



**Lumistar LS-37 Family of
Telemetry Recorder Up & Downconverters
(LS-37-P95 & LS-37-P50)**

Operations Manual

Preliminary



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Lumistar, Inc.
5870 El Camino Real
Carlsbad, CA 92008
(760) 431-2181
www.lumi-star.com

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Lumistar, Inc.
5870 El Camino Real
Carlsbad, CA 92008
(760) 431-2181
(760) 431-2665 Fax
www.lumi-star.com

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1 Introduction

1.1 General Information

This manual has two (2) chapters including this *Introduction*, and the *LS-37 Application*. The Introduction covers General Information, Equipment Description, Theory of Operation and System Use Configurations. The LS-37 Application chapter deals with primary software application and its setup and use.

1.1.1 Scope

This is an operations manual for the Lumistar family of Telemetry Recorder Up & Downconverters (LS-37-P95 & LS-37-P50) used to support terrestrial flight testing as well as many types of satellite operations. There are two primary variants in the LS-37 family; the *LS-37-P95* is a dual channel unit, while the *LS-37-P50* is a single channel unit.

1.1.1.1 Warranty Information

Lumistar warrants all of its products for two years from the date of shipment. This includes all card level products, systems, firmware and Lumistar designed software delivered.

This warranty extends past the original purchaser to the end user of the product. If a product is integrated into a system and delivered as part of an overall system – i.e. Antenna Controller or Decommutation system – Lumistar warrants its components in that system. If a customer buys Lumistar products as part of a government deliverable, the government can exercise the warranty directly from Lumistar.

If a product is found to be defective or fails under normal operating conditions, Lumistar will repair or replace the items at its discretion at no cost to the customer. While Lumistar understands that its customers sometime work in harsh environments and designs for hard use of its products, submersion, exposure to jet blast, or receiving 10 Watts of RF power is not normal operation. Lumistar will be the sole decider of product abuse.

Lumistar's repair philosophy is to cover core costs of non-warranty repair. Lumistar does not typically charge an evaluation fee, and repair costs are kept minimal. Typical repair costs are \$500-\$1,000 for a board level product.

The warranty can be extended at time of purchase for up to 5 years, and the cost is a percentage of the purchase price and whether it is a board or a system being sold.

1.2 Equipment Description

The LS-37 family of Telemetry Recorder Up- and Down-Converter (UDC) PCI boards employ sophisticated fourth generation Field Programmable Gate Array (FPGA) technologies to support both current and legacy telemetry recorders used in numerous telemetry range applications.

1.2.1 LS-37 Characteristics, Capabilities, and Features

The LS-37 family of PCI cards employ multiple analog down conversion signals for use with legacy tape recorders. The LS-37 can down convert a 70 MHz input to a signal centered at one of the standard IRIG values including; 112.5, 150, 225, 300, 450, 600, 900, 1200, 1800, 2100 and 2400 kHz. It also supports several non IRIG frequencies including 3.6, 4.8, 7.2 and 9.6 MHz. Moreover, the user can also select any unique frequency between 5 kHz and 10 MHz for the output. The input to the LS-37 is a standard 70 MHz signal coming from a LS-28 series chassis receiver or a LS-25 or LS-27 card receiver. The dynamic range of the 70 MHz input signal is -20 ± 10 dBm into 50 Ohms. The output amplitude of the resulting down converted signal can be adjusted up to +4V into a 50 Ohm load.

The LS-37 also performs tape up conversion taking the same standard (and nonstandard) IRIG input frequencies and outputs a 70 MHz signal which can be input to the LS-28 series receivers for demodulation and data re-generation.

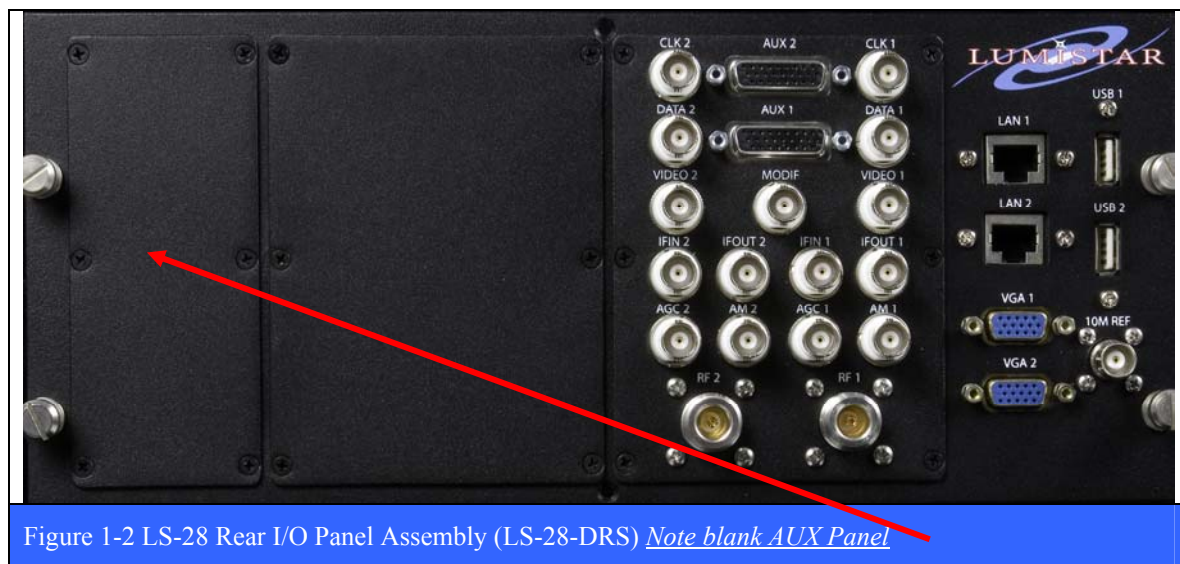
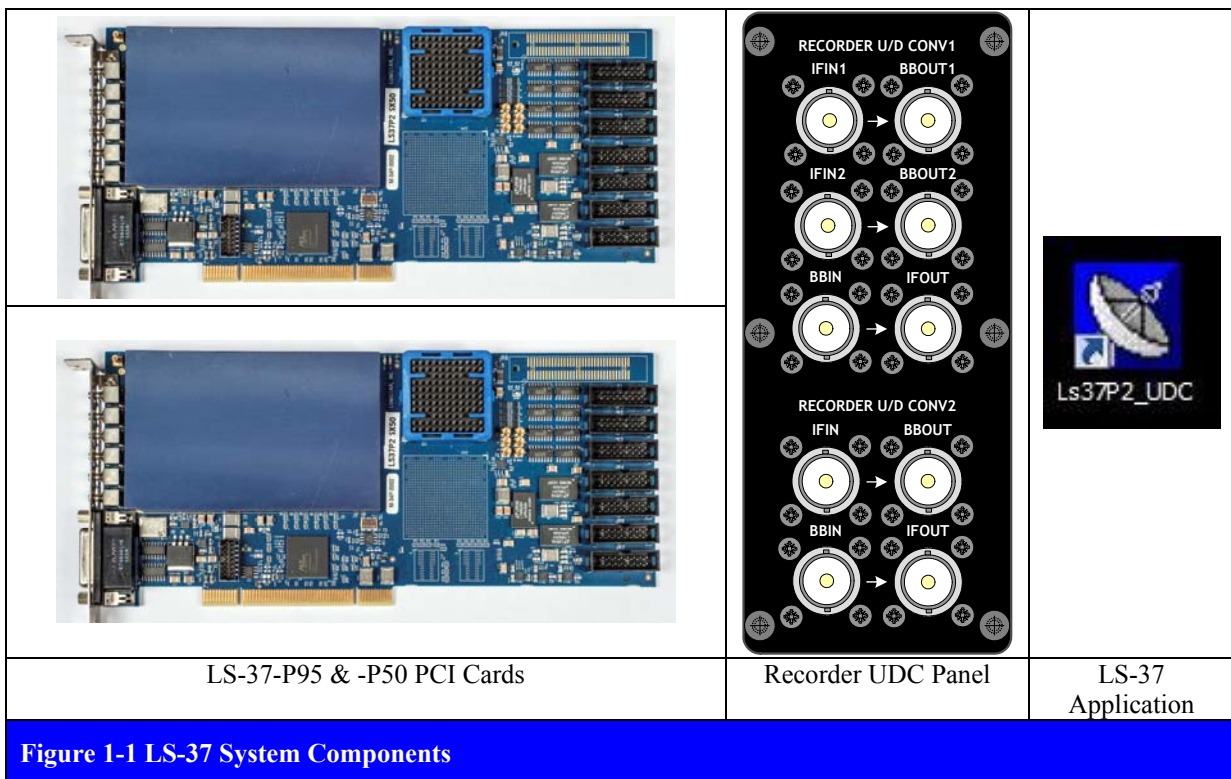
The Lumistar LS-37-P is part of the Lumistar family of digital processing boards used for programmable telemetry systems. The LS-37-P consists of a analog to digital and digital to analog processing board with a high capacity Xilinx Virtex-5 array.

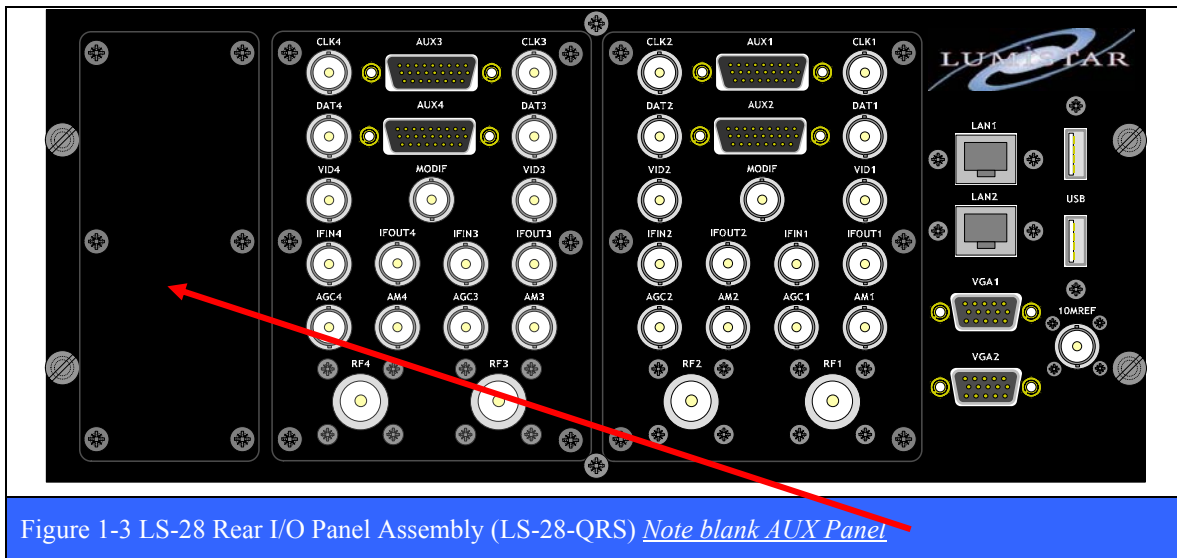
1.2.2 LS-37 System Components

The LS-37 Telemetry Recorder Up/Down-Converter (UDC) is a collection of hardware and software components that together form a system that supports the use of legacy FM, as well as the latest digital telemetry data recorders found on today's test ranges. These elements are shown in Figure 1-1 below.

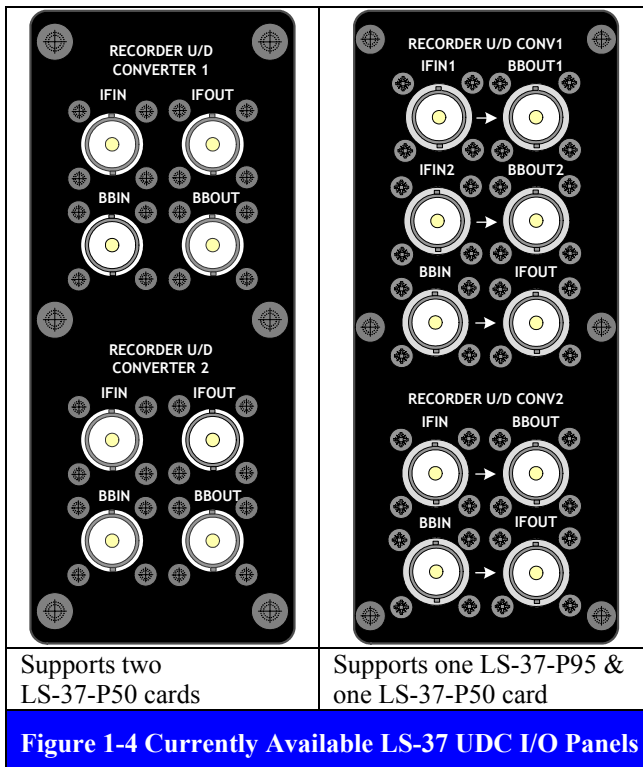
The hardware elements include: the Lumistar LS-37-P95 and LS-35-P50 Recorder Up/Down Converter PCI cards, and a customized rear panel I/O connector assembly designed to be integrated into the rear panel of the Lumistar LS-28, 4U family of Chassis type receivers. The software element - the LS-37 UDC application and the custom firmware loaded into the FPGA on each LS-37 card, perform the up and down conversion signal processing.

All that is required to support both legacy FM and current digital telemetry data recorders with a Lumistar LS-28 4U chassis type receiver are two empty PCI slots and a blank auxiliary panel located on the rear chassis I/O panel. The location of this blank panel is shown for the LS-28-DRS and LS-28-QRS receivers in Figure 1-2 and Figure 1-3 below.



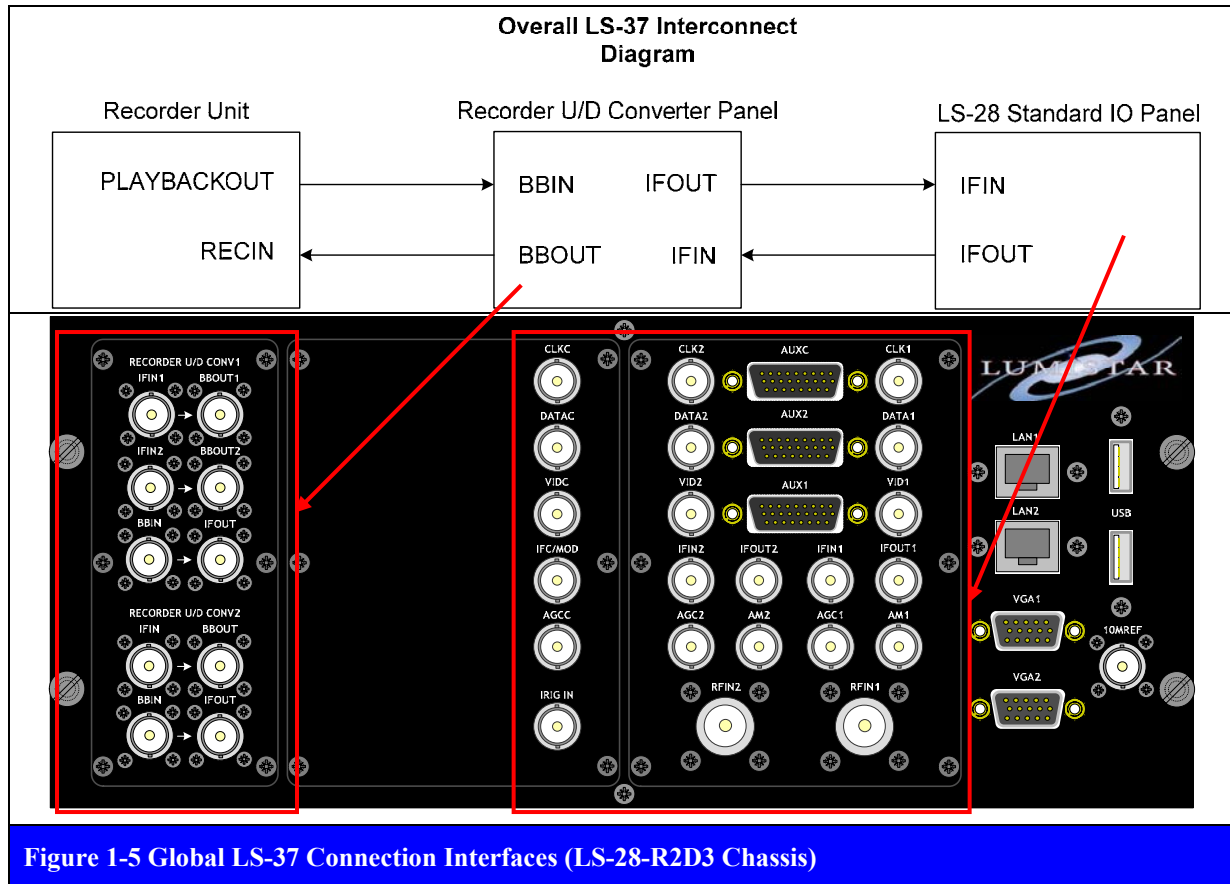


There are currently two LS-37 UDC I/O panels available (more are possible) that are shown in Figure 1-4 below. The panel on the left can support two LS-37-P50 cards. The panel on the right¹ can support one LS-37-P95 and one LS-37-P50 card.



¹ This is the default UDC panel for the Lumistar LS-28-R2D3 receiver.

The UDC functionality in the LS-37 is standalone, meaning that there are no internal connections inside the chassis between the LS-37 hardware and the LS-28 radio hardware. All such connections must be made externally via coaxial cabling between the UDC I/O panel and the LS-28 Standard I/O panel as shown in Figure 1-5 below. Specific examples of this external cabling are discussed in paragraph 1.4 on page 12.



1.2.3 Differences between Models

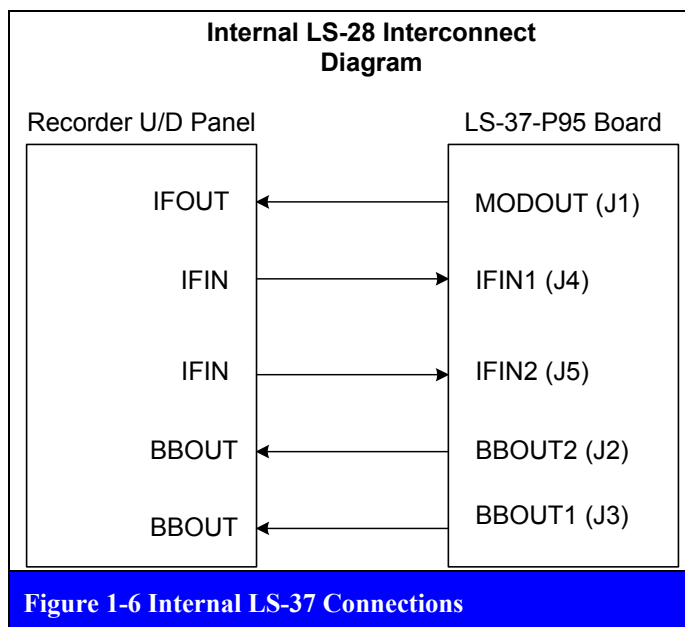
The LS-37-P95 card can support either two separate down converter channels (each independent of the other), OR one up converter channel. The LS-37-P50 card can support either one downconverter channel, OR one upconverter channel.

1.2.4 LS-37 Family Specifications

Table 1-1 LS-37 Tape Up/Down-Converter Specifications	
Parameter	Specification
I/O:	4 SMB connectors: 70 MHz In & Out, Tape In & Out
Tape In & Out Frequencies:	112.5, 150, 225, 300, 450, 600, 900 kHz 1.2, 1.8, 2.1, 2.4, 3.6, 4.8, 7.2, 9.6 MHz Custom - Selectable from 5 kHz to 10 MHz.
Step Size:	100 Hz
Tape Output Signal:	Adjustable from +1 V to +4 V into a 50 Ω load.
Tape Input Signal:	Between +1 V to +4 V into a 50 Ω impedance
IF Output Signal:	70 MHz @ -20 \pm 10 dBm with 50 Ω impedance
IF Input Signal:	70 MHz @ -20 \pm 10 dBm with 50 Ω impedance
Input Bandwidth:	67% of the input frequency
Reference Clock:	10 MHz
Form Factor:	PCI card 8.9" L x 3.9" W x 0.65" H
Current Requirements:	+12V – 60mA, -12V-170mA, 5V-1.7A, +3.3V 1.4A
Power:	16 Watts from the PC Bus
Weight:	7 Oz. (200 grams)

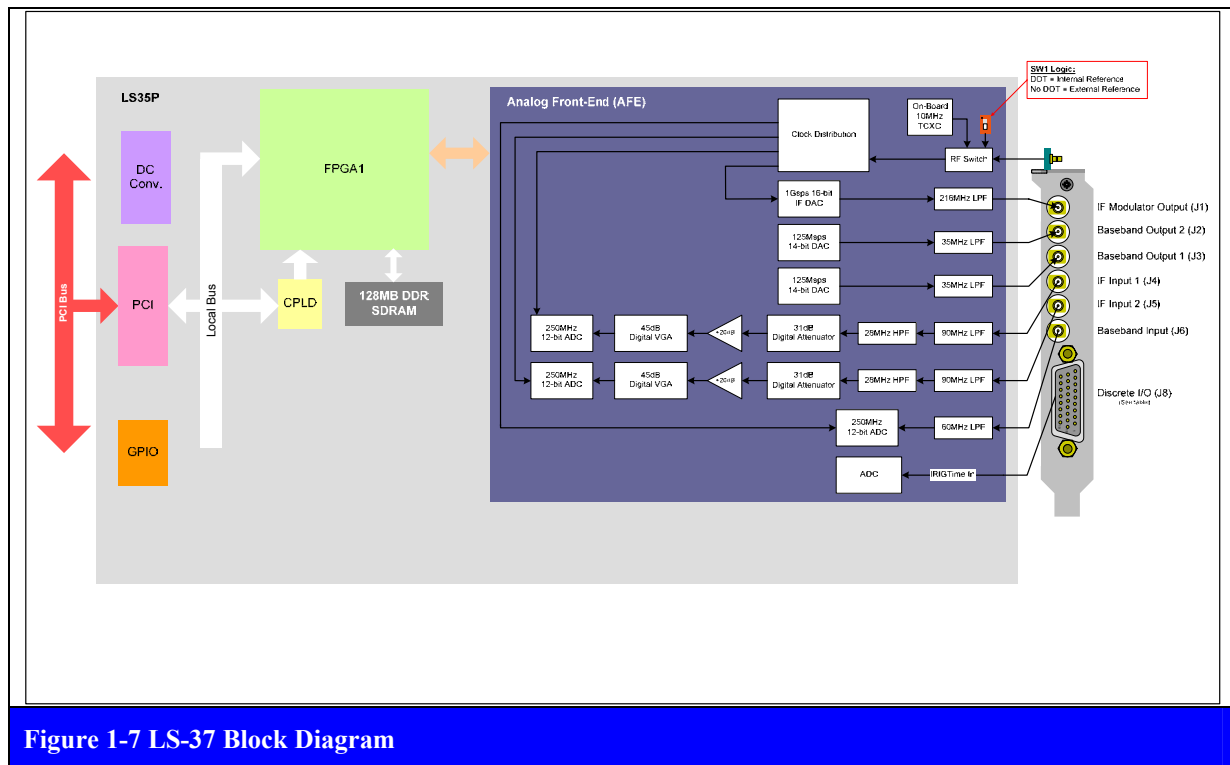
1.3 Theory of Operation

The UDC functionality in the LS-37 is standalone, meaning that there are no internal connections inside the chassis between the LS-37 hardware and the LS-28 radio hardware. All such connections must be made externally via coaxial cabling between the UDC I/O panel and the LS-28 Standard I/O panel as shown in Figure 1-6 below.



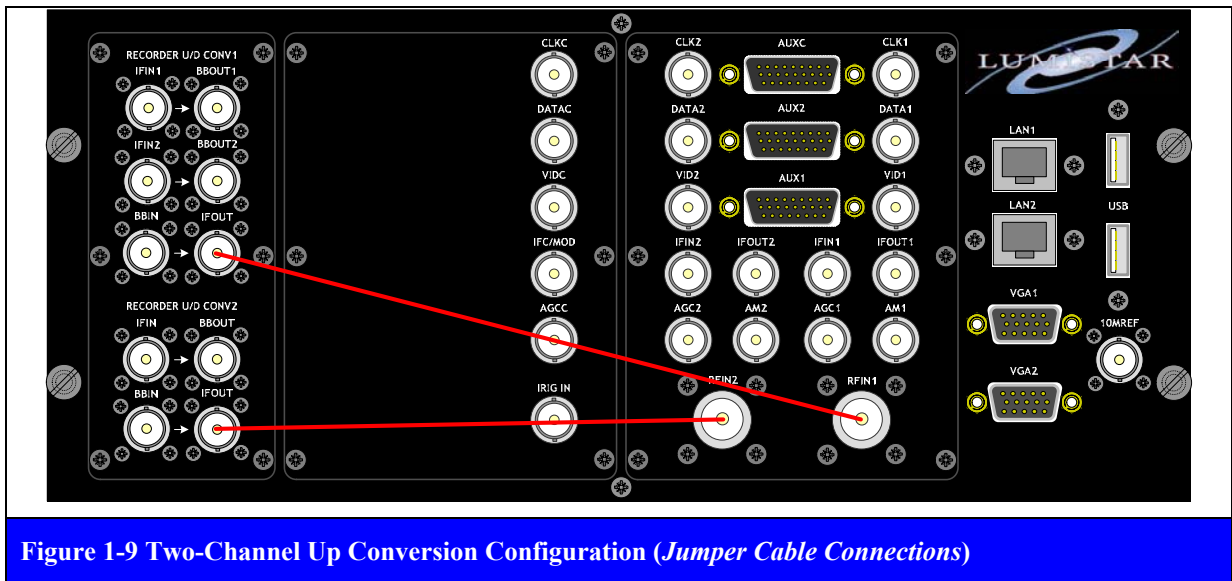
1.3.1 LS-37-P95 & -P50 Tape Up/Down Frequency Converter PCI Cards

The Lumistar LS-37 Telemetry Recorder Up/Down-Converter (UDC) is part of the Lumistar family of digital processing boards used to build programmable telemetry systems. As shown in the figure below, the LS-37 consists of an analog front-end and a FPGA (up to 10 million gate) based digital processing engine. The LS-37 is firmware configured to perform the up and down conversion functions required to support an external recording device. The analog front-end performs pre-conditioning of the 70 MHz IF input signal prior to acquisition. The digital processing engine is implemented in one large FPGA and performs the up and down conversion functions. The all-digital design and implementation assures a consistent product with high reliability and long-term stability



1.4 System Use Configurations

The UDC functionality of the Lumistar LS-28-R2D3 telemetry receiver is described in the following paragraphs. The LS-37 configuration in the LS-28-R2D3 is the most common among the many that are possible with this technology. The LS-28-R2D3 is an advanced, multi-mode, multi-band, two-channel receiver/combiner that provides both independent and combined channel output signals. In its most common use scenario, the LS-28-R2D3 ingests the two RF inputs coming from the Left and Right hand feeds of a polarized tracking antenna. It first down converts these two signals to a 70 MHz intermediate frequency (IF), both of which come out the back of the receiver. Next it demodulates each of the two independent IF signals down to both baseband and further down to the final clock and data



2 LS-37 Application Program

Start the LS-37 application by double clicking the LS-37 icon on the desktop of the computer where the hardware is installed. The resulting window is shown below³. The main LS-37 application launch banner has six commands; *System*, *Project*, *View*, *Setup*, *Tools*, *About*, and *Factory*. Each of these commands will be further discussed in the following numbered paragraphs.

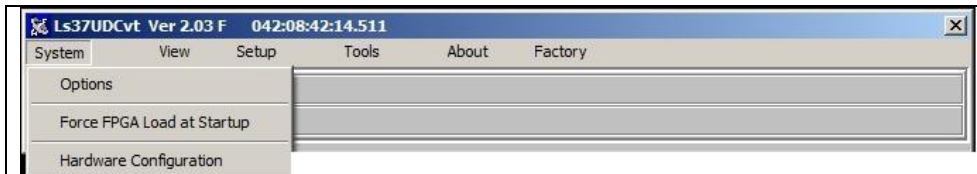


Below the commands are one or more UD Converter card configuration displays. Depending on the card type, each UD Converter can have either two downconverter channels and one upconverter channel (LS-37-P95), or one downconverter channel and one upconverter channel (LS-37-P50). The card configuration display lists all LS-37 cards installed in the system, but does not indicate the card type.

2.1 System Command Menu

The main System command has three sub-commands; *Options*, *Force FPGA Load at Startup*, and *Hardware Configuration*.

The **System** command and its associated sub-commands are not typically invoked by the end-user but are rather used in the initial phases of installing and configuring the LS-37 application at the factory for the first time. As such, the System commands should only be used with caution and at the direction technical support.



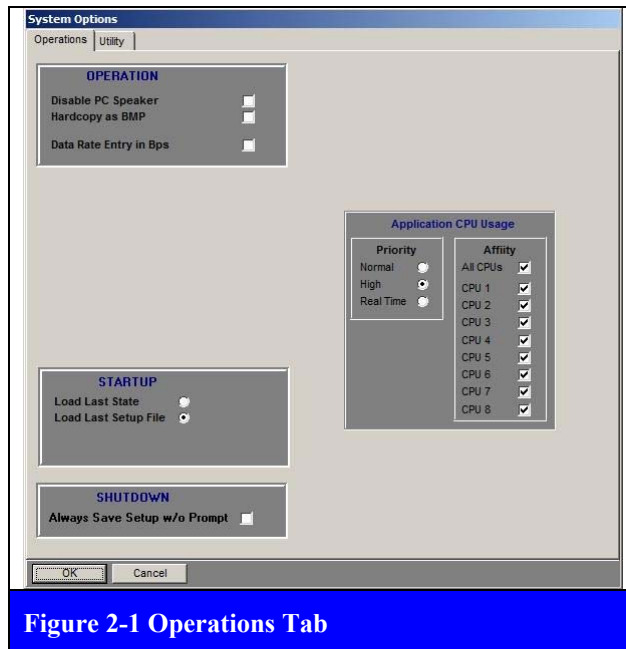
³ The hardware configuration described in this manual includes one LS-37-P95 and one LS-37-P50. Other configuration scenarios are possible, but are not addressed in this document.

2.1.1 Options Sub-Command

(System->Options) invokes the multi-tab window shown in Figure 2-1 below. The systems options window has two tabs; *Operations*, and *Utility*.

2.1.1.1 The Operations Tab

shown in Figure 2-1 below allows the user to setup and configure the individual peculiarities of how the LS-37 application works. This includes those things that occur automatically upon the Startup of the application, as well as the Operation and Shutdown of the application.



The **Operation** section allows the user to setup and configure the individual peculiarities of how the LS-37 application works. The operational configuration for LS-37 includes the following features:

- **Disable PC Speaker** – By selecting this option, audio warnings generated by the application will be disabled. The default state of this parameter is off (unchecked).
- **Hardcopy as BMP** – Check this box and all hardcopies made by the application will be saved as Windows BMP files in the hardcopy directory selected in the directory options. Otherwise, the hardcopies will be saved as JPG files. The default state of this parameter is off (unchecked).
- **Data Rate Entry in Bps** - By selecting this option, the operator will be required to enter the data rate in Bits-Per-Second (BPS). If this option is NOT selected, then the operator must enter the data rate in MBPS.

Below the Operation block are the **Startup** controls for the LS-37 application. The Startup configuration for the application includes the following features:

Load Last State - If this option is selected, then the last valid hardware state (not saved in any setup file) loaded when the LS-37 application was shut down will automatically load when the application is started up again. The default state of this parameter is On (selected).

Load Last Setup File - If this option is selected, then the last valid setup file loaded when the LS-37 application was shut down will automatically load when the application is started up again. The default state of this parameter is off (unselected).

Below the Startup block are the **Shutdown** controls for the LS-37 application. The shutdown configuration for the application includes the following feature:

Always Save Setup w/o Prompt – By selecting this option, when the LS-37 application terminates, the state of all hardware settings, including firmware mode, will be automatically saved without prompting the user. The default state of this parameter is off (unchecked).

To the right of the Shutdown controls are the **Application CPU Usage** controls. These controls include *Priority* settings for the LS-37 application and individual *Affinity* settings for any/all of the CPU cores found in the systems main CPU.

2.1.1.2 The Utility Tab

is shown in Figure 2-2 below, allows the user to customize the color schemes used for all of the windows and displays used in the LS-37 application.

By clicking on the **Change Colors** button, the user may change the LS-37 graphics color scheme to just about anything. There are a few default settings that can be used. Select the default colors radio button of interest (currently Browns, Blues, etc) and click the Set Default Colors button and the respective pre selected color scheme will occur. Otherwise, in the Display Color Window (Figure 2-3), click on the individual Data Label buttons for; *Main*, *Status*, and *Setup*. Each will invoke the generic windows color picker shown in Figure 2-4 on page 18.

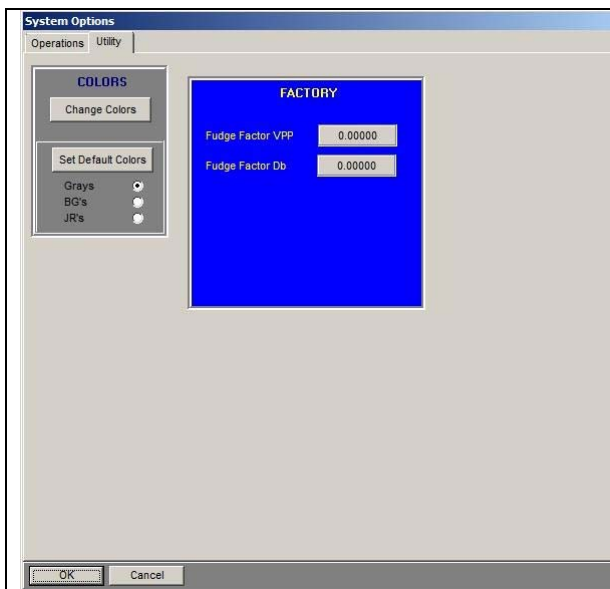


Figure 2-2 The Utility Tab

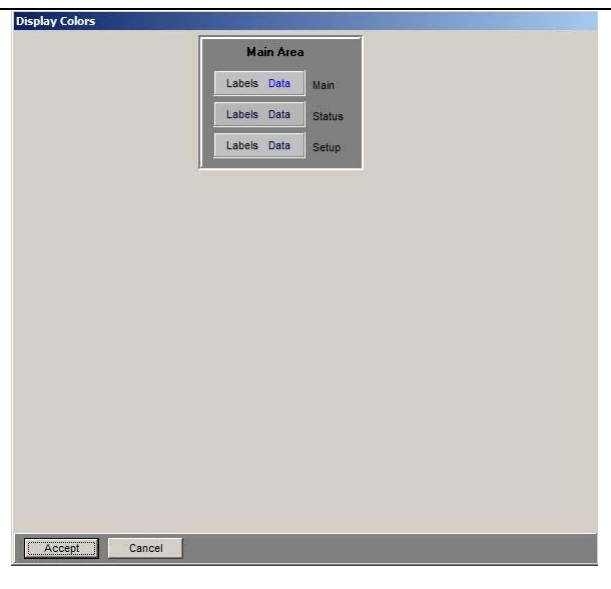


Figure 2-3 The Change Colors Window

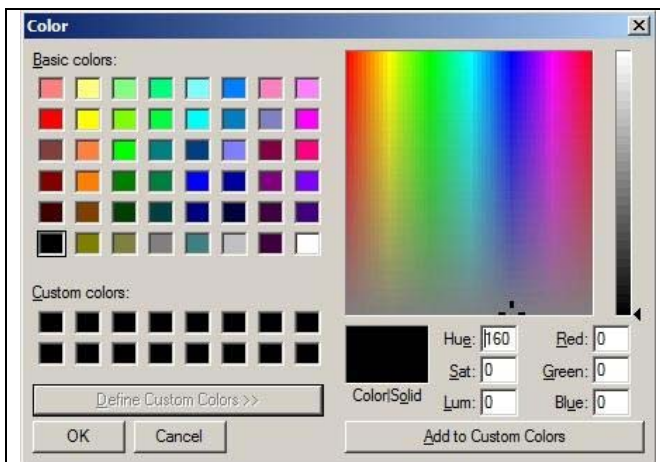


Figure 2-4 Windows Color Picker

2.1.2 FPGA Load at Start Up Sub-Command

(System->Force FPGA Load at Startup) does what the name implies; it forces the FPGA on the LS-37 to load firmware as a result of launching the application (the default is for the application to NOT load the firmware at application startup).

2.1.3 Hardware Configuration Sub-Command

(System->Hardware Configuration), invokes the setup window shown in Figure 2-5 below. This command is not typically invoked by the end-user but rather in the initial phases of

installing and configuring the LS-37 application at the factory for the first time. As such, this command should only be used with caution and at the direction technical.

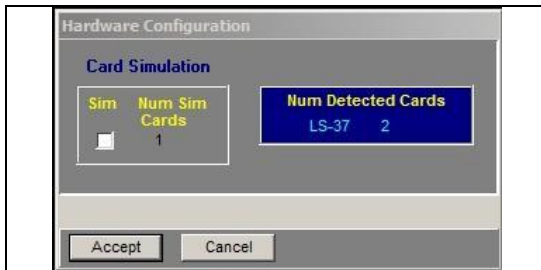


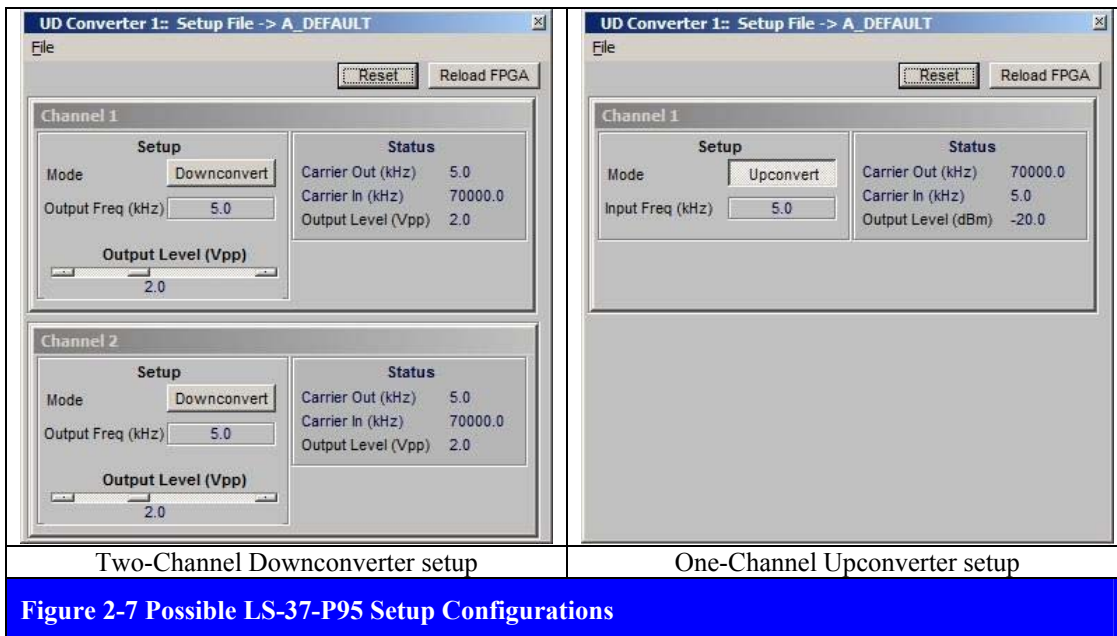
Figure 2-5 Hardware Configuration Window

2.3 Setup Command Menu

The main Setup command has one sub-command; *Card Setup*. This sub-command in turn will produce a list of all LS-37 cards installed in the system. The typical configuration (shown below) will consist of one LS-37-P95 and one LS-37-P50 card. To setup each card, the user selects the card from the list. The resulting setup windows for the LS-37-P95 are shown below in Figure 2-7. The setup windows for the LS-37-P50 are shown below in Figure 2-8 on page 22.



The LS-37-P95 card can support either two separate down converter channels (each independent of the other), OR one up converter channel. The two channel downconverter scenario is shown below left. The one channel upconverter case (LS-37-P50) is shown below right.

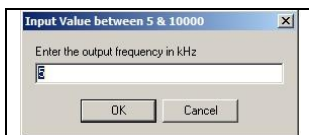


At the top of each card setup window (regardless of mode), are two buttons; *Reset* and *Reload FPGA*. The **Reset** button causes the various software & firmware (FPGA) algorithms involved in up/down conversion to restart to their initial states and begin running. The **Reload FPGA** button does what the name implies; it forces the FPGA on the LS-37 to reload firmware after the application has started running. In general, neither button will ordinarily be invoked by the user during normal operation. They are present in the GUI for

test/troubleshooting scenarios and should only be used as directed by Lumistar customer support.

Below the Reset & Reload FPGA buttons on the card setup GUI are separate *Setup* and *Status* areas. The *Setup* area will have a single button that indicates the current mode state (**Upconvert** or **Downconvert**). This button acts as a toggle – click on it to change the mode. Below the mode button is a numeric display of the frequency currently associated with the mode. In Upconvert mode, the *Input* Frequency (MHz) will be displayed. In Downconvert mode, the *Output* Frequency (MHz) will be displayed. Irregardless of mode, the user may change the frequency value by mouse clicking on the numeric value. This will invoke the list of pre-set frequencies shown right. To select one of the pre-set frequencies, simply click on it. To enter a custom value, mouse click on the *Custom* entry. This will invoke a numeric input box as shown below. Enter a frequency value (kHz) between 50 kHz and 10 MHz and click on the OK button. This will result in the update of the displayed numeric frequency value in the GUI. Also be aware that the numeric *bandwidth* associated with any selected frequency will be 70% of the entered frequency value. Below the numeric frequency display (and only when in Downconverter mode) is a slider bar control that allows the user to set the voltage Output Level (Vpp) of the converted signal. The user may adjust the Output Level between 1.0 Vpp and 3.0 Vpp, with 2.0 Vpp being the default.

- ✓ Custom
- 112.5 kHz
- 150.0 kHz
- 225.0 kHz
- 300.0 kHz
- 450.0 kHz
- 600.0 kHz
- 900.0 kHz
- 1.2 MHz
- 1.5 MHz
- 1.8 MHz
- 2.1 MHz
- 2.4 MHz
- 3.6 MHz
- 4.8 MHz
- 7.2 MHz
- 9.6 MHz



To the right of the Setup area in the GUI is the *Status* area. The Status area has numerical displays for parameters associated with the particular mode. In Upconverter mode, the *Carrier Output* (kHz) frequency (70 MHz), *Carrier Input* (kHz) frequency, and *Output Level* (dBm) are displayed. In Downconverter mode, the *Carrier Output* (kHz) frequency (70 MHz), *Carrier Input* (kHz) frequency, and *Output Level* (Vpp) are displayed.

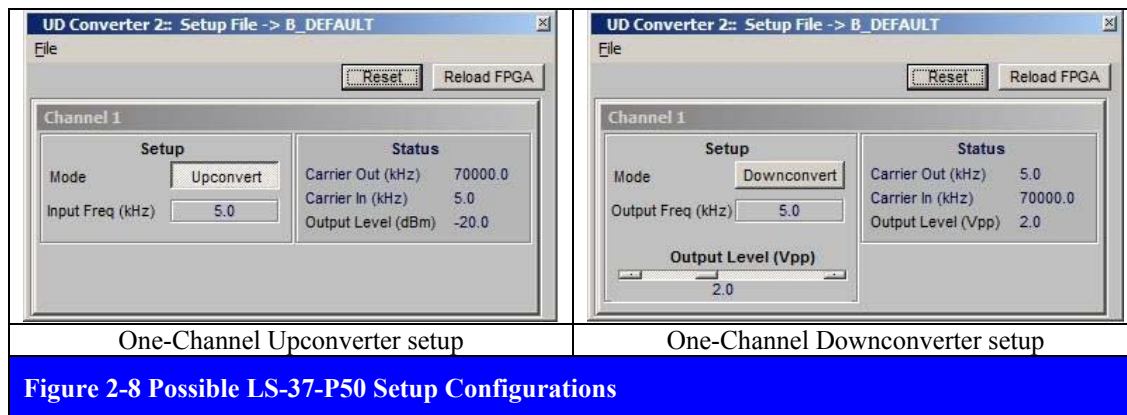


Figure 2-8 Possible LS-37-P50 Setup Configurations

2.4 The About Command

The About command, when invoked, produces the information window shown below and displays the version number of the LS-37 application. It is often necessary when dealing with Lumistar customer support to know what the exact version of the application is for troubleshooting purposes. Also, it is very often the case that Lumistar personnel will need to see the contents of various error log files such as the one shown in Figure 2-6 on page 20. To view a log file, press the View Log button on the About window and select the Load command from the resulting window. Navigate using the file browser to the C:\Lumistar\LRRS_3X\System\ErLogs directory and select the log file of interest.

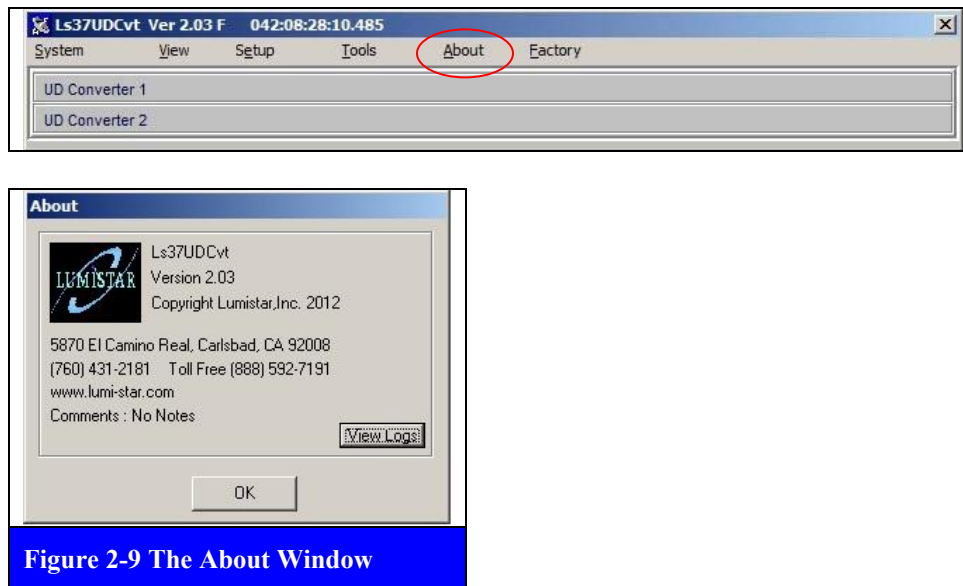


Figure 2-9 The About Window

2.5 The Factory Command

The main Factory command under normal circumstances does not even show up in the menu of commands in the LS-37 application launch banner and the user never sees it. It is only documented here for completeness. Factory mode is used by Lumistar personnel when installing the application and for specific troubleshooting procedures. In very rare circumstances, a user may be directed by customer support to place the application into Factory mode for troubleshooting purposes. The details of this process will not be described here.

