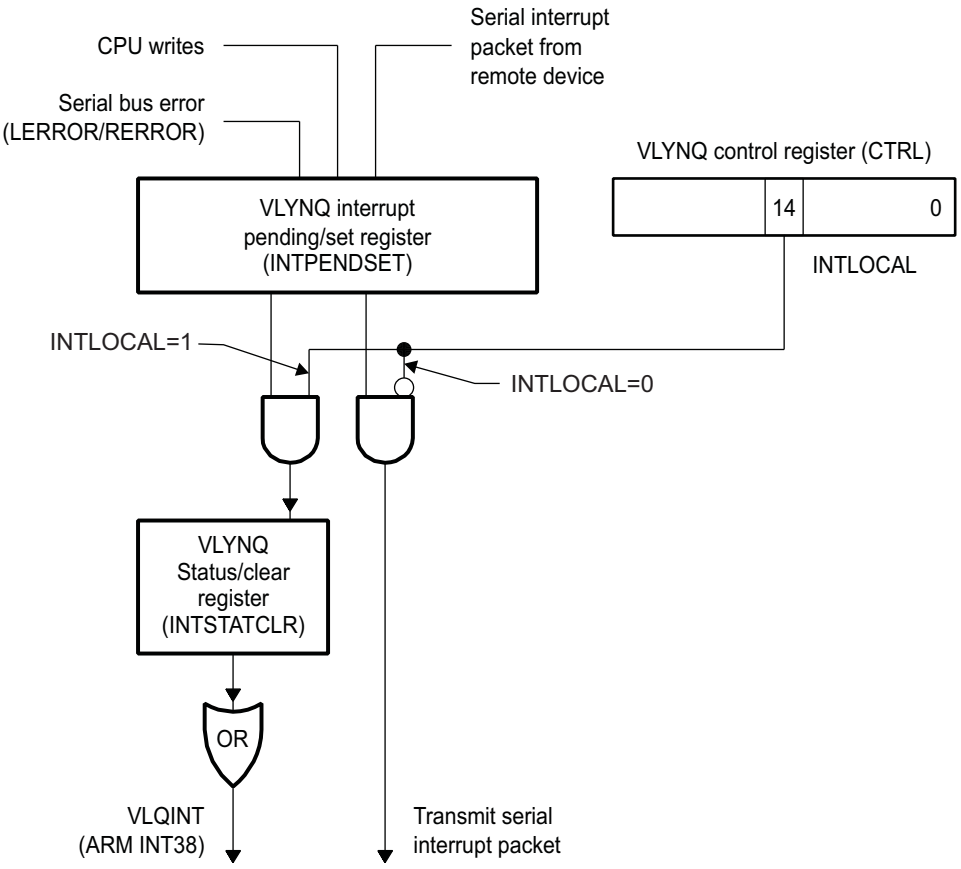
When the VLYNQ interrupt pending/set register (INTPENDSET) is a non-zero value, the method of forwarding the interrupt status depends on the state of the INTLOCAL bit in the VLYNQ control register (CTRL).

When INTLOCAL = 0, the contents of INTPENDSET are inserted into an interrupt packet and sent over the serial interface. When packet transmission completes, the associated bits clear in INTPENDSET. When INTLOCAL = 1, bits in INTPENDSET transfer to the VLYNQ interrupt status/clear register (INTSTATCLR). The logical-OR of all of the bits in INTSTATCLR is driven onto the interrupt line, causing the VLYNQINT to pulse.

If the system writes to INTSTATCLR while interrupts are still pending, a new VLQINT interrupt is generated.

The VLYNQ interrupt generation mechanism is shown in Figure 8.

Figure 8. Interrupt Generation Mechanism Block Diagram



For additional flexibility of interrupt handling, there is an interrupt priority vector status/clear register (INTPRI) that reports the highest priority interrupt asserted in the VLYNQ interrupt pending/set register (INTPENDSET) when INTLOCAL = 1. VLYNQ interprets bit 0 as the highest priority and it interprets bit 31 as the lowest priority. The value that is returned when read is the vector of the highest priority interrupt. Software can clear that interrupt by writing back the vector value. Additionally, INTRPRI provides a read-only status bit (NOINTPEND) to indicate whether or not there are any pending interrupts in the interrupt status/clear register (INTSTATCLR).

2.10.2 Writes to Interrupt Pending/Set Register

As previously discussed, if the ARM CPU writes to the VLYNQ interrupt pending/set register (INTPENDSET), then depending on the value of the INTLOCAL bit in the VLYNQ control (CTRL) register, this will result in a local interrupt (to the device interrupt controller) or an interrupt packet transmitted over the serial interface to the remote device.

2.10.3 Remote Interrupts

Remote interrupts occur when an interrupt packet is received over the serial interface from a remote device. The interrupt status is extracted from the packet and written to a location pointed to by the interrupt pointer register (INTPTR).

The INTPTR should contain the address of the interrupt pending/set register (INTPENDSET). To get INTPTR to contain the address of INTPENDSET, program INTPTR with a value of 14h (the offset for INTPENDSET). Additionally, the INT2CFG bit in the VLYNQ control register (CTRL) must be set to 1, dictating that the VLYNQ writes to a local register space (in this case, INTPENDSET).

Once an interrupt packet is received over the serial interface, the interrupt status is extracted and written to INTPENDSET. After the interrupt status is extracted and written to INTPENDSET, the interrupt generation occurs as previously described in Section 2.10.2.

The following summarizes the steps that are required to ensure that the device receives the remote interrupts:

- Program the VLYNQ interrupt pointer register (INTRPTR) with a value of 14h, which is the offset address of the VLYNQ interrupt/pending set register (INTPENDSET).
- Set the INT2CFG bit to 1 in the VLYNQ control register (CTRL).

2.10.4 Serial Bus Error Interrupts

Due to erroneous transmit packets that are detected by remote devices (remote error) or errors in the inbound packets (local error), the serial bus errors result in the setting of the RERROR or LERROR bits in the VLYNQ status register (STAT).

Additionally, if the INTENABLE bit is set in the VLYNQ control register (CTRL), setting the RERROR or LERROR bits cause these status interrupts to post to the interrupt pending/set register (INTPENDSET), causing the VLYNQINT to be asserted to the ARM CPU.

To ensure that serial bus errors result in interrupts to notify the application software, you must perform the following steps:

1. Set the INTENABLE bit to 1 in the VLYNQ control register (CTRL).
2. Set the INTVEC bits in CTRL to point to a free bit in the VLYNQ interrupt pending/set register (INTPENDSET). The serial bus error should result in setting the bits in INTPENDSET that are not used by the application software for other interrupts (bit locations written directly in INTPENDSET or via remote interrupts).
3. During VLYNQ initialization, the RERROR bit is set after the VLYNQ module achieves a link. When the link bit is set in the VLYNQ status register (STAT), write a 1 to the RERROR bit. Writing a 1 to the RERROR bit clears the RERROR bit and prevents the software interrupt handler from seeing the first RERROR as a legitimate serial bus error interrupt.

2.11 DMA Event Support

The VLYNQ module on the DM646x device is classified as a master peripheral. Classification as a master peripheral normally implies that the peripheral is able to sustain its own transfers without relying on any external peripherals (for example, the system DMA, etc). However, the VLYNQ module does not have an internal DMA (as some other master peripherals).

Therefore, it is likely that the VLYNQ module can rely on the on-chip enhanced DMA (EDMA3) controller for performing burst transfer. The EDMA3 can still be used to perform burst transfers out to remote VLYNQ memory map (writes). This use model provides better throughput with less overhead.

Note: There is no VLYNQ event that allows hardware synchronization to occur with the EDMA3 controller on the DM646x device.

The VLYNQ module uses a 16-word deep FIFO to buffer the burst writes. Since the EDMA3 controller is much faster compared to the serial VLYNQ interface, a data back-up can occur. Therefore, configuring EDMA3 for optimal transfer size, etc. is essential.

2.12 Power Management

The VLYNQ module can be placed in reduced-power modes to conserve power during periods of low activity. The power management of the peripheral is controlled by the processor Power and Sleep Controller (PSC). The PSC acts as a master controller for power management of all of the peripherals on the processor.

The power conservation modes that are available via the PSC are:

- Idle/Disabled state : Idle/disabled state stops the clocks from going to the peripheral and prevents all of the register accesses. After re-enabling the peripheral from its idle state, all registers prior to setting in the disabled state are restored and data transmission proceeds. Re-initialization is not required.
- Synchronized reset : The synchronized reset state is similar to the power-on reset (POR) state. When the processor is turned on, reset to the peripheral is asserted, then clocks to the peripheral are gated. Registers reset to their default values. When powering-up after a synchronized reset, all of the VLYNQ module registers must be reconfigured and the link must be re-established before data transmission.

For more detailed information on power management procedures using the PSC, see the *TMS320DM646x DMSoC ARM Subsystem Reference Guide* (SPRUEP9).

If the serial clock is internally sourced, you can use the CLKDIV bit in the VLYNQ control register (CTRL) to divide the serial clock down. This saves normal mode operation power consumption (at the expense of reduced performance).

Additionally, the module provides the capability of auto-idling the serial clock domain (disable the VLYNQ CLK) when the serial clock is sourced from the DM646x device and the VLYNQ SCRUN pin is connected to the remote device. This allows power savings when there is no activity on the serial interface.

Note: There is no support for external wake-up for the VLYNQ module on the DM646x device. If the VLYNQ module on the DM646x device has been disabled via the PSC, then even though serial activity requests can be indicated from the remote VLYNQ device via the VLYNQ SCRUN pin, it does not allow the serial clock (VLYNQ CLK) to be sourced until the VLYNQ module is re-enabled via the PSC.

This can be configured by enabling the power management enable (PMEN) bit in the VLYNQ control registers (CTRL, 0 = disable, 1 = enable) . This bit should only be set if the SCRUN pin is connected to the remote VLYNQ device.

The SCRUN pin is a bi-directional pin which is driven low whenever there is serial activity on the local or remote VLYNQ interface.

2.13 Emulation Considerations

During debug, the ARM CPU may be halted for single stepping, bench marking, profiling, or other debug uses using the emulator. VLYNQ does not support emulation halts/suspend operation. VLYNQ operations continue during emulation halt/suspend.

2.14 Programming Guide

The sequence below sets up the local VLYNQ to function in basic mode. Additional fields in the CTRL register can be set to utilize additional features of VLYNQ. The remote registers can be set only after the link is established to control the remote VLYNQ.

- Set CTRL.RESET to 1, and then back to 0.
  - Resets the internal state machines and attempts to re-establish the link.
- Set XAM, RAMSn, and RAMOn to desired values.
  - Sets up the memory map.
- Clear INTSTATCLR to clear all the interrupts.
- Set INTPTR to point to INTPENDSET.
  - Allows the VLYNQ to be interrupted by remote interrupt.
- Set INTPRI to desired values.
  - Assigns the outbound interrupt with a priority.
- Set CTRL.CLKDIR, CTRL.INTLOCAL, and CTRL.INTENABLE.
  - Sets up the VLYNQ source clock and the interrupt source.
- Poll STAT.LINK to wait for the link to be established.
  - VLYNQ communication can be started only after the link is established.

3 Registers

Table 5 describes the address space for the VLYNQ registers and memory.

Table 5. VLYNQ Register Address Space

Block Name	Start Address	End Address	Size
VLYNQ Control Registers	2001 0000h	2001 0FFFh	32 bytes
VLYNQ Remote Memory Map	4C00 0000h	4FFF FFFFh	64 Mbytes

Table 6 lists the memory-mapped registers for the VLYNQ port controller. See the device-specific data manual for the memory address of these registers.

The first 128 bytes map to the VLYNQ configuration registers that are maintained by the local (device) VLYNQ register control module while the second 128 bytes map to the remote configuration registers that are physically located in the remote device linked by the VLYNQ serial interface. Any access to the second set of registers causes VLYNQ to issue a read or write VLYNQ packet to be transmitted and only completes if a link is established between the two devices.

Table 6. VLYNQ Port Controller Registers

Offset	Acronym	Register Description	Section
0h	REVID	Revision Register	Section 3.1
4h	CTRL	Control Register	Section 3.2
8h	STAT	Status Register	Section 3.3
Ch	INTPRI	Interrupt Priority Vector Status/Clear Register	Section 3.4
10h	INTSTATCLR	Interrupt Status/Clear Register	Section 3.5
14h	INTPENDSET	Interrupt Pending/Set Register	Section 3.6
18h	INTPTR	Interrupt Pointer Register	Section 3.7
1Ch	XAM	Transmit Address Map Register	Section 3.8
20h	RAMS1	Receive Address Map Size 1 Register	Section 3.9
24h	RAMO1	Receive Address Map Offset 1 Register	Section 3.10
28h	RAMS2	Receive Address Map Size 2 Register	Section 3.11
2Ch	RAMO2	Receive Address Map Offset 2 Register	Section 3.12
30h	RAMS3	Receive Address Map Size 3 Register	Section 3.13
34h	RAMO3	Receive Address Map Offset 3 Register	Section 3.14
38h	RAMS4	Receive Address Map Size 4 Register	Section 3.15
3Ch	RAMO4	Receive Address Map Offset 4 Register	Section 3.16
40h	CHIPVER	Chip Version Register	Section 3.17
44h	AUTNGO	Auto Negotiation Register	Section 3.18

3.1 Revision Register (REVID)

The revision register (REVID) contains the major and minor revisions for the VLYNQ module. The REVID is shown in Figure 9 and described in Table 7.

Figure 9. Revision Register (REVID)

31	16
ID	
R-1h	

15	8	7	0
REVMAJ		REVMIN	
R-2h		R-6h	

LEGEND: R = Read only; -*n* = value after reset

Table 7. Revision Register (REVID) Field Descriptions

Bit	Field	Value	Description
31-16	ID	01h	Unique module ID.
15-8	REVMAJ	0-FFh	Major revision.
		2h	Current major revision.
7-0	REVMIN	0-FFh	Minor revision.
		6h	Current minor revision.

3.2 Control Register (CTRL)

The control register (CTRL) determines operation of the VLYNQ module. The CTRL is shown in Figure 10 and described in Table 8.

Figure 10. Control Register (CTRL)

31	30	29 27	26 24	23	22	21	20 19	18 16
PMEN	SCLKPUDIS	Reserved	RXSAMPELVAL	RTMVALIDWR	RTMENABLE	TXFASTPATH	Reserved	CLKDIV
R/W-0	R/W-0	R-0	R/W-3h	R/W-0	R/W-0	R/W-0	R-0	R/W-0

15	14	13	12 8	7	6 3	2	1	0
CLKDIR	INTLOCAL	INTENABLE	INTVEC	INT2CFG	Reserved	AOPTDISABLE	ILOOP	RESET
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R-0	R/W-0	R/W-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; *-n* = value after reset

Table 8. Control Register (CTRL) Field Descriptions

Bit	Field	Value	Description
31	PMEN		Power management enable.
		0	VLYNQ CLK is always active if it is set as an output (assuming that VLYNQ module is enabled). If set as an output, VLYNQ CLK becomes inactive when there is no traffic over the serial bus.
		1	The PMEN bit should only be set to 1 when the SCRUN is connected to the remote/external VLYNQ device.
30	SCLKPUDIS	0	Serial clock pull-up disable. Always write 0.
29-27	Reserved	0	Reserved. Always read as 0. Writes have no effect.
26-24	RXSAMPELVAL	0-7h	RTM sample value. If the RTMENABLE bit is 0, the receive timing manager forces the value in the RXSAMPELVAL bit as the clock sample value. If the RTMENABLE bit is 1, then the value set by the RXSAMPELVAL bit is ignored. In order to modify the value, you must simultaneously write a 1 to the RTMVALIDWR bit.
23	RTMVALIDWR		RTM valid write bit.
		0	Will not allow writes to RXSAMPLEVAL bits.
		1	Will allow writes to RXSAMPLEVAL bits.
22	RTMENABLE		RTM enable bit.
		0	The receive timing manager uses the value set in the RXSAMPLEVAL bit as the clock sample value.
		1	The receive timing manager is enabled. It automatically selects the receive clock.
21	TXFASTPATH	0-1	Transmit fast path. When set, the fastest path is chosen for the serial data.
20-19	Reserved	0	Reserved. Always read as 0. Writes have no effect.
18-16	CLKDIV	0-7h	Serial clock output divider.
15	CLKDIR		Serial CLK direction. Determines whether the VLYNQ CLK is an input or an output.
		0	The VLYNQ CLK is externally sourced.
		1	The VLYNQ CLK is internally sourced and equal to the VLYNQ module system clock divided by the divider value set in the CLKDIV bit.
14	INTLOCAL		Interrupt local.
		0	The interrupt is forwarded to the remote VLYNQ device over the serial interface as an interrupt packet.
		1	Interrupt is posted in the interrupt status/clear register (INTSTATCLR) and results in the assertion of the VLYNQ interrupt (VLQINT) to the device interrupt controllers.
13	INTENABLE		Interrupt enable.
		0	VLYNQ module status interrupts are ignored.
		1	VLYNQ module status interrupts (if RERROR or LERROR bits are set) are posted to the interrupt pending/set register.
12-8	INTVEC	0-1Fh	Interrupt vector. This bit indicates which bit in the interrupt pending/set register is set for VLYNQ module status (RERROR/LERROR) interrupts.

Table 8. Control Register (CTRL) Field Descriptions (continued)

Bit	Field	Value	Description
7	INT2CFG		Interrupt to configuration register. Determines which register is written with the status contained in interrupt packets that are received over the serial interface. Always write 1 to this bit and configure the interrupt pointer register to point to the interrupt pending/set register.
		0	Bits[31:2] of the interrupt pointer register are used to point to a system interrupt register.
		1	The least significant 8 bits of the interrupt pointer register are used to point to a VLYNQ module local register (typically the interrupt pending/set register).
6-3	Reserved	0	Reserved. Always read as 0. Writes have no effect.
2	AOPTDISABLE		Address optimization disable.
		0	Address optimization is enabled, eliminating unnecessary address bytes.
		1	Address optimization is disabled.
1	ILOOP		Internal loop back.
		0	Normal operation.
		1	Serial transmit data is wrapped back to the serial receive data.
0	RESET		Software reset. It does not reset the VLYNQ MMR registers (except for the VLYNQ status register). You have to reprogram the VLYNQ MMRs if they must have a different value after a software reset.
		0	Normal operation.
		1	All internal state machines are reset, the serial interface is disabled, and the link is lost.

3.3 Status Register (STAT)

The status register (STAT) is used to detect conditions that may be of interest to the system designer. The STAT is shown in Figure 11 and described in Table 9.

Figure 11. Status Register (STAT)

31–28	27–24	23–20	19–15
Reserved	SWIDTHIN	SWIDTHOUT	Reserved
R-0	R-0	R-0	R-0

14–12	11	10	9	8
RXCURRENTSAMPLE	RTM	IFLOW	OFLOW	RERROR
R-0	R-1	R-0	R-0	W1C-0

7	6	5	4	3	2	1	0
LERROR	NFEMPTY3	NFEMPTY2	NFEMPTY1	NFEMPTY0	SPEND	MPEND	LINK
W1C-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; W1C = Write 1 to clear bit; -*n* = value after reset

Table 9. Status Register (STAT) Field Descriptions

Bit	Field	Value	Description
31-28	Reserved	0	Reserved. Always read as 0. Writes have no effect.
27-24	SWIDTHIN	0-Fh	Size of the inbound serial data. Indicates the number of receive pins that are being used to establish the serial interface.
		0	No pins used
		1h	1 RX pin used
		2h	2 RX pins used
		3h	3 RX pins used
		4h	4 RX pins used
		5h-Fh	Reserved
23-20	SWIDTHOUT	0-Fh	Size of the outbound serial data. Indicates the number of transmit pins that are being used to establish the serial interface.
		0	No pins used
		1h	1 TX pin used
		2h	2 TX pins used
		3h	3 TX pins used
		4h	4 TX pins used
		5h-Fh	Reserved
19-15	Reserved	0	Reserved. Always read as 0. Writes have no effect.
14-12	RXCURRENTSAMPLE	0-Fh	Current RTM sample. Indicates the current clock sample value used by RTM.
11	RTM	1	RTM enable. Always read as 1. Indicates that the VLYNQ module on the DM646x DMSoC has the receive timing manager (RTM).
10	IFLOW		Inbound flow control.
		0	Free to transmit.
		1	Indicates that a flow control enable request has been received and has stalled transmit until a flow control disable request is received.
9	OFLOW		Outbound flow control. Indicates the status of the two inbound FIFOs (FIFO1 or FIFO2).
		0	Indicates that the internal flow control threshold is not yet reached.
		1	Indicates that the internal flow control threshold has been reached (FIFO1 or FIFO2 is full) and a flow control enable request has been sent to the remote device.

Table 9. Status Register (STAT) Field Descriptions (continued)

Bit	Field	Value	Description
8	RERROR		Remote Error. Write a 1 to this bit to clear it.
		0	No error
		1	This bit indicates that a downstream VLYNQ module has detected a packet error. This bit is set when an error indication, /E/, is received from the serial interface. See Appendix A.
			If this bit is set, and the INTENABLE (bit 13 in VLYNQ control register) is also set, it asserts the VLYNQ interrupt (VLQINT).
7	LERROR		Local error. Write a 1 to this bit to clear it.
		0	No error.
		1	This bit indicates that an inbound packet contains an error that is detected by the local VLYNQ module.
			If this bit is set, and the INTENABLE (bit 13 in VLYNQ control register) is also set, it asserts the VLYNQ interrupt (VLQINT).
6	NFEMPTY3		FIFO 3 is not empty.
		0	Indicates that the slave command FIFO is empty.
		1	Indicates that the slave command FIFO is not empty.
5	NFEMPTY2		FIFO 2 is not empty.
		0	Indicates that the slave data FIFO is empty.
		1	Indicates that the slave data FIFO is not empty.
4	NFEMPTY1		FIFO 1 is not empty.
		0	Indicates that the master command FIFO is empty.
		1	Indicates that the master command FIFO is not empty.
3	NFEMPTY0		FIFO 0 is not empty.
		0	Indicates that the master data FIFO is empty.
		1	Indicates that the master data FIFO is not empty.
2	SPEND		Pending slave request.
		0	No pending slave requests.
		1	Indicates detection of a transfer request initiated by the VLYNQ module to the off-chip peripheral (TX slave configuration bus interface).
1	MPEND		Pending master requests.
		0	No pending master requests.
		1	Indicates detection of a transfer request initiated by an off-chip peripheral to the VLYNQ module (RX master configuration bus interface).
0	LINK		Link
		0	Indicates that the serial interface initialization sequence has not yet completed or the link has timed out.
		1	Indicates that the serial interface initialization sequence has completed successfully.

3.4 Interrupt Priority Vector Status/Clear Register (INTPRI)

The interrupt priority vector status/clear register (INTPRI) displays the highest priority vector with a pending interrupt when read. When writing, only bits [4:0] are valid, and the value represents the vector of the interrupt to be cleared. The INTPRI is shown in Figure 12 and described in Table 10.

Figure 12. Interrupt Priority Vector Status/Clear Register (INTPRI)

31	30	16
NOINTPEND	Reserved	
R-1h	R-0	

15	5	4	0
Reserved		INSTAT	
R-0		R/W-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 10. Interrupt Priority Vector Status/Clear Register (INTPRI) Field Descriptions

Bit	Field	Value	Description
31	NOINTPEND		Interrupt pending status.
		0	Indicates there is a pending interrupt.
		1	Indicates that there are no pending interrupts from the interrupt status/clear register.
30-5	Reserved	0	Reserved. Always read as 0. Writes have no effect.
4-0	INSTAT	0-1Fh	When read, this field displays the vector that is mapped to the highest priority interrupt bit that is pending from the interrupt status/clear register, with bit 0 as the highest priority, and bit 31 as the lowest. Writing the vector value back to this field clears the interrupt.

3.5 Interrupt Status/Clear Register (INTSTATCLR)

The interrupt status/clear register (INTSTATCLR) indicates the unmasked interrupt status. The INTSTATCLR is shown in Figure 13 and described in Table 11.

Figure 13. Interrupt Status/Clear Register (INTSTATCLR)

31	0
INTCLR	
R/W-0	

LEGEND: R/W = Read/Write; -*n* = value after reset

Table 11. Interrupt Status/Clear Register (INTSTATCLR) Field Descriptions

Bit	Field	Value	Description
31-0	INTCLR	0-FFFF FFFFh	This field indicates the unmasked status of each interrupt. Writing a 1 to any set bit in this field clears the corresponding interrupt. If there is a bit set in this register and if the INTLOCAL bit in the control register (CTRL) is also set, the VLYNQ interrupt (VLQINT) is asserted.

3.6 Interrupt Pending/Set Register (INTPENDSET)

The interrupt pending/set register (INTPENDSET) indicates the pending interrupt status when the INTLOCAL bit in the control register (CTRL) is not set. When the interrupt packet is forwarded on the serial interface, these bits are cleared. The INTPENDSET is shown in Figure 14 and described in Table 12.

Figure 14. Interrupt Pending/Set Register (INTPENDSET)

31	0
INTSET	
R/W-0	

LEGEND: R/W = Read/Write; *-n* = value after reset

Table 12. Interrupt Pending/Set Register (INTPENDSET) Field Descriptions

Bit	Field	Value	Description
31-0	INTSET		This field indicates the unmasked status of each pending interrupt.
		0	Writing a 0 has no effect.
		1	Writing a 1 to any bit:
			if INTLOCAL = 0 in CTRL, interrupt packet is sent on the serial interface.
			If INTLOCAL = 1 in CTRL, VLYNQ module interrupt (VLQINT) is asserted.

3.7 Interrupt Pointer Register (INTPTR)

The interrupt pointer register (INTPTR) typically contains the address of the interrupt pending/set register (INTPENDSET) within the VLYNQ module. To program INTPTR to point to INTPENDSET, program a value of 14h (the offset of INTPENDSET). Additionally, the INT2CFG bit in the control register (CTRL) should be set to 1. The INTPTR is shown in Figure 15 and described in Table 13.

Figure 15. Interrupt Pointer Register (INTPTR)

31	2	1	0
INTPTR		Reserved	
R/W-0		R-0	

LEGEND: R/W = Read/Write; R = Read only; *-n* = value after reset

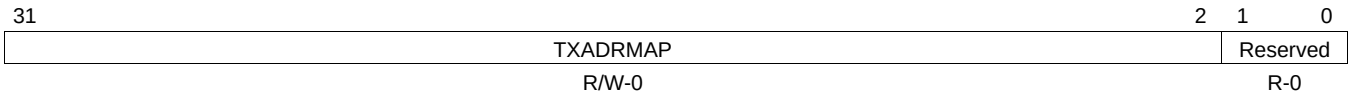
Table 13. Interrupt Pointer Register (INTPTR) Field Descriptions

Bit	Field	Value	Description
31-2	INTPTR	0-3FFF FFFFh	Interrupt pointer. Program this register with the address of the interrupt pending/set register (14h).
1-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

3.8 Transmit Address Map Register (XAM)

The transmit address map register (XAM) is used to translate transmit packet addresses to remote device configuration bus addresses. The XAM is shown in Figure 16 and described in Table 14.

Figure 16. Transmit Address Map Register (XAM)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 14. Address Map Register (XAM) Field Descriptions

Bit	Field	Value	Description
31-2	TXADRMAP	0-3FFF FFFFh	This field is subtracted from the slave configuration bus address [25:0] to obtain the zero relative transmit packet address. This field should be programmed with a value of 0 (reset value).
1-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

3.9 Receive Address Map Size 1 Register (RAMS1)

The receive address map size 1 register (RAMS1) is used to identify the intended destination of inbound serial packets. The RAMS1 is shown in Figure 17 and described in Table 15.

Figure 17. Receive Address Map Size 1 Register (RAMS1)

31	2	1	0
RXADRSIZE1		Reserved	
R/W-0		R-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 15. Receive Address Map Size 1 Register (RAMS1) Field Descriptions

Bit	Field	Value	Description
31-2	RXADRSIZE1	0-3FFF FFFFh	The RXADRSIZE1 field is used to determine if receive packets are destined for the first of four mapped address regions. RXADRSIZE1 is compared with the address contained in the receive packet. If the received packet address is less than the value in RXADRSIZE1, the packet address is added to the receive address map offset 1 register (RAMO1) to obtain the translated address.
1-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

3.10 Receive Address Map Offset 1 Register (RAMO1)

The receive address map offset 1 register (RAMO1) is used with the receive address map size 1 register (RAMS1) to translate receive packet addresses to local device configuration bus addresses. The RAMO1 is shown in Figure 18 and described in Table 16.

Figure 18. Receive Address Map Offset 1 Register (RAMO1)

31	2	1	0
RXADROFFSET1		Reserved	
R/W-0		R-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

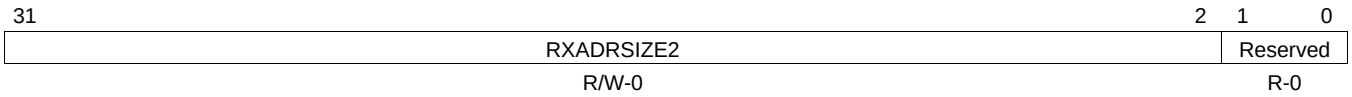
Table 16. Receive Address Map Offset 1 Register (RAMO1) Field Descriptions

Bit	Field	Value	Description
31-2	RXADROFFSET1	0-3FFF FFFFh	The RXADROFFSET1 field is used with the receive address map size 1 register (RAMS1) to determine the translated address for serial data. If the received packet address is less than the value in RAMS1, the packet address is added to the contents of this register to obtain the translated address.
1-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

3.11 Receive Address Map Size 2 Register (RAMS2)

The receive address map size 2 register (RAMS2) is used to identify the intended destination of inbound serial packets. The RAMS2 is shown in Figure 19 and described in Table 17.

Figure 19. Receive Address Map Size 2 Register (RAMS2)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

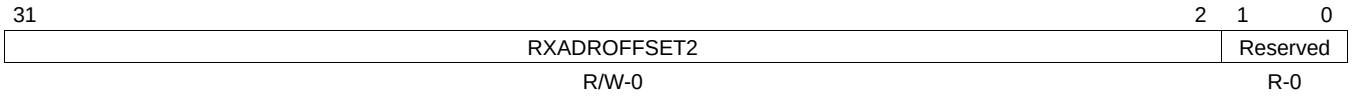
Table 17. Receive Address Map Size 2 Register (RAMS2) Field Descriptions

Bit	Field	Value	Description
31-2	RXADRSIZE2	0-3FFF FFFFh	The RXADRSIZE2 field is used to determine if receive packets are destined for the second of four mapped address regions. RXADRSIZE2 is compared with the address contained in the receive packet. If the received packet address is less than the value in RXADRSIZE2, the packet address is added to the receive address map offset 2 register (RAMO2) to obtain the translated address.
1-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

3.12 Receive Address Map Offset 2 Register (RAMO2)

The receive address map offset 2 register (RAMO2) is used with the receive address map size 2 register (RAMS2) to translate receive packet addresses to local device configuration bus addresses. The RAMO2 is shown in Figure 20 and described in Table 18.

Figure 20. Receive Address Map Offset 2 Register (RAMO2)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 18. Receive Address Map Offset 2 Register (RAMO2) Field Descriptions

Bit	Field	Value	Description
31-2	RXADROFFSET2	0-3FFF FFFFh	The RXADROFFSET2 field is used with the receive address map size 2 register (RAMS2) to determine the translated address for serial data. If the received packet address is less than the value in RAMS2, the packet address is added to the contents of this register to obtain the translated address.
1-0	Reserved	0	Reserved. Always read as 0. Writes have no affect.

3.13 Receive Address Map Size 3 Register (RAMS3)

The receive address map size 3 register (RAMS3) is used to identify the intended destination of inbound serial packets. The RAMS3 is shown in Figure 21 and described in Table 19.

Figure 21. Receive Address Map Size 3 Register (RAMS3)

31	2	1	0
RXADRSIZE3		Reserved	
R/W-0		R-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 19. Receive Address Map Size 3 Register (RAMS3) Field Descriptions

Bit	Field	Value	Description
31-2	RXADRSIZE3	0-3FFF FFFFh	The RXADRSIZE3 field is used to determine if receive packets are destined for the third of four mapped address regions. RXADRSIZE3 is compared with the address contained in the receive packet. If the receive packet address is less than the value in RXADRSIZE3, the packet address is added to the receive address map offset 3 register (RAMO3) to obtain the translated address.
1-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

3.14 Receive Address Map Offset 3 Register (RAMO3)

The receive address map offset 3 register (RAMO3) is used with the receive address map size 3 register (RAMS3) to translate receive packet addresses to local device configuration bus addresses. The RAMO3 is shown in Figure 22 and described in Table 20.

Figure 22. Receive Address Map Offset 3 Register (RAMO3)

31	2	1	0
RXADROFFSET3		Reserved	
R/W-0		R-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 20. Receive Address Map Offset 3 Register (RAMO3) Field Descriptions

Bit	Field	Value	Description
31-2	RXADROFFSET3	0-3FFF FFFFh	The RXADROFFSET3 field is used with the receive address map size 3 register (RAMS3) to determine the translated address for serial data. If the receive packet address is less than the value in RAMS3, the packet address is added to the contents of this register to obtain the translated address.
1-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

3.15 Receive Address Map Size 4 Register (RAMS4)

The receive address map size 4 register (RAMS4) is used to identify the intended destination of inbound serial packets. The RAMS4 is shown in Figure 23 and described in Table 21.

Figure 23. Receive Address Map Size 4 Register (RAMS4)

31	2	1	0
RXADRSIZE4		Reserved	
R/W-0		R-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 21. Receive Address Map Size 4 Register (RAMS4) Field Descriptions

Bit	Field	Value	Description
31-2	RXADRSIZE4	0-3FFF FFFFh	The RXADRSIZE4 field is used to determine if receive packets are destined for the fourth of four mapped address regions. RXADRSIZE4 is compared with the address contained in the receive packet. If the receive packet address is less than the value in RXADRSIZE4, the packet address is added to the receive address map offset 4 register (RAMO4) to obtain the translated address.
1-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

3.16 Receive Address Map Offset 4 Register (RAMO4)

The receive address map offset 4 register (RAMO4) is used with the receive address map size 4 register (RAMS4) to translate receive packet addresses to local device configuration bus addresses. The RAMS4 is shown in Figure 24 and described in Table 22.

Figure 24. Receive Address Map Offset 4 Register (RAMO4)

31	2	1	0
RXADROFFSET4		Reserved	
R/W-0		R-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

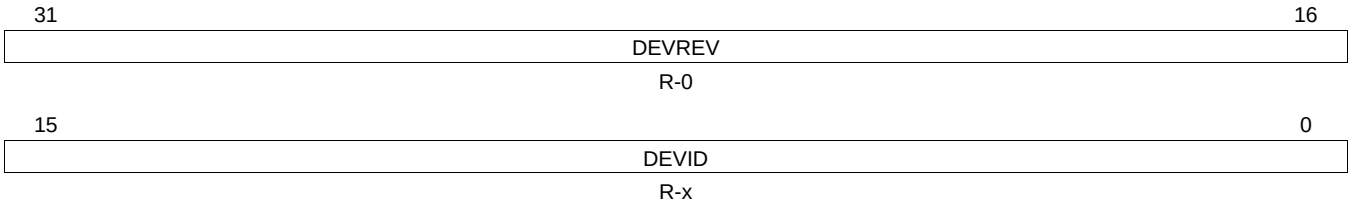
Table 22. Receive Address Map Offset 4 Register (RAMO4) Field Descriptions

Bit	Field	Value	Description
31-2	RXADROFFSET4	0-3FFF FFFFh	The RXADROFFSET4 field is used with the receive address map size 4 register (RAMS4) to determine the translated address for serial data. If the receive packet address is less than the value in RAMS4, the packet address is added to the contents of this register to obtain the translated address.
1-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

3.17 Chip Version Register (CHIPVER)

Each chip that has a VLYNQ module on it has a unique device ID associated with it, which is software readable via the chip version register (CHIPVER). The CHIPVER is shown in Figure 25 and described in Table 23.

Figure 25. Chip Version Register (CHIPVER)



LEGEND: R = Read only; -*n* = value after reset

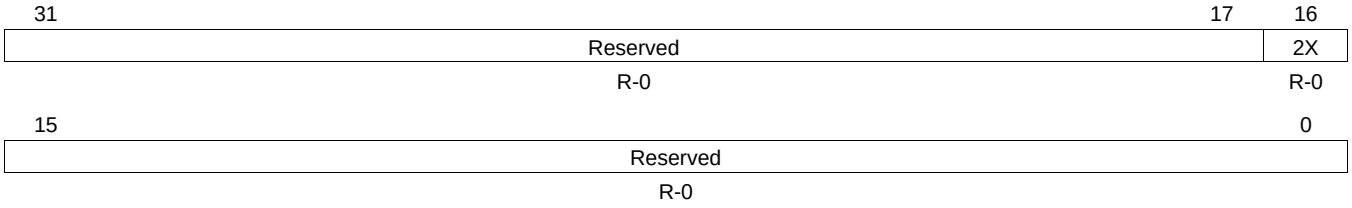
Table 23. Chip Version Register (CHIPVER) Field Descriptions

Bit	Field	Value	Description
31-16	DEVREV	0-FFFFh	Device revision. This field reflects the value of the device revision pins.
15-0	DEVID	0-FFFFh	Device ID. See the device-specific data manual for this value.

3.18 Auto Negotiation Register (AUTNGO)

The auto negotiation register (AUTNGO) reflects the ability of the VLYNQ module residing in the device to communicate with the remote VLYNQ device on their respective abilities after reset. The AUTNGO is shown in Figure 26 and described in Table 24.

Figure 26. Auto Negotiation Register (AUTNGO)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 24. Auto Negotiation Register (AUTNGO) Field Descriptions

Bit	Field	Value	Description
31-17	Reserved	0	Reserved. Always read as 0. Writes have no effect.
16	2X		Version 2.x mode.
		0	Indicates that a link was established with a remote device that has a version 1.x VLYNQ module in it.
		1	Indicates that a link was established with a remote device that has a version 2.x VLYNQ module in it.
15-0	Reserved	0	Reserved. Always read as 0. Writes have no effect.

4 Remote Configuration Registers

The remote configuration registers listed in Table 25 are the same registers as previously described, but they are for the remote VLYNQ device.

Note: Before attempting to access the remote registers (offsets 80h through C0h) , you must ensure that a link is established with the remote device. Poll the LINK bit in the VLYNQ status register (STAT) to do this.

It is not necessary to configure the address translation registers to access the remote device's memory-mapped registers after the link has been established.

Depending on the version and chip specific implementation, the VLYNQ module on the remote device might have additional registers or different reset values. Refer to the remote device data sheet for a precise description of the VLYNQ registers that exist in the remote device.

Table 25. VLYNQ Port Remote Controller Registers

Offset	Acronym	Register Description
80h	RREVID	Remote Revision Register
84h	RCTRL	Remote Control Register
88h	RSTAT	Remote Status Register
8Ch	RINTPRI	Remote Interrupt Priority Vector Status/Clear Register
90h	RINTSTATCLR	Remote Interrupt Status/Clear Register
94h	RINTPENDSET	Remote Interrupt Pending/Set Register
98h	RINTPTR	Remote Interrupt Pointer Register
9Ch	RXAM	Remote Transmit Address Map Register
A0h	RRAMS1	Remote Receive Address Map Size 1 Register
A4h	RRAMO1	Remote Receive Address Map Offset 1 Register
A8h	RRAMS2	Remote Receive Address Map Size 2 Register
ACh	RRAMO2	Remote Receive Address Map Offset 2 Register
B0h	RRAMS3	Remote Receive Address Map Size 3 Register
B4h	RRAMO3	Remote Receive Address Map Offset 3 Register
B8h	RRAMS4	Remote Receive Address Map Size 4 Register
BCh	RRAMO4	Remote Receive Address Map Offset 4 Register
C0h	RCHIPVER	Remote Chip Version Register
C4h	RAUTNGO	Remote Auto Negotiation Register
C8h	RMANNGO	Remote Manual Negotiation Register
CCh	RNGOSTAT	Remote Negotiation Status Register
E0h	RINTVEC0	Remote Interrupt Vector 3-0 Register
E4h	RINTVEC1	Remote Interrupt Vector 7-4 Register

Appendix A VLYNQ Protocol Specifications

VLYNQ relies on 8b/10b block coding to minimize the number of serial pins and allow for in-band packet delineation and control. The following sections include general 8b/10b coding definitions and their implementation.

A.1 Special 8b/10b Code Groups

Table A-1. Special 8b/10b Code Groups

Code Group Name	Octet Value	Octet Bits	Current RD -	Current RD +
K28.0	1C	0001 1100	001111 0100	110000 1011
K28.1	3C	0011 1100	001111 1001	110000 0110
K28.2	5C	0101 1100	001111 0101	110000 1010
K28.3	7C	0111 1100	001111 0011	110000 1100
K28.4	9C	1001 1100	001111 0010	110000 1101
K28.5	BC	1011 1100	001111 1010	110000 0101
K28.6	DC	1101 1100	001111 0110	110000 1001
K28.7	FC	1111 1100	001111 1000	110000 0111
K23.7	F7	1111 0111	111010 1000	000101 0111
K27.7	FB	1111 1011	110110 1000	001001 0111
K29.7	FD	1111 1101	101110 1000	010001 0111
K30.7	FE	1111 1110	011110 1000	100001 0111

A.2 Supported Ordered Sets

Each VLYNQ module must support a limited number of ordered sets. Ordered sets provide for the delineation of packets and synchronization between VLYNQ modules at opposite ends of the serial connection. VLYNQ 2.0 and later versions do not require some of the following ordered sets.

Table A-2. Supported Ordered Sets

Code	Ordered Set	Encoding	Octet Value
/I/	Idle	/K28.5/	BC
/T/	End of Packet	/K29.7/	FD
/M/	Byte Disable	/K23.7/	F7
/P/	Flow Control Enable	/K28.0/	IC
/C/	Flow Control Disable	/K28.2/	5C
/E/	Error Indication	/K28.1/	3C
/0/	Init0	/K28.4/	9C
/I/	Init1	/K28.6/	DC
/L/	Link	/K30.7/	FE

A.2.1 Idle (/I/)

The idle ordered sets are transmitted continuously and repetitively whenever the serial interface is idle. Idle is also used in the place of the flowed code in VLYNQ versions 2.0 and later.

A.2.2 End of Packet (/T/)

An end of packet delimiter delineates the ending boundary of a packet.

A.2.3 Byte Disable (/M/)

The byte disable symbol masks bytes for write operations.

A.2.4 Flow Control Enable (/P/)

A flow control enable request is transmitted when a VLYNQ module's receive FIFO is full or nearly full. This code causes the remote VLYNQ device to cease transmission of data.

A.2.5 Flow Control Disable (/C/)

The flow control disable request is transmitted by a VLYNQ module when RX FIFO resources are available to accommodate additional data.

A.2.6 Error Indication (/E/)

The error indication is transmitted when errors are detected within a packet. Examples of such errors include illegal packet types and code groups.

A.2.7 Init0 (/0/)

The Init0 code group is used during the link initialization sequence. VLYNQ 2.0 and later versions use this code with an extra byte for identifying version 1.X devices.

A.2.8 Init1 (/1/)

The Init1code group is used during the Link initialization sequence. VLYNQ 2.0 and later uses this code with an extra byte for identifying version 1.X devices.

A.2.9 Link (/L/)

The link code group is used during the link initialization sequence. A link code group is also transmitted each time the internal link timer expires.

A.3 VLYNQ 2.0 Packet Format

The VLYNQ 2.0 packet format is shown in Figure A-1 and described in Table A-3, where 0<N<65. Multi-byte fields are transferred least-significant byte first.

Figure A-1. Packet Format (10-bit Symbol Representation)

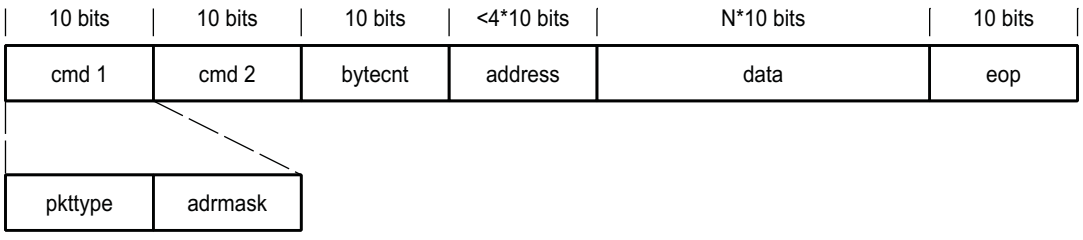


Table A-3. Packet Format (10-bit Symbol Representation) Description

Field	Value	Description
PKTTYPE[3:0]		This field indicates the packet type.
	0000	Reserved
	0001	Write with address increment.
	0010	Reserved
	0011	Write 32-bit word with address increment.
	0100	Reserved
	0101	Configuration write with address increment.
	0110	Reserved for extended command indicator (cmd2).
	0111	Interrupt
	1000	Reserved
	1001	Read with address increment.
	1010	Reserved
	1011	Read 32-bit word with address increment.
	1100	Reserved
	1101	Configuration read with address increment.
	1110	Reserved for VLYNQ version 2.0 and later.
	1111	Read response for all VLYNQ versions.
ADRMASK[3:0]		Indicates which byte of the address is included in the packet. Only address bytes that have changed since the previous address will be included. Each bit corresponds to one byte of address.
BYTECNT[7:0]		Byte count. This field indicates the total number of bytes in the packet. This field is only included for write, read, and configuration packet types. All other packet types have fixed lengths and do not require this field.
ADDRESS[7:0]		Address byte 0. This byte is included only if ADRMASK[0] is set to 1. If ADRMASK[0] is cleared to 0, assume this byte is equal to bits 7:0 of the previous address. Read response packets do not include this field.
ADDRESS[15:8]		Address byte 1. This byte is included only if ADRMASK[1] is set to 1. If ADRMASK[1] is cleared to 0, assume this byte is equal to bits 15:8 of the previous address. Read response packets do not include this field.
ADDRESS[23:16]		Address byte 2. This byte is only included if ADRMASK[2] is set to 1. If ADRMASK[2] is cleared to 0, this assume this byte is equal to bits 23:16 of the previous address. Read response packets do not include this field.
ADDRESS[31:24]		Address byte 3. This byte is only included if ADRMASK[3] is set to 1. If ADRMASK[3] is cleared to 0, assume this byte is equal to bits 31:24 of the previous address. Read response packets do not include this field.
DATA		Data payload. The maximum data payload size is limited to sixteen 32-bit words to allow it to fit in the RX FIFO.
EOP		End of packet indicator, /T/.

The CMD2 bit is only included in the packet, if the packet type indicates extended command (PKTTYPE = 0110).

Use configuration packet types to remotely access VLYNQ module registers. The configuration packet types do not depend on control register bit settings.

A.4 VLYNQ 2.X Packets

An example of what can happen to a write burst due to remote and local FIFO state changes and the link pulse timer expiring is shown in Example A-1. This protocol can be extended to apply to multiple channels; therefore, the data return channel is logically isolated from the command channel.

Example A-1. A write burst due to remote and local FIFO state changes and the link pulse timer expiring

```
Basic packets:
Read32 - caaaaT

Write32 - caaaaddddT

ReadCfg - claaaaT

WriteCfg - claaaaddddddddT

ReadBurst - claaaaT

WriteBurst - claaaaddddddddddddT

Int - cddddT

ReadReturn - clddddddddT
Where
I - Idle

T - EndOfPacket

d - data

a - address

c - command

l  - length

M - Byte mask
I[#] - Flowed, # is used when exiting flowed for a channel, the # is actually the current
channel command.
P# - Flow Enable for a channel

C# - Flow Disable for a channel
L - Link pulse
and what is in italics is optional data up to 16 words total.
Packet with byte enables:
WriteBurst - claaaaMMddMMddMMddT
The above packet wrote to the LS half words from the specified address.
Packet that has been flowed due to remote FIFO status:
WriteBurst - claaaaMMddMIIIIIIIIIIIII#MddMMddT
The packet was extended using the I code. The # is used to
indicate that the same channel was continued.
To the same packet, the potential flowing of the local FIFO's is added:
WriteBurst - claaaaMMddMIIP#IIIIIIIIIIIII#MddMMdC#dT
Link pulse to the stream is added:


WriteBurst - claaLaaMMddMIIP#IIIIIIIIIII#MddMMdC#dT
```

An example of a write burst flowed and interrupted by a read return data burst is shown below. In the example, a 1 indicates a data return channel (it is actually the return data command) and a 0 indicates a command channel, which is the command for the transaction.

```
IIIIclaaaaddddIcldddIII1ddddII0ddddddddddddddIIIIII0dddTIIIII1dTIIII
```

A command, length, address, and start receive data from the idle stream. A flow enable was received for the command channel, but there is data to return, so the flow is followed by a channel 1 descriptor (the command for return data actually indicates a channel 1), and the channel 1 packet is now under way. A flow is now received for channel 1, but it is soon disabled so the channel 1 packet continues. The flow is enabled for channel one again, quickly after flow is released for channel 0, so the data continues for channel 0 when a flow is received again for channel 0. Channel 0 then receives a flow disable, completes its packet, followed by channel 1 flow disable, where the channel 1 packet is also completed.

Appendix B Write/Read Performance

The following sections discuss the write versus read performance and how the throughput (read or write) should be calculated for a given data width and serial clock frequency.

Note: The data and throughput calculations shown here are sample calculations for most ideal situations. In general, the data rates depend on a variety of other factors, such as efficiency of read/write burst transactions, ability of buffering up read/write data, and how best it can be serially shifted out without stalling additional read/write data burst, remote and local components , both external and internal (device operations, board considerations, etc.).

B.1 Write Performance

The max write rate describes the maximum available data rate of the serial interface for transmission, taking into consideration the 8b/10b encoding overheads. This is calculated as follows:

`Max write rate = VLYNQ Serial Clock (MHZ) × No. of Pins × 8b/10b encoding overhead`

The 8b/10b encoding overhead essentially accounts for 20% overhead, thus the actual data throughput after subtraction of the encoding overhead gives a factor of 0.8. For example, if the VLYNQ clock is running at 99 MHZ on a 4 pin per direction interface, the raw data is 99 × 4 or 396 Mbps. After the 8B10B encoding is removed, the maximum write rate is 396 × 0.8 = 316.8 Mbps.

The total throughput on the VLYNQ interface includes both transmit and receive directions. Therefore, for the above configuration, a remote device can also be writing to the local device at the same data rates, then the total throughput is the sum of transmit and receive rates, or 633.6 Mbps.

In addition to the 8b/10b encoding, the packet structure for read/write operations also results in additional overheads. The VLYNQ module can transfer single 32-bit words or a burst of up to sixteen 32-bit words.

The packet structure of the writes is shown below, here each character represents a byte.

```
Write32 - caaaaddddT

WriteBurst - claaaaddddddddddddddddT
Where

T - EndOfPacket

d - data, dddd represents additional 32-bit words in burst, up to 16 words.

a - address

c - command

l  - length
```

The example above illustrates that single writes require 6 bytes of overhead, while burst writes require 8 bytes of overhead (due to the additional length of the field). From this, a scaling factor can be calculated (data bytes/total bytes), as show in Table B-1. The actual throughput is then calculated as the [scaling factor] × [max write rate].

Table B-2 compares the throughput using a VLYNQ interface running at 76.5 MHZ and 99 MHZ.

Table B-1. Scaling Factors

Burst Size in 32-bit words	Data Bytes	Overhead Bytes	Scaling Factor
1	4	6	40%
4	16	7	69.56%
8	32	7	82.05%
16	64	7	90.14%

Table B-2. Expected Throughput (VLYNQ Interface Running at 76.5 MHZ and 99 MHZ)

Number of VLYNQ Pins	Burst Size in 32-bit Words	Interface Running at 76.5 MHZ		Interface Running at 99 MHZ	
		Mbits/sec	Mbytes/sec	Mbits/sec	Mbytes/sec
1	1	24.19	3.02	31.68	3.96
	4	42.07	5.26	55.09	6.89
	8	49.62	6.20	64.98	8.12
	16	54.52	6.81	71.39	8.92
2	1	48.38	6.05	63.36	7.92
	4	84.14	10.52	110.18	13.77
	8	99.25	12.41	129.97	16.25
	16	109.03	13.63	142.78	17.85
3	1	72.58	9.07	95.04	11.88
	4	126.21	15.78	165.27	20.66
	8	148.87	18.61	194.95	24.37
	16	163.55	20.44	214.17	26.77
4	1	96.77	12.10	126.72	15.84
	4	168.28	21.03	220.37	27.55
	8	198.50	24.81	259.93	32.49
	16	218.07	27.26	285.56	35.70

B.2 Read Performance

Since reads must complete a transmit-remote read-receive cycle before starting another read transaction, the data throughput is lower as compared to writes. There is latency involved in reading the data from the remote device; and in some cases, a local latency in writing the returned data before the next read can start.

The max read rate is calculated the same way as the max write rate. The packet overhead is as shown below:

```
Read32 - caaaaT

ReadBurst - claaaaT

ReadReturn - clddddddddT
Where

T - EndOfPacket

d - data, dddd represents additional 32-bit words in burst, up to 16 words.

a - address

c - command

l  - length
```

There are 6 bytes of overhead for a single read, 7 bytes for burst reads, and 3 bytes for read returns. The time required for a read is the total of the time for the read request, remote latency, read return, and local latency. Thus, the throughput can be calculated as data bytes/total transaction time, where the latency of both local and remote devices is combined.

$$\text{Read Throughput} = \text{data}/\left(\left(\left(\text{Read} + \text{ReadReturn} + \text{data}\right)/\text{max read rate}\right) + \text{Latency}\right) = \left(\text{data} \times \text{max read rate}\right)/\left(\left(\text{Read} + \text{ReadReturn} + \text{data}\right) + \text{Latency} \times \text{max read rate}\right)$$

For example, with a 4 pin, 99 MHZ VLYNQ connection, for a single 32-bit word read:

$$\text{Read Throughput} = 32\ \text{bits} \times 316.8\ \text{Mbps}/\left(6 \times 8 + 3 \times 8 + 4 \times 8 + \text{Latency} \times 316.8\ \textit{Mbps}\right) = 10137.6/\left(104 + \text{Latency} \times 316.8\ \textit{Mbps}\right)$$

Similarly, for a burst read of sixteen 32-bit words, with a 4 pin, 99 MHZ VLYNQ connection

$$\text{Read Throughput} = 16 \times 32\ \text{bits} \times 316.8\text{Mbps}/\left(6 \times 8 + 3 \times 8 + 16 \times 4 \times 8 + \text{Latency} \times 316.8\textit{Mbps}\right) = 162201.6/\left(584 + \text{Latency} \times 316.8\textit{Mbps}\right)$$

Using the formula above, the relative performance with various latencies is illustrated for a 4 pin, 99 MHZ VLYNQ clock, burst read (sixteen 32-bit words) throughput rate, as shown in Table B-3:

Table B-3. Relative Performance with Various Latencies

Number of VLYNQ Pins (99 MHZ)	Burst Size in 32-bit Words	Latency (μsec)	Throughput (Mbits/sec)	Throughput (Mbytes/sec)
4	16	0	277.74	34.72
		1	179.70	22.46
		10	43.02	5.38
		100	5.00	0.62

To efficiently use VLYNQ bandwidth, it is desirable for each VLYNQ device to write from the local device to the remote device. Burst transactions are more efficient than single read/write transactions.

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