

# ARM® CoreLink™ LPD-500 Low Power Distributor

Revision: r0p0

## Technical Reference Manual



# ARM® CoreLink™ LPD-500 Low Power Distributor

## Technical Reference Manual

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### Release Information

### Document History

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0000-01	22 September 2015	Non-Confidential	Second release for r0p0
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0000-03	22 July 2016	Non-Confidential	Fourth release for r0p0

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**Product Status**

The information in this document is Final, that is for a developed product.

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# Preface

This preface introduces the *ARM® CoreLink™ LPD-500 Low Power Distributor Technical Reference Manual*.

It contains the following:

- *About this book* on page 7.
- *Feedback* on page 10.

## About this book

This book is for the ARM® CoreLink™ LPD-500 Low Power Distributor.

### Product revision status

The *mpn* identifier indicates the revision status of the product described in this book, for example, r1p2, where:

*rm* Identifies the major revision of the product, for example, r1.

*pn* Identifies the minor revision or modification status of the product, for example, p2.

### Intended audience

This book is written for system designers, system integrators, and programmers who are designing or programming a *System-on-Chip* (SoC) that uses the LPD-500.

### Using this book

This book is organized into the following chapters:

#### **Chapter 1 Introduction**

This chapter describes the LPD-500 Low Power Distributor.

#### **Chapter 2 Functional description**

This chapter describes the functionality of the LPD-500.

#### **Chapter 3 Programmers model**

This chapter describes the programmers model.

#### **Appendix A Signal descriptions**

This appendix describes the external signals of the LPD-500.

#### **Appendix B Revisions**

This appendix describes the technical changes between released issues of this book.

### Glossary

The ARM Glossary is a list of terms used in ARM documentation, together with definitions for those terms. The ARM Glossary does not contain terms that are industry standard unless the ARM meaning differs from the generally accepted meaning.

See the *ARM Glossary* for more information.

### Typographic conventions

*italic*

Introduces special terminology, denotes cross-references, and citations.

**bold**

Highlights interface elements, such as menu names. Denotes signal names. Also used for terms in descriptive lists, where appropriate.

monospace

Denotes text that you can enter at the keyboard, such as commands, file and program names, and source code.

monospace

Denotes a permitted abbreviation for a command or option. You can enter the underlined text instead of the full command or option name.

*monospace italic*

Denotes arguments to monospace text where the argument is to be replaced by a specific value.

**monospace bold**

Denotes language keywords when used outside example code.

<and>

Encloses replaceable terms for assembler syntax where they appear in code or code fragments.  
For example:

```
MRC p15, 0, <Rd>, <CRn>, <CRm>, <Opcode_2>
```

SMALL CAPITALS

Used in body text for a few terms that have specific technical meanings, that are defined in the *ARM glossary*. For example, IMPLEMENTATION DEFINED, IMPLEMENTATION SPECIFIC, UNKNOWN, and UNPREDICTABLE.

## Timing diagrams

The following figure explains the components used in timing diagrams. Variations, when they occur, have clear labels. You must not assume any timing information that is not explicit in the diagrams.

Shaded bus and signal areas are undefined, so the bus or signal can assume any value within the shaded area at that time. The actual level is unimportant and does not affect normal operation.

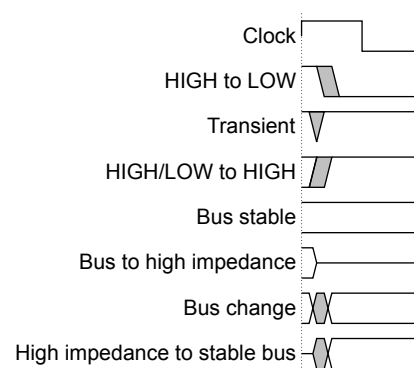


Figure 1 Key to timing diagram conventions

## Signals

The signal conventions are:

### Signal level

The level of an asserted signal depends on whether the signal is active-HIGH or active-LOW.  
Asserted means:

- HIGH for active-HIGH signals.
- LOW for active-LOW signals.

### Lowercase n

At the start or end of a signal name denotes an active-LOW signal.

## Additional reading

This section lists publications by ARM and by third parties.

See *Infocenter* <http://infocenter.arm.com>, for access to ARM documentation.

### ARM publications

This book contains information that is specific to this product. See the following documents for other relevant information:

- *Low Power Interface Specification, ARM® Q-Channel and P-Channel Interfaces* (ARM IHI 0068).
- *ARM® Power Control System Architecture* (ARM DEN 0050).



The following confidential books are only available to licensees:

- *ARM® CoreLink™ LPD-500 Low Power Distributor Integration and Implementation Manual* (ARM 100362).

## Feedback

### Feedback on this product

If you have any comments or suggestions about this product, contact your supplier and give:

- The product name.
- The product revision or version.
- An explanation with as much information as you can provide. Include symptoms and diagnostic procedures if appropriate.

### Feedback on content

If you have comments on content then send an e-mail to [errata@arm.com](mailto:errata@arm.com). Give:

- The title *ARM® CoreLink™ LPD-500 Low Power Distributor Technical Reference Manual*.
- The number ARM 100361\_0000\_03\_en.
- If applicable, the page number(s) to which your comments refer.
- A concise explanation of your comments.

ARM also welcomes general suggestions for additions and improvements.

————— **Note** —————

ARM tests the PDF only in Adobe Acrobat and Acrobat Reader, and cannot guarantee the quality of the represented document when used with any other PDF reader.

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# Chapter 1

## Introduction

This chapter describes the LPD-500 Low Power Distributor.

It contains the following sections:

- *1.1 About the LPD-500 Low Power Distributor* on page 1-12.
- *1.2 Compliance* on page 1-13.
- *1.3 Features* on page 1-14.
- *1.4 Interfaces* on page 1-15.
- *1.5 Configuration options* on page 1-16.
- *1.6 Product documentation and design flow* on page 1-17.
- *1.7 Product revisions* on page 1-18.

## 1.1 About the LPD-500 Low Power Distributor

The LPD-500 Low Power Distributor is a standalone configurable component to distribute Q-Channel interfaces to multiple devices and subsystems.

Q-Channels are used to manage quiescence in components of the system that allow the clock to be gated off or power to be removed. Gating off a clock or removing power is done to save power when not operational.

The LPD-500 supports use cases where not all signals of the Q-Channel are used by an attached device. See the *ARM® CoreLink™ LPD-500 Low Power Distributor Integration and Implementation Manual* for more information.

## 1.2 Compliance

The LPD-500 Low Power Distributor implements the ARM Power Control System Architecture and complies with the *Low Power Interface Specification, ARM Q-Channel and P-Channel Interfaces*.

This Technical Reference Manual complements architecture reference manuals, architecture specifications, protocol specifications, and relevant external standards. It does not duplicate information from these sources.

See the *ARM® Power Control System Architecture* and the *Low Power Interface Specification, ARM® Q-Channel and P-Channel Interfaces* for more information.

## 1.3 Features

The LPD-500 provides a low latency method of controlling multiple, device-level, *Low Power Interfaces* (LPIs) from a single controller.

The LPD-500 Low Power Distributor supports the following key features:

- Expands a single Q-Channel LPI from a power controller or a clock controller into multiple Q-Channel LPIs for controlled devices.
- Low latency to and from device channels.
- Up to 32 device control channels.
- Cascadable to multiple levels to expand beyond 32 devices.
- Optionally integrates synchronizers on request and accepts inputs for use in systems with different clock domains.
- Configurable as an expander, where all devices are controlled together, or as a sequencer, where all devices are controlled in a sequence.
- Optional active deny feature to allow a denial of quiescence that is based on a device **QACTIVE** signal.

## 1.4 Interfaces

The LPD-500 has two external interfaces.

The interfaces are:

- An input Q-Channel CTRLQ interface to receive commands.
- A configurable number of output Q-Channel DEVQ interfaces that forward commands to other devices.

## 1.5 Configuration options

This section describes the configuration options available in the LPD-500.

### 1.5.1 Configuration parameters

There are several configuration options available in the LPD-500.

#### **Related references**

[2.4 Parameter summary on page 2-24.](#)

### 1.5.2 Static parameters

There are no configurable static parameters in the LPD-500.

### 1.5.3 Tie-off signals

There are no configurable tie-off signals in the LPD-500.



## 1.6 Product documentation and design flow

The LPD-500 documentation includes a *Technical Reference Manual* (TRM) and an *Integration and Implementation Manual* (IIM). These books relate to the LPD-500 design flow.

### Documentation

The LPD-500 documentation includes the following books:

#### Technical Reference Manual

The TRM describes the functionality and the effects of functional options on the behavior of the LPD-500. It is required at all stages of the design flow. The choices that you make in the design flow can mean that some of the behavior that is described in the TRM is not relevant.

#### Integration and Implementation Manual

The IIM describes:

- The available build configuration options and related issues in selecting them.
- How to configure the *Register Transfer Level* (RTL) with the build configuration options.
- How to integrate the LPD-500 into a SoC.
- How to implement the LPD-500 into your design. This section includes floorplanning guidelines and instructions on how to perform netlist dynamic verification on the LPD-500.
- The processes to sign off the integration and implementation of the design.

The ARM product deliverables include reference scripts and information about using them to implement your design.

Reference methodology documentation from your EDA tools vendor complements the IIM.

The IIM is a confidential book that is only available to licensees.

### Design flow

The LPD-500 is delivered as synthesizable RTL. Before it can be used in a product, it must go through the following processes:

#### Implementation

The implementer configures and synthesizes the RTL.

#### Integration

The integrator connects the implemented design into a SoC.

Each process can include implementation and integration choices that affect the behavior and features of the LPD-500.

The operation of the final device depends on the build configuration. The configuration stage is where the implementer chooses the options that affect how the RTL source files are pre-processed. These options usually include or exclude logic that affects one or more of the area, maximum frequency, and features of the resulting macrocell.

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#### Note

This Technical Reference Manual refers to implementation-defined features that are dependent on build configuration options. Optional features are only available if the appropriate build configuration options are selected.

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## 1.7 Product revisions

This section describes the differences in functionality between product revisions of the LPD-500 Low Power Distributor.

**r0p0** First release.

# Chapter 2

## Functional description

This chapter describes the functionality of the LPD-500.

It contains the following sections:

- [2.1 About the functions](#) on page 2-20.
- [2.2 Interfaces](#) on page 2-22.
- [2.3 Clocking and reset](#) on page 2-23.
- [2.4 Parameter summary](#) on page 2-24.

## 2.1 About the functions

This section describes the functional blocks in the LPD-500.

When the LPD-500 receives a request on the CTRL Q-Channel, it starts the same request on all the DEV Q-Channels, either together or in sequence. When configured as a sequencer, the LPD-500 waits for the response from each device before starting the next request. The LPD-500 waits for all devices to respond before generating the response to the Controller. The type of response that the LPD-500 generates to the Controller depends on the responses that the LPD-500 received from the devices, and whether the LPD-500 is configured as an expander or sequencer.

The LPD-500 ORs together all the device **qactive** signals to form the **ctrlqactive** output. The path from the **devqactive** signals to the **ctrlqactive** output is a combinatorial path through the design. The particular behavior of the LPD-500 depends on whether it is configured as an expander or sequencer.

The following figures show the LPD-500 configured as an expander, and as a sequencer.

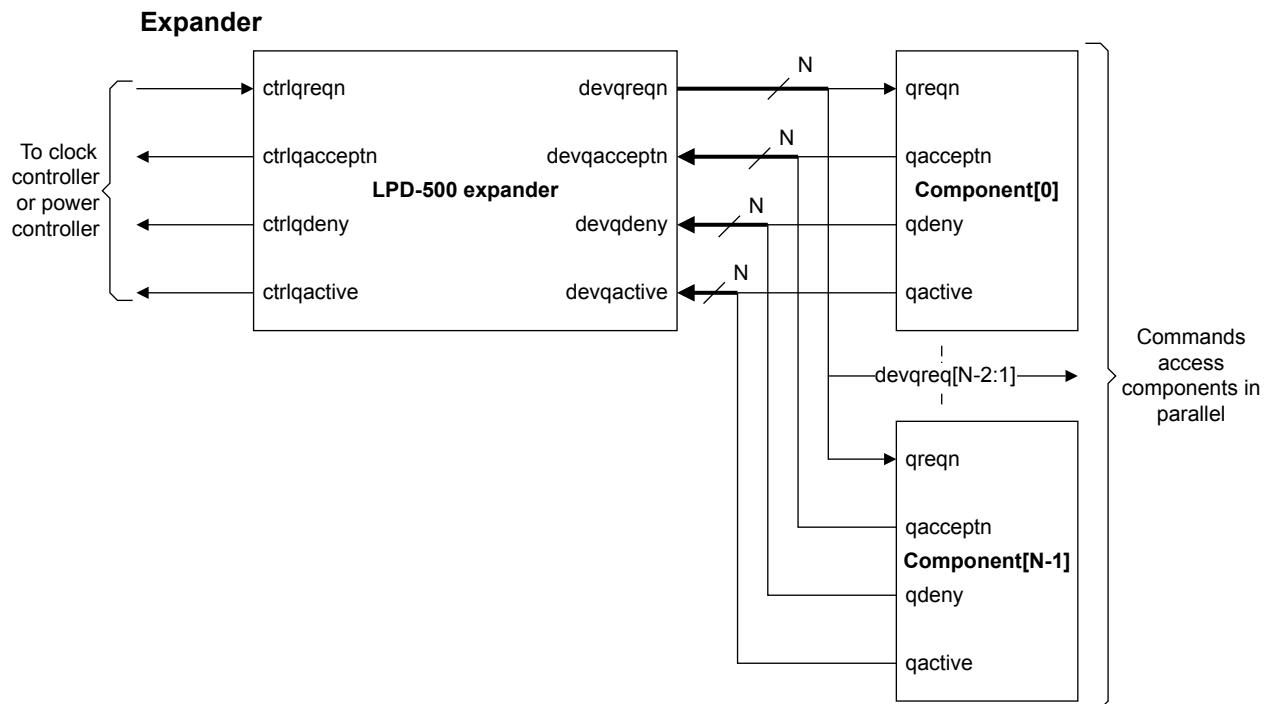


Figure 2-1 Example LPD-500 expander connections

If all devices respond with **qacceptn** asserted, then the LPD-500 accepts the request from the Controller.

The LPD-500 denies the request from the Controller under either of the following circumstances:

- A **devqactive** becomes HIGH, between the time that all **devqreqn** signals are asserted and the time that last **devqacceptn** is asserted, when **ACTIVE\_DENY** is set to 1.
- Any **devqdeny** is asserted, after **devqreqn** is asserted.

To complete the handshake, all device channels have to assert either **devqacceptn** or **devqdeny**. If any of them assert **devqdeny**, then **ctrlqdeny** is asserted in place of **ctrlqacceptn**.

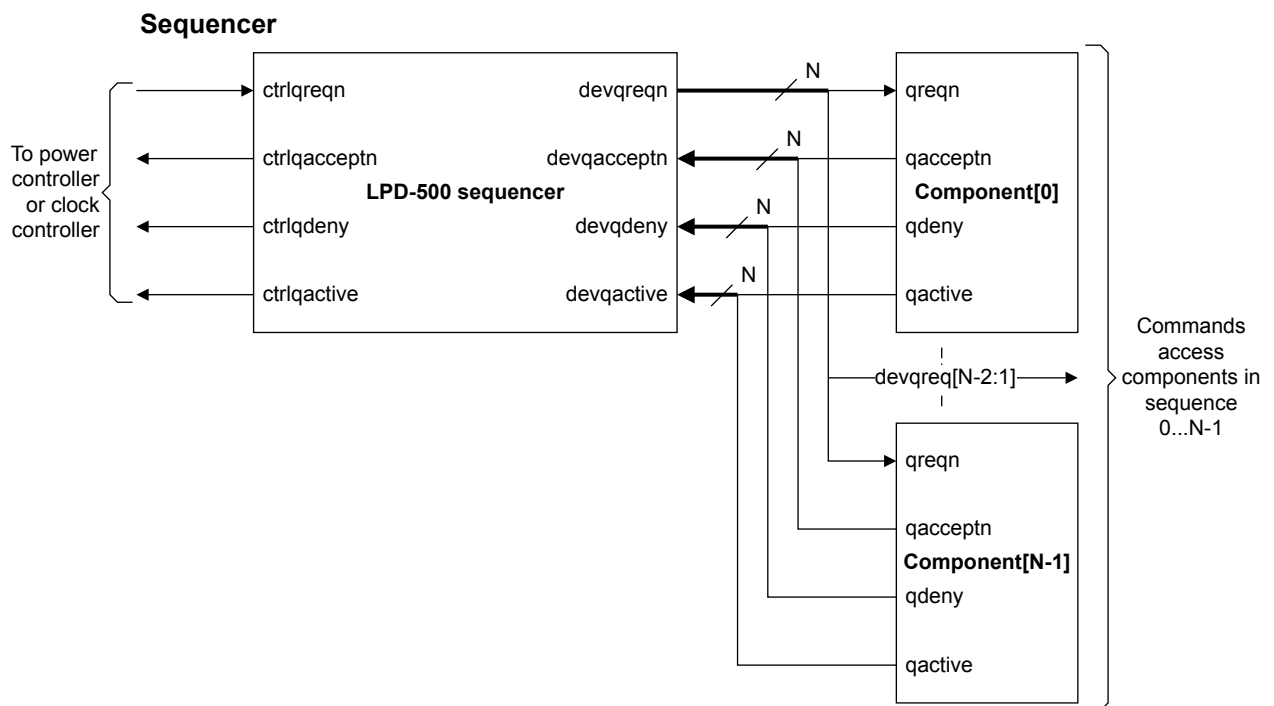


Figure 2-2 Example LPD-500 sequencer connections

The request that is received on the CTRL interface determines the ordering of the accesses that the LPD-500 makes to the connected devices.

- When the Controller starts an entry into the quiescent state by asserting **ctrlqreqn**, the LPD-500 starts sending entry requests on the *Device Channel*[N-1] (DEV[N-1]), where N is equal to NUM\_QCHL, and decrements.
- When the Controller starts an exit from a quiescent state, that is **ctrlqreqn** is deasserted, the LPD-500 starts sending exit requests on DEV[0] and increments.

The LPD-500 only sends an accept response to the Controller, by asserting **ctrlqacceptn**, when all devices have accepted the requests. If any device denies the request, by asserting **devqdeny**, or **devqactive** is asserted with ACTIVE\_DENY=1, it causes the LPD-500 to stop sending any more entry requests to channels still in the Q\_RUN state, and to assert the **ctrlqdeny** output. The behavior of the LPD-500 changes if the **devqdeny** for the channel generates a denial, or by any **devqactive** being asserted.

The response of the LPD-500 to assertion of a **devqdeny** signal or a **devqactive** signal varies in the following ways:

#### **devqdeny**

The LPD-500 returns all channels to the Q\_RUN state, starting with the channel that asserted **devqdeny**, followed by the rest of the channels in ascending numerical order, from zero up to DEV[N-1].

#### **devqactive**

The LPD-500 returns all channels to the Q\_RUN state, starting with the last channel to enter the Q\_STOPPED state, followed by the rest of the channels in ascending numerical order, from zero up to DEV[N-1].

A channel, that has not asserted **devqacceptn** when **devqactive** is asserted, waits until **devqacceptn** or **devqdeny** asserts before it is returned to Q\_RUN. The point at which this channel returns to Q\_RUN might not be in sequence with the other channels.

The LPD-500 only deasserts **ctrlqacceptn** when all device channels have returned to the Q\_RUN state and the controller has driven **ctrlqreqn** high.

## 2.2 Interfaces

The LPD-500 has at least two external Q-Channel interfaces, one for control and the others to connect to devices.

The LPD-500 has the following external interfaces:

- A single CTRL interface that is the input Q-Channel. It receives commands from a power controller, a clock controller, or another LPD-500. The LPD-500 splits these commands to distribute them to connected devices on the multiple DEV interfaces.

The CTRL interface has the following signals:

- **ctrlreqn** - an active-LOW request input for a device to go into quiescence.
- **ctrlacceptn** - an active-LOW acknowledge output of a request for quiescence to the controller.
- **ctrldeny** - an active-HIGH output indicating denial of request for quiescence.
- **ctrlactive** - an active-HIGH output indicating that a device has requested to exit quiescence.
- NUM\_QCHL DEV interfaces, that are numbered 0:NUM\_QCHL-1. The DEV interfaces are the output Q-Channels that were split by the LPD-500. The DEV interfaces drive either a Q-Channel device or another LPD-500.

Each DEV interface has the following signals, where N is the number of the interface:

- **devreqn[N]** - an active-LOW request output for a device to go into quiescence.
- **devacceptn[N]** - an active-LOW acknowledge input from device.
- **devdeny[N]** - an active-HIGH input indicating denial of request for quiescence.
- **devactive[N]** - an active-HIGH input indicating request for exit from quiescence.

The following figure shows the interfaces of the LPD-500.

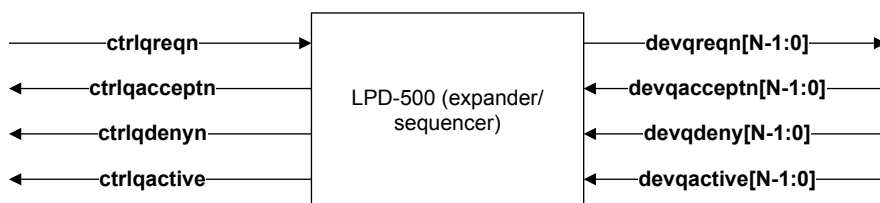


Figure 2-3 LPD-500 top-level diagram

### Related references

[2.4 Parameter summary on page 2-24.](#)

## 2.3 Clocking and reset

This section describes the clock and reset signals and procedures for the LPD-500 Low Power Distributor.

### 2.3.1 Clocking

The LPD-500 has a single clock input, **clk**.

### 2.3.2 Reset

The LPD-500 has a single active-LOW reset, **resetn**, that can be asserted asynchronously, but must be deasserted synchronously, to **clk**.

## 2.4 Parameter summary

There are six configuration parameters that determine the functionality of the LPD-500.

The following table shows the configuration parameters.

**Table 2-1 LPD-500 configuration parameters**

Parameter	Possible settings	Default	Description
SEQUENCER	0 or 1	0	0: LPD-500 configured as an expander.
			1: LPD-500 configured as a sequencer.
NUM_QCHL	2-32	2	Defines the number of DEV interfaces.
CTRL_Q_CH_SYNC	0 or 1	1	0: Synchronizers are not present on <b>ctrlqreqn</b> inputs.
			1: Synchronizers are present on <b>ctrlqreqn</b> inputs.
DEV_Q_CH_SYNC	0 or 1	1	0: Synchronizers are not present on <b>devqacceptn</b> or <b>devqdeny</b> inputs.
			1: Synchronizers are present on <b>devqacceptn</b> and <b>devqdeny</b> inputs.
ACTIVE_DENY	0 or 1	1	0: Support for denying a quiescence request using <b>QACTIVE</b> is not included.
			1: Support for denying a quiescence request using <b>QACTIVE</b> is included. Synchronizers are included on <b>devqactive</b> inputs.
TARGET_DIRECTORY	A valid directory path	../..	The path for the configured IP-XACT. It can be either an absolute path or relative to the location of the IP-XACT file.

### Related references

[2.2 Interfaces on page 2-22.](#)

[A.2 Q-Channel signals on page Appx-A-29.](#)



# Chapter 3

## Programmers model

This chapter describes the programmers model.

It contains the following sections:

- [3.1 Programmers model summary](#) on page 3-26.

### 3.1 **Programmers model summary**

There are no user-programmable registers in the LPD-500.

# Appendix A

## Signal descriptions

This appendix describes the external signals of the LPD-500.

It contains the following sections:

- *A.1 Clock and reset signals on page Appx-A-28.*
- *A.2 Q-Channel signals on page Appx-A-29.*

## A.1 Clock and reset signals

The following table shows the LPD-500 clock and reset signals.

**Table A-1 Clock and reset signals**

Signal name	Type	Clock	Description
<b>clk</b>	Input	-	Clock input.
<b>resetn</b>	Input	<b>clk</b>	Reset input.

## A.2 Q-Channel signals

The following tables show the LPD-500 Q-Channel signals.

**Table A-2 Control interface signals**

Signal name	Type	Clock	Description
<b>ctrlqreqn</b>	Input	Asynchronous or <b>clk</b> <sup>a</sup>	Controller <b>QREQn</b> request for device quiescence.
<b>ctrlqacceptn</b>	Output	<b>clk</b>	Controller <b>QACCEPTn</b> acknowledge of quiescence request from device.
<b>ctrlqdeny</b>			Controller <b>QDENY</b> denial of quiescence request from device.
<b>ctrlqactive</b>		Asynchronous	Controller <b>QACTIVE</b> request from device to exit quiescence.

**Table A-3 Device interface signals, where N is the number of the interface**

Signal name	Type	Clock	Description
<b>devqreqn[N]</b>	Output	<b>clk</b>	Device <b>QREQn</b> request for device quiescence.
<b>devqacceptn[N]</b>	Input	Asynchronous or <b>clk</b> <sup>b</sup>	Device <b>QACCEPTn</b> acknowledge of quiescence request from device.
<b>devqdeny[N]</b>			Device <b>QDENY</b> denial of quiescence request from device.
<b>devqactive[N]</b>		Asynchronous	Device <b>QACTIVE</b> request from device to exit quiescence.

### Related references

[2.4 Parameter summary on page 2-24.](#)

<sup>a</sup> Depends on the value of parameter CTRL\_Q\_CH\_SYNC. If CTRL\_Q\_CH\_SYNC = 0 then **clk**, else Asynchronous.  
<sup>b</sup> Depends on the value of parameter DEV\_Q\_CH\_SYNC. If DEV\_Q\_CH\_SYNC = 0 then **clk**, else Asynchronous.

# Appendix B

## Revisions

This appendix describes the technical changes between released issues of this book.

It contains the following sections:

- [B.1 Revisions on page Appx-B-31](#).

## B.1 Revisions

**Table B-1 Issue 0000-00**

Change	Location	Affects
First release	-	-

**Table B-2 Differences between issue 0000-00 and issue 0000-01**

Change	Location	Affects
Added TARGET_DIRECTORY parameter	<a href="#">2.4 Parameter summary on page 2-24</a>	0000-01
Corrected DEV_Q_CH_SYNC and ACTIVE_DENY default values - changed from 0 to 1		
Signal names changed to lowercase	Throughout document	

**Table B-3 Differences between issue 0000-01 and issue 0000-02**

Change	Location	Affects
Updated section 1.1	<a href="#">1.1 About the LPD-500 Low Power Distributor on page 1-12</a>	0000-02

**Table B-4 Differences between issue 0000-02 and issue 0000-03**

Change	Location	Affects
There are no functional changes in this release	-	All revisions