REFERENCE DESIGN

4 x 4 DVI KVM Switch

MAXIM

*Maxim Integrated Products*

1 Table of Contents

2 Features

- 4 x 4 video, audio, and USB switch
- Fully buffered signals for extended reach
- Supports DVI resolutions up to 1920 x 1200 per port
- Simple navigation switch/LCD control
- DVI data-input equalization and adjustable data-output preemphasis
- Schematics and Bill of Materials provided
- Firmware and Gerber files available

3 Overview

High-Frequency Reference Design (HFRD)-34.0 is a fully buffered 4 x 4 DVI KVM switch. The design switches high-resolution DVI video (up to 1920 x 1200 resolution), analog audio, and USB signals from one to four inputs to one to four outputs. HFRD-34.0 supports both video and audio fanout operation (one source to multiple outputs). The reference design also provides 1:2 hubs on each USB port for keyboard and mouse connections of up to four different users.

All signals are fully buffered, allowing extended connection distances. Additionally, equalization is provided on all DVI data input signals and adjustable preemphasis on all DVI data outputs. All control and configuration selections are made through a simple navigational switch and LCD display.

This document provides an overview of the design and operation of HFRD-34.0.
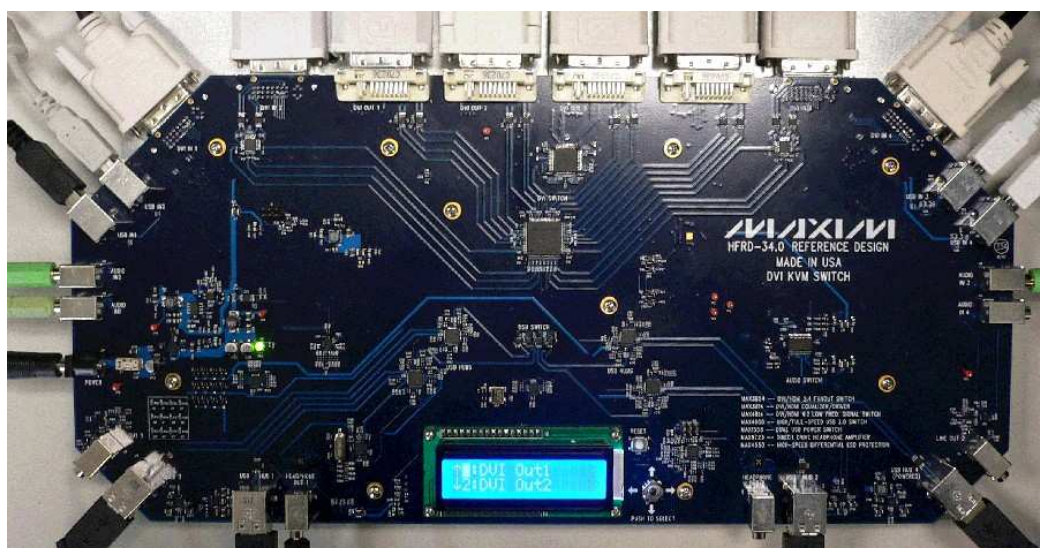
4 Application Diagrams

HFRD-34.0 can be configured in a variety of application environments. Three possible applications are shown in Figures 1 through 3 below.

Figure 1. Typical application.

Figure 2. Typical application.

Figure 3. Typical application.
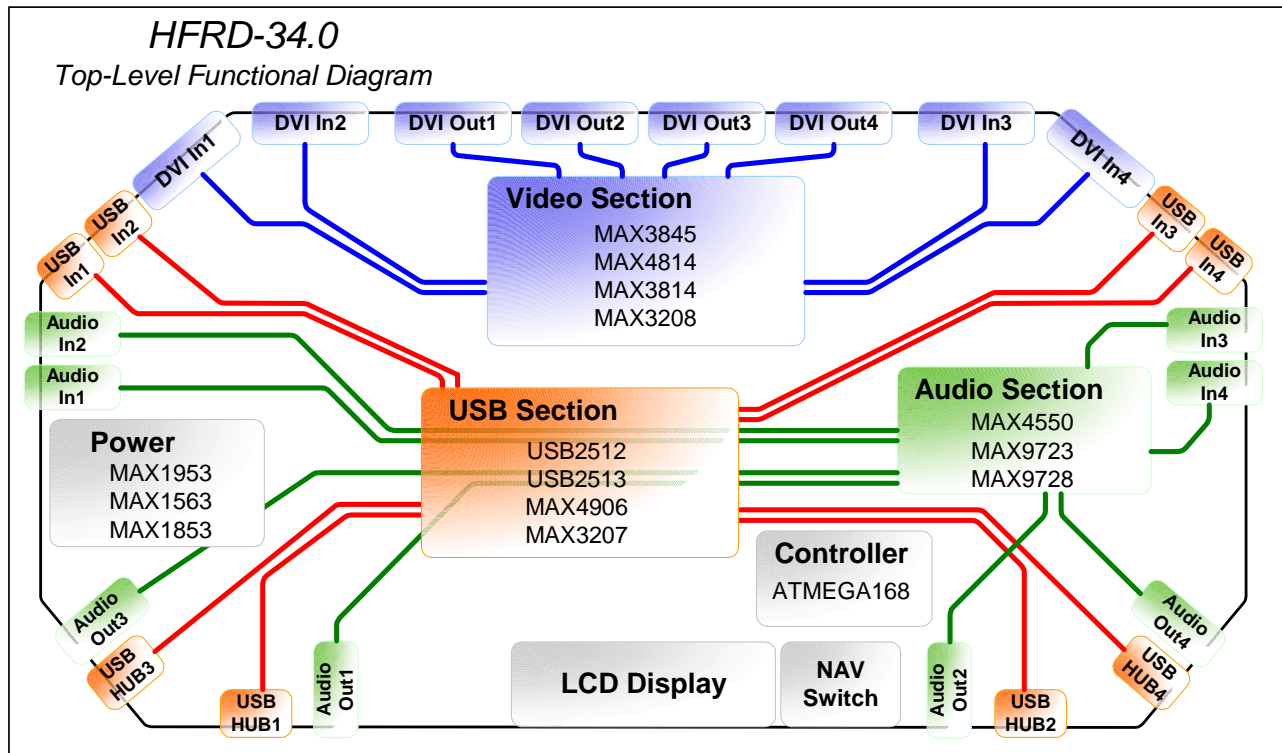
5 Functional Diagrams

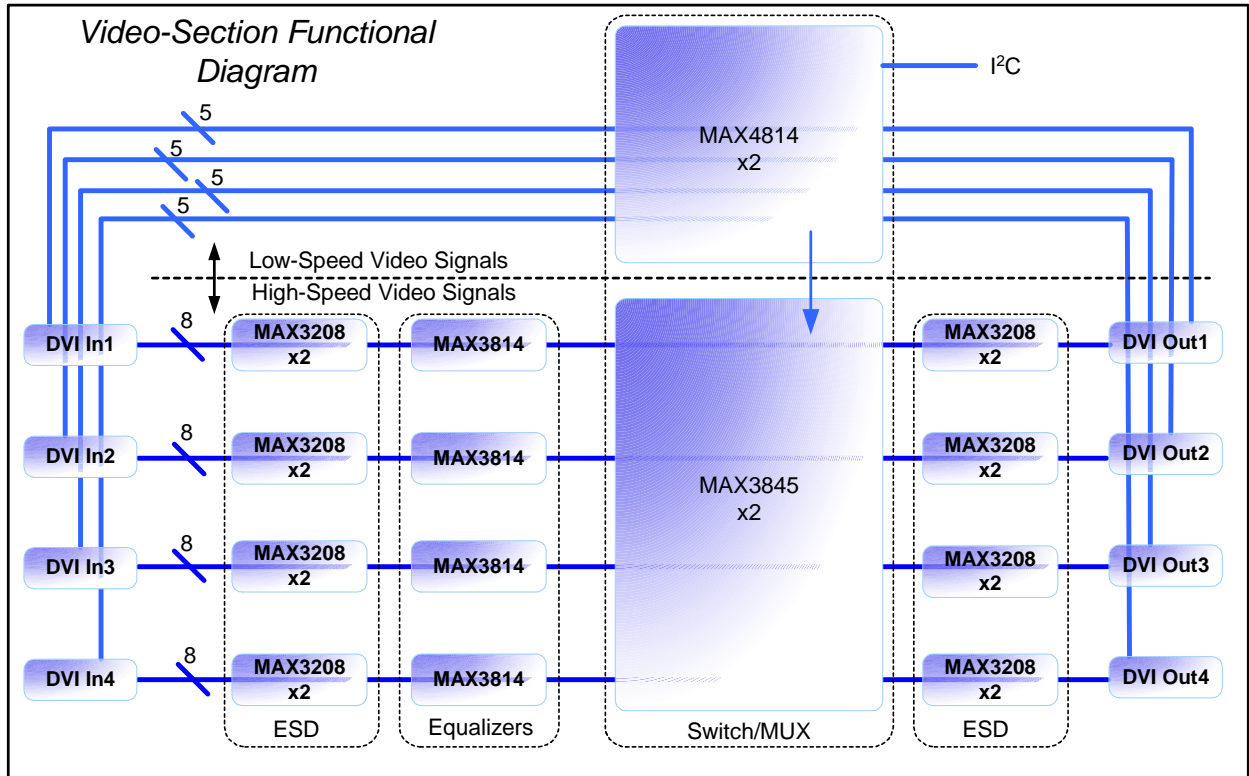Figure 4. HFRD-34.0 Top-level functional diagram.

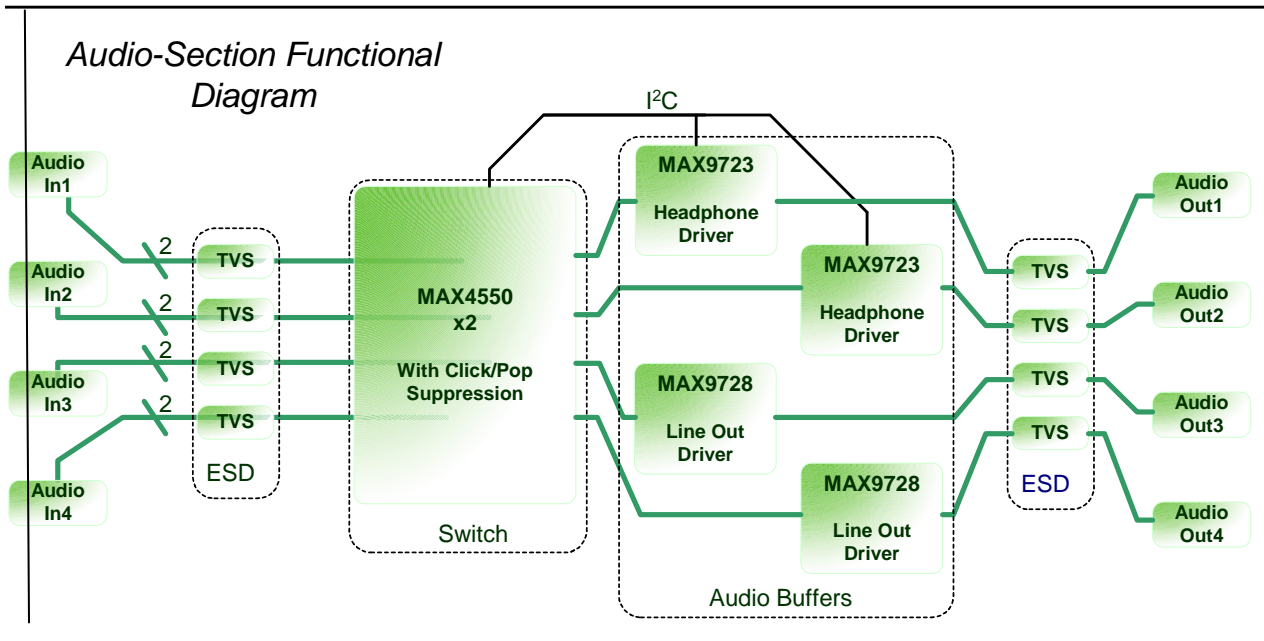*Figure 5. Video-section functional diagram.*
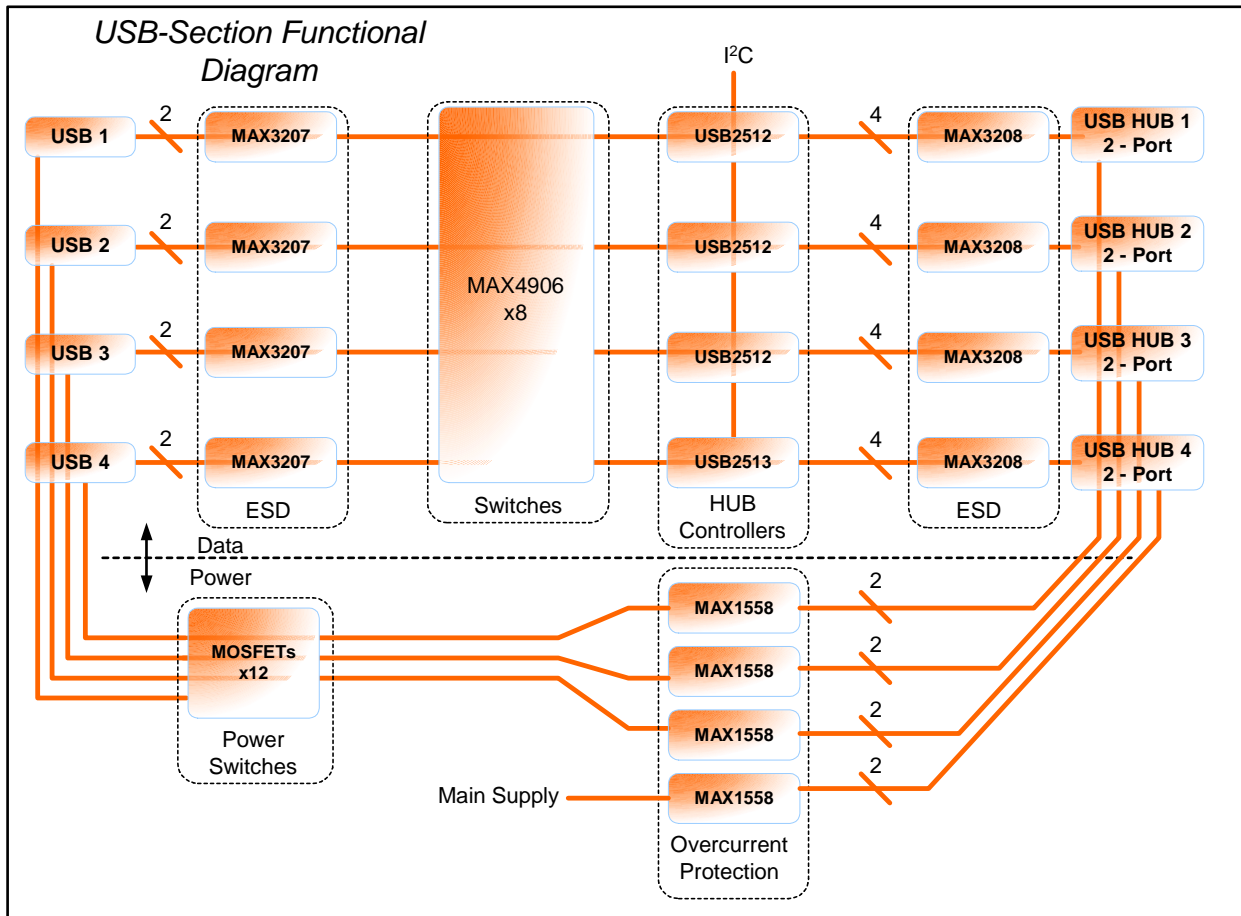

Figure 6. Audio-section functional diagram.

Figure 7. USB-section functional diagram.

6 IC Summary

A summary of the ICs used in this reference design is provided below, along with links to additional information for each device.

HFRD-34.0 demonstrates the operation of a small sample of Maxim's digital and analog switches, digital video equalizers, power-management products, and audio drivers. For additional information about other Maxim products for this and many other applications, please visit: www.maxim-ic.com.

Video Section Components

Part Number	Functional Description
MAX3845	The MAX3845 is a TMDS® 2-to-4 fanout switch and cable driver for multimonitor distribution of DVI or HDMI™ (high-definition multimedia interface) signaling up to 1.65Gbps. Both inputs and outputs are standard TMDS signaling, as per DVI and HDMI standards. Because TMDS links are "point-to-point," buffering is required for fanout applications. Four DVI/HDMI TMDS outputs are provided for fanout distribution. Each TMDS output can be independently sourced from either input or can be turned off. Each TMDS input or output is composed of four differential channels that can be arbitrarily assigned to the three data signals and the 1/10th-rate clock. The data rate depends on resolution, but it can vary from 250Mbps (VGA) to 1.65Gbps (UXGA or 1080p/60). Typical applications include multiroom display of the same video source, and industrial and commercial signage applications such as airport monitors or trading-room floor displays. The MAX3845 includes selectable output preemphasis that extends output cable reach up to an additional 7m. Additional information: www.maxim-ic.com/MAX3845
MAX3814	The MAX3814 TMDS EQ/driver compensates for FR-4 and cable losses to the DVI/HDMI transmit connector, and provides a fully compliant DVI/HDMI TMDS output. The device can also be used in DVI/HDMI cable applications to extend reach and improve jitter margin of cable channels at the receive-side connector. Additional information: www.maxim-ic.com/MAX3814
MAX4814E	The MAX4814E bidirectional 2:4 HDMI switch provides routing for low-frequency signals. The MAX4814E operates from a single +5.0V ±10% supply voltage and is ideal for connecting multiple HDMI sources to multiple loads. Additional information: www.maxim-ic.com/MAX4814
MAX3208	The MAX3208E is a low-capacitance, ±15kV ESD-protection diode array with an integrated transient voltage suppressor (TVS) clamp. The device is suitable for high-speed and general-signal ESD protection. Low input capacitance makes this device ideal for ESD protection of signals in HDTV; PC monitors (DVI, HDMI); PC peripherals (FireWire®, USB 2.0); server interconnect (PCI Express®, Infiniband®); datacom; and interchassis interconnect. Additional information: www.maxim-ic.com/MAX3208

USB Section Components

Part Number	Functional Description
MAX4906F	The MAX4906F analog multiplexer combines the low on-capacitance (C_{ON}) and low on-resistance (R_{ON}) necessary for high-performance switching applications. This device is designed for USB 2.0 Hi-Speed applications at 480Mbps. The MAX4906F also handles all the requirements for USB low- and full-speed signaling. Additional information: www.maxim-ic.com/MAX4906F
USB251x	SMSC's USB251x is a family of versatile, cost-effective, and power-efficient USB 2.0 hub controllers. Leveraging innovative MultiTRAK™ technology that delivers industry-leading data throughput in mixed-speed USB environments, the USB251x family is a USB port-expansion solution for applications that demand low power and small footprint without compromising on performance. Additional information: www.smsc.com
MAX4899AE	The MAX4899AE analog multiplexer combines the low on-capacitance (C_{ON}) and low on-resistance (R_{ON}) necessary for high-performance switching applications. This device is designed for USB 2.0 Hi-Speed applications at 480Mbps. The MAX4899AE also handles all the requirements for USB low- and full-speed signaling. Additional information: www.maxim-ic.com/MAX4899AE
MAX3207	The MAX3207E is a low-capacitance, ±15kV ESD-protection diode array with an integrated TVS clamp. The device is suitable for high-speed and general-signal ESD protection. Low input capacitance makes this device ideal for ESD protection of signals in HDTV; PC monitors (DVI, HDMI); PC peripherals (FireWire, USB 2.0); server interconnect (PCI Express, Infiniband); datacom; and interchassis interconnect. Additional information: www.maxim-ic.com/MAX3207
MAX1558H	The MAX1558H is a dual, current-limited switch with autoreset that latches the switch off if it is shorted for more than 20ms, thus saving system power. The shorted output is then tested to determine when the short is removed so the channel can restart automatically. Each channel delivers up to 1.2A and meets all IEC specifications for USB ports. The MAX1558H safety features ensure that the USB port is protected. Additional information: www.maxim-ic.com/MAX1558H

Audio Section Components

Part Number	Functional Description
MAX4550	The MAX4550 serial-interface, programmable, dual 4x2 audio/video crosspoint switch is ideal for multimedia applications. It contains two identical crosspoint switch arrays, each with four inputs and two outputs. To improve off-isolation, the additional crosspoint inputs, SA and SB, can be used as shunts. The output is selectively programmable for clickless or regular mode operation. A set of internal resistive voltage-dividers supplies DC bias for each output when using AC-coupled inputs. Additionally, four auxiliary outputs control additional circuitry through the MAX4550's 2-wire interface. Additional information: www.maxim-ic.com/MAX4550
MAX9728A	The MAX9728A stereo headphone amplifier is designed for display and notebook applications or portable equipment where board space is at a premium. This device uses a unique, patented DirectDrive™ architecture to produce a ground-referenced output from a single supply, thereby eliminating the need for large DC-blocking capacitors. It saves cost, board space, and component height. The MAX9728A offers an externally adjustable gain and delivers up to 60mW per channel into a 32Ω load with 0.02% THD+N. An 80dB at 1kHz power-supply rejection ratio (PSRR) allows these devices to operate from noisy digital supplies without an additional linear regulator. Comprehensive click-and-pop circuitry suppresses audible clicks and pops at startup and shutdown. Additional information: www.maxim-ic.com/MAX9728A
MAX9723	The MAX9723 stereo DirectDrive™ headphone amplifier with BassMax and volume control is ideal for portable audio applications where space is at a premium and high performance is essential. The MAX9723 operates from a single 1.8V to 3.6V power supply. The device includes features that reduce external component count, system cost, and board space; other features improve audio reproduction. The headphone amplifier uses Maxim's patented DirectDrive architecture that produces a ground-referenced output from a single supply, thereby eliminating the need for large DC-blocking capacitors. The headphone amplifiers deliver 62mW into a 16Ω load, feature low 0.006% THD+N, and high 90dB PSRR. The MAX9723 features Maxim's industry-leading click-and-pop suppression. The BassMax feature boosts the amplifier's bass response, thus improving audio reproduction when inexpensive headphones are used. The integrated volume control features 32 discrete volume levels, eliminating the need for an external potentiometer. BassMax and the volume control are enabled through the I2C/SMBus™-compatible interface. Shutdown is controlled through either the hardware or software interfaces. Additional information: www.maxim-ic.com/MAX9723

Control, Power Management, and Miscellaneous Components

Part Number	Functional Description
ATMEGA48	The ATMega48 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing instructions in a single clock cycle, the ATMega48 achieves throughputs approaching 1 MIPS per MHz, allowing the system designer to optimize power consumption versus processing speed. The ATMega48 features a multiple-input 10-bit ADC, an 8-bit and a 16-bit timer with two PWM outputs each, an internal 8MHz oscillator, a 2-wire compatible interface, and a POR and brown-out circuit. The ATMega48 provides 4k flash, 256B of EEPROM, and 512B of SRAM. Additional information: www.atmel.com
MAX7312	The MAX7312 2-wire-interfaced expander provides 16-bit parallel input/output (I/O) port expansion in SMBus and I2C applications. The MAX7312 consists of input port registers, output port registers, polarity inversion registers, configuration registers, a bus timeout register, and an I2C-compatible serial interface logic, compatible with SMBus. Additional information: www.maxim-ic.com/MAX7312
MAX3397E	The MAX3397E ±15kV ESD-protected, bidirectional level translator provides level shifting for data transfer in a multivoltage system. Externally applied voltages, V_{CC} and V_L, set the logic levels on either side of the device. A logic-low signal present on the V_L side of the device appears as a logic-low signal on the V_{CC} side of the device, and vice versa. The MAX3397E utilizes a transmission and gate-based design to allow data translation in either direction on any single data line. Additional information: www.maxim-ic.com/MAX3397E
MAX6348	The MAX6348 microprocessor (µP) supervisory circuit monitors the power supplies in µP and digital systems. This device provides excellent circuit reliability and low cost by eliminating external components and adjustments when it is used with 2.5, 3, 3.3, and 5V powered circuits. The MAX6348 asserts a reset signal whenever the V_{CC} supply voltage declines below a preset threshold; the device keeps the signal asserted for at least 100ms after V_{CC} has risen above the reset threshold. Additional information: www.maxim-ic.com/MAX6348
MAX1563	The MAX1563 single, current-limited switch provides up to 4A to power up to eight USB ports. It operates from a 4V to 5.5V input supply, and consumes only 40µA of quiescent current when operating and only 3µA in shutdown. Additional information: www.maxim-ic.com/MAX1563

MAX1853	The MAX1853 monolithic, CMOS charge-pump voltage inverter in the ultra-small SC70 package features a low 15Ω output resistance, which permits loads up to 30mA with maximum efficiency. The MAX1853 is available with an operating frequency of 200kHz, allowing optimization of supply current or external component size. Small external components and micropower shutdown mode make this device ideal for both battery-powered and board-level voltage conversion applications. Additional information: www.maxim-ic.com/MAX1853
MAX6817	The MAX6817 dual switch debouncer provides clean interfacing of mechanical switches to digital systems. The device accepts one or more bouncing inputs from a mechanical switch and produces a clean digital output after a short, preset qualification delay. Both the switch opening and closing bounces are removed. Robust switch inputs handle ±25V levels and are ±15kV ESD protected for use in harsh industrial environments. The MAX6817 features single-supply operation from +2.7V to +5.5V. Undervoltage lockout circuitry ensures that the output is in the correct state upon power-up. The MAX6817 is offered in a SOT package and requires no external components. Additional information: www.maxim-ic.com/MAX6817
MAX1953	The MAX1953/MAX1954/MAX1957 is a family of versatile, economical, synchronous current-mode, pulse-width modulation (PWM) buck controllers. These step-down controllers are targeted for applications where cost and size are critical. The MAX1953 operates at a fixed 1MHz switching frequency, thus significantly reducing external component size and cost. Additionally, excellent transient response is obtained using less output capacitance. The MAX1953 operates from low 3V to 5.5V input voltage and can supply up to 10A of output current. Selectable current limit is provided to tailor to the external MOSFETs' on-resistance for optimal cost and performance. The output voltage is adjustable from 0.8V to 0.86VIN. Additional information: www.maxim-ic.com/MAX1953
MAX4070	The MAX4069–MAX4072 low-cost, bidirectional, high-side, current-sense amplifiers are ideal for monitoring battery charge and discharge currents in notebook PCs, cell phones, and other portable equipment. The devices feature up to 24V input common-mode voltage range, low 100µA supply current (which drops to only 10µA in shutdown), and a total output error of less than 1.5%. The wide 1.35V to 24V input common-mode range is independent of the supply voltage, thus ensuring that the current-sense feedback remains accurate even when connected to a battery pack in deep discharge. Additional information: www.maxim-ic.com/MAX4070

MAX3420	The MAX3420E contains the digital logic and analog circuitry necessary to implement a full-speed USB peripheral compliant to USB specification rev 2.0. A built-in full-speed transceiver features ±15kV ESD protection and programmable USB connect and disconnect. An internal serial-interface engine (SIE) handles low-level USB protocol details such as error checking and bus retries. The MAX3420E operates using a register set accessed by an SPI™ interface that operates up to 26MHz. Any SPI master (microprocessor, ASIC, DSP, etc.) can add USB functionality by using the simple 3- or 4-wire SPI interface. Additional information: www.maxim-ic.com/MAX3420
MAX4788	The MAX4785–MAX4788 family of switches feature internal current limiting to prevent host devices from being damaged due to faulty load conditions. These analog switches have a low 0.7Ω on-resistance and operate from a 2.3V to 5.5V input voltage range. They are available with guaranteed 50mA and 100mA current limits, making them ideal for load-switching applications. Additional information: www.maxim-ic.com/MAX4788

7 Navigation Menu

HFRD-34.0 is controlled through an easy-to-use navigation switch (up, down, left, right, and push to select) and LCD display. Through this menu-based interface, the user can set, save, and load configurations and control a variety of other features available in the reference design. The table below details the menu options available.

Table 1. Navigation Menu Details

Menu*	Index	LCD Label	Action Taken by Pushing "Select" on Menu Item
MM	1	Configuration	Configuration Menu (CM) is opened
MM	2	Video Switch	Video Switch Menu (VSM) is opened
MM	3	Audio Switch	Audio Switch Menu (ASM) is opened
MM	4	USB Switch	USB Switch Menu (USM) is opened
MM	5	Audio Control	Audio Control Menu (ACM) is opened
MM	6	Advanced Ctrl	Advanced Control Menu (ADVM) is opened
CM	1	Load Config	Opens a menu to allow the user to load one of four saved configurations.
CM	2	Save Config	Opens menu to allow the user to save the current configuration to one of four memory locations. Saved configurations are retained during power cycles.

CM	3	**Default**	Sets the default configuration for the reference design (Audio/Video/USB In1 to Audio/Video/USB Out1; Audio/Video/USB In2 to Audio/Video/USB Out2, etc.)
CM	4	**Demo Mode**	Puts the reference design into a demonstration mode. When in this mode, the controller will loop through the default and saved configurations at a preset time interval. This operation allows for automatic switching of the DVI and audio signals. **Please note**: The USB configuration is not switched in demo mode (only DVI and Audio).
CM	5	**Main Menu**	Return to Main Menu
VSM	1	**DVI Out1**	Allows the user to switch DVI output 1 to any DVI input (1 through 4). The current switch selection is highlighted.
VSM	2	**DVI Out2**	Allows the user to switch DVI output 2 to any DVI input (1 through 4). The current switch selection is highlighted.
VSM	3	**DVI Out3**	Allows the user to switch DVI output 3 to any DVI input (1through 4). The current switch selection is highlighted.
VSM	4	**DVI Out4**	Allows the user to switch DVI output 4 to any DVI input (1through 4). The current switch selection is highlighted.
VSM	5	**Main Menu**	Return to Main Menu
ASM	1	**HeadphoneOut1**	Allows the user to switch headphone output 1 to any audio input (1 through 4). The current switch selection is highlighted.
ASM	2	**HeadphoneOut1**	Allows the user to switch headphone output 2 to any audio input (1 through 4). The current switch selection is highlighted.
ASM	3	**Line Out1**	Allows the user to switch line output 1 to any audio input (1 through 4). The current switch selection is highlighted.
ASM	4	**Line Out2**	Allows the user to switch line output 2 to any audio input (1 through 4). The current switch selection is highlighted.
ASM	5	**Main Menu**	Return to Main Menu
USM	1	**USB HUB1 Out**	Allows the user to switch USB hub 1 to any USB input (1 through 4). The current switch selection is highlighted. **Note**: Fanout is not supported in the USB switch.
USM	2	**USB HUB2 Out**	Allows the user to switch USB hub 2 to any USB input (1 through 4). The current switch selection is highlighted. **Note**: Fanout is not supported in the USB switch.
USM	3	**USB HUB3 Out**	Allows the user to switch USB hub 3 to any USB input (1 through 4). The current switch selection is highlighted. **Note**: Fanout is not supported in the USB switch.
USM	4	**USB HUB4 Out**	Allows the user to switch USB hub 4 to any USB input (1through 4). The current switch selection is highlighted. **Note**: Fanout is not supported in the USB switch.
USM	5	**Main Menu**	Return to Main Menu
ACM	1	**HP1 Volume**	Allows the user to adjust headphone 1 output volume (1 through 7).

			The current volume selection is highlighted.
ACM	**2**	**HP2 Volume**	Allows the user to adjust headphone 2 output volume (1through 7). The current volume selection is highlighted.
ACM	**3**	**Main Menu**	Return to Main Menu
ADVM	**1**	**DVI1 Pre-Emph**	Allows the user to adjust DVI Out 1 preemphasis level between 0dB, 3dB, and 6dB. The preemphasis can be increased to improve signal integrity when using long cables between HFRD-34.0 and the monitor.
ADVM	**2**	**DVI2 Pre-Emph**	Allows the user to adjust DVI Out 2 preemphasis level between 0dB, 3dB, and 6dB. The preemphasis can be increased to improve signal integrity when using long cables between HFRD-34.0 and the monitor.
ADVM	**3**	**DVI3 Pre-Emph**	Allows the user to adjust DVI Out 3 preemphasis level between 0dB, 3dB, and 6dB. The preemphasis can be increased to improve signal integrity when using long cables between HFRD-34.0 and the monitor.
ADVM	**4**	**DVI4 Pre-Emph**	Allows the user to adjust DVI Out 4 preemphasis level between 0dB, 3dB, and 6dB. The preemphasis can be increased to improve signal integrity when using long cables between HFRD-34.0 and the monitor.
ADVM	**5**	**Main Menu**	Return to Main Menu

*Abbreviations: MM: Main Menu; CM: Configuration Menu; VSM: Video Switch Menu; ASM: Audio Switch Menu; USM: USB Switch Menu; ACM: Audio Control Menu; ADVM: Advanced Control Menu.

8 Schematics, Component List, and Layout Drawings

The full schematics, component list, and PCB layout drawings are available to download in PDF format at:

http://www.maxim-ic.com/tools/other/appnotes/4232/4232_software.zip.

See sections 10 and 11 for additional details regarding the use of the schematics and layout drawings for new designs.

9 Gerber Files and Firmware

The Gerber files and firmware assist design engineers in developing their projects, and are available to Maxim customers upon request. See sections 10 and 11 for additional details regarding the use of Gerber files and firmware. To receive the Gerber or firmware files, please send an email to StrategicApps@maxim-ic.com with HFRD-34.0 in the subject line. Include the following information:

1. Your name
2. Company name
3. Company website
4. Brief description of your project

10 Design Notes

Please review the following design notes:

1. Line Out1 and Line Out2 are designed to drive an audio line impedance ($> 1k\Omega$) with typical line-out voltage levels. These two audio outputs can be optimized to drive headphone loads by changing external component values. See the MAX9728 data sheet for additional information.

2. The USB hub controllers (U26, U27, U36, and U39) have configurations and settings that can be adjusted through a 2-wire bus controlled by the μC. Currently these features and configurations are set through the μC firmware.

3. The USB HUB reset connection for the four HUBs (pin 26 of USB2512 and USB2513 devices) are tied together on the current version of the reference design. Splitting these connections to have individual control will improve the overall USB switching operation.

4. If desired, U47 (MAX3420) is provided to facilitate control of the switch through a USB interface. Currently these features are not preprogrammed into the reference design.

5. USB HUB 4 is a self-powered HUB (power is drawn from the HFRD-34.0 supply). USB HUBs 1-3 are powered from the host. All USB HUBs include overcurrent shutdown protection.

6. It is recommended that you increase the supply filtering (i.e., add series inductance and bulk capacitance) of the host USB power supplies (for HUBs 1-3) in order to reduce crosstalk from the USB power-supply noise to the audio outputs.

7. The power MOSFET transistors (Q2-Q13) used for switching the USB host power are flipped over due to a layout error in the pin order. When copying this section of the design, the transistor footprint should be corrected.

8. The ATMEL μC (U49, ATMEGA168) can be in-circuit reprogrammed to perform custom features. Use the AVRISP-MKII programmer and the connections provided through J15.

9. A $10k\Omega$ pull-up resistor should be added to pin 9 of the MAX3420 (U47) in any design revisions.

10. Connecting pins 14 and 16 together on each DVI input will increase the

compatibility of the reference design with a wider variety of DVI video cards.

2. 0.5oz copper foil before platting.
3. For USB signal-transmission lines: **10mil W, 8mil S -> 90Ω Differential**
4. For DVI signal-transmission lines: **8mil W, 8mil S -> 100Ω Differential**

11 Evaluation/Use Notes

This reference design aids designers and is not intended to replace the entire design process. The designer should evaluate the reference design and modify it, as necessary, to meet the specification for a particular project. The designer should also carefully consider safety and EMI issues related to the specific application.

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

12 Layer Profile

The HFRD-34.0 DVI KVM switch includes controlled-impedance transmission lines. The layer profile is based on the following assumptions:

1. Dielectric material is FR-4 with a dielectric constant of ~ 4.2.

Table 2. HFRD-34.0 Layer Profile

Layer	Dielectric Thickness (inches)	Copper Clad	Layer Desc.
1		0.5	SIGNAL
	0.0081		
2		0.5	PLANE
	0.005		
3		0.5	SIGNAL
	0.0036		
4		0.5	SIGNAL
	0.005		
5		0.5	PLANE
	0.0088		
6		0.5	SIGNAL
	0.005		
7		0.5	PLANE
	0.0036		
8		0.5	SIGNAL
	0.005		
9		0.5	PLANE
	0.0081		
10		0.5	SIGNAL

1312   Board Dimensions

Figure 8. HFRD-34.0 Board dimensions (not to scale).

DVI is a trademark of Digital Display Working Group (DDWG).
FireWire is a registered trademark of Apple Computer, Inc.
HDMI is a trademark of HDMI Licensing, LLC.
InfiniBand is a registered trademark of InfiniBand Trade Association.
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TMDS is a registered trademark of Silicon Image, Inc.

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