

LMH0036

SD SDI Reclocker with 4:1 Input Multiplexer

General Description

The LMH0036 SD SDI Reclocker with 4:1 Input Multiplexer retimes serial digital video data conforming to the SMPTE 259M (C) standard. The LMH0036 operates at the serial data rate of 270 Mbps, and also supports DVB-ASI operation at 270 Mbps. The LMH0036 includes an integrated 4:1 input multiplexer for selecting one of four input data streams for re-timing.

The LMH0036 retimes the incoming data to suppress accumulated jitter. The LMH0036 recovers the serial data-rate clock and optionally provides it as an output. The LMH0036 has two differential serial data outputs; the second output may be selected as a low-jitter, data-rate clock output. Controls and indicators are: serial clock or second serial data output select, manual rate select input, SD indicator output, lock detect output, auto/manual data bypass, and output mute. The serial data inputs, outputs, and serial data-rate clock outputs are differential LVPECL compatible. The CML serial data and serial data-rate clock outputs are suitable for driving 100 Ω differentially terminated networks. The control logic inputs and outputs are LVCMOS compatible.

The LMH0036 is powered from a single 3.3V supply. Power dissipation is typically 360 mW. The device is housed in a 48-pin LLP package.

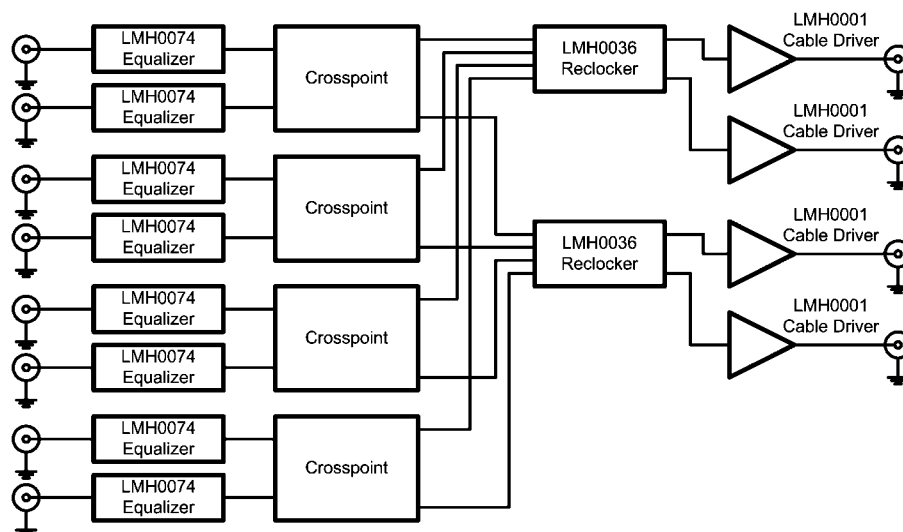
Features

- Supports SMPTE 259M (C) serial digital video standard
- Supports 270 Mbps serial data rate operation
- Supports DVB-ASI at 270 Mbps
- Single 3.3V supply operation
- 360 mW typical power consumption
- Integrated 4:1 multiplexed input
- Two differential, reclocked outputs
- Choice of second reclocked output or low-jitter, differential, data-rate clock output
- Single 27 MHz external crystal or reference clock input
- Lock Detect indicator output
- Output mute function for data and clock
- Auto/Manual reclocker bypass
- Differential LVPECL compatible serial data inputs and outputs
- LVCMOS control inputs and indicator outputs
- 48-Pin LLP package
- Industrial temperature range: -40°C to +85°C
- Footprint compatible with the LMH0056 and LMH0356

Applications

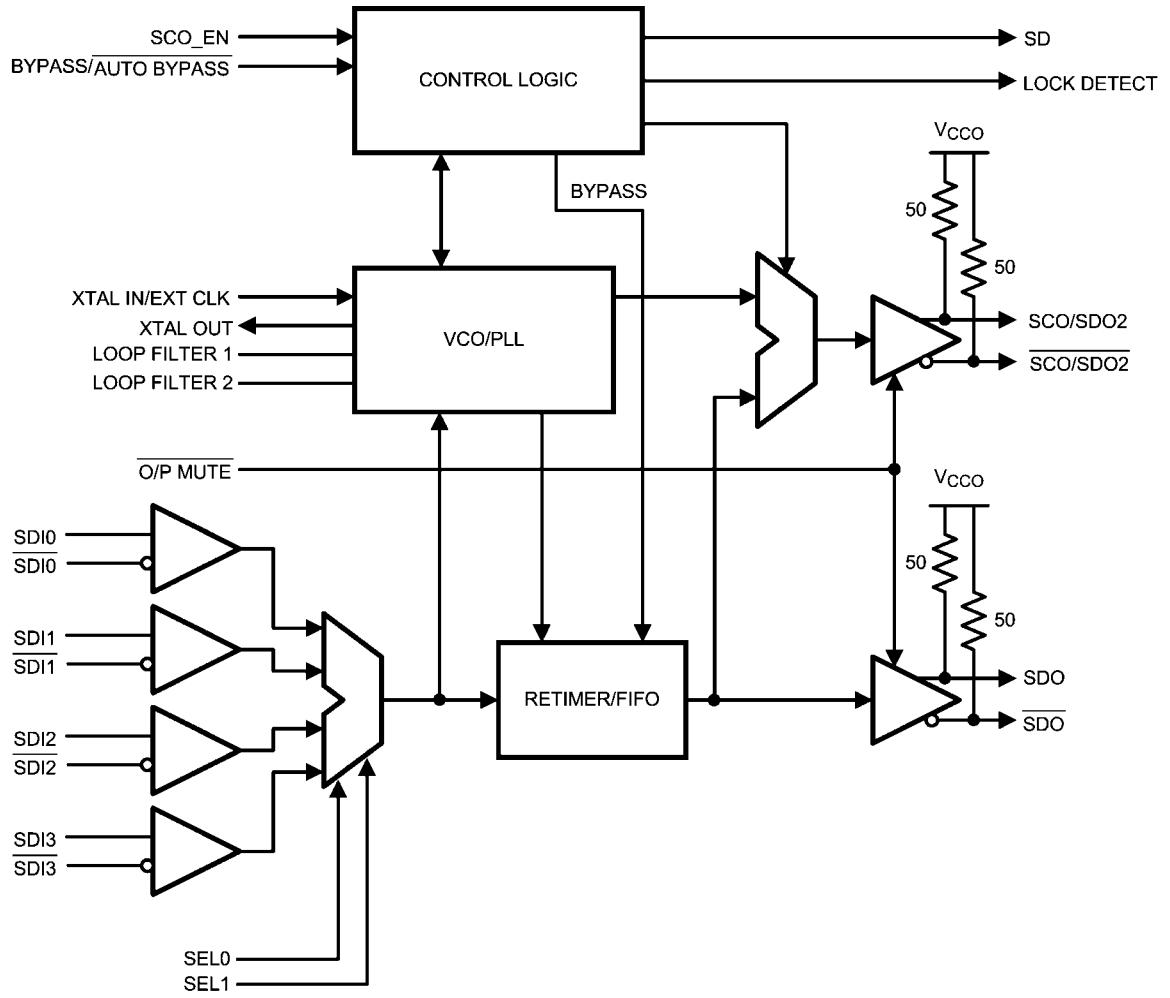
- SDTV serial digital video interfaces for:
 - Digital video routers and switchers
 - Digital video processing and editing equipment
 - DVB-ASI equipment
 - Video standards and format converters

Typical Application



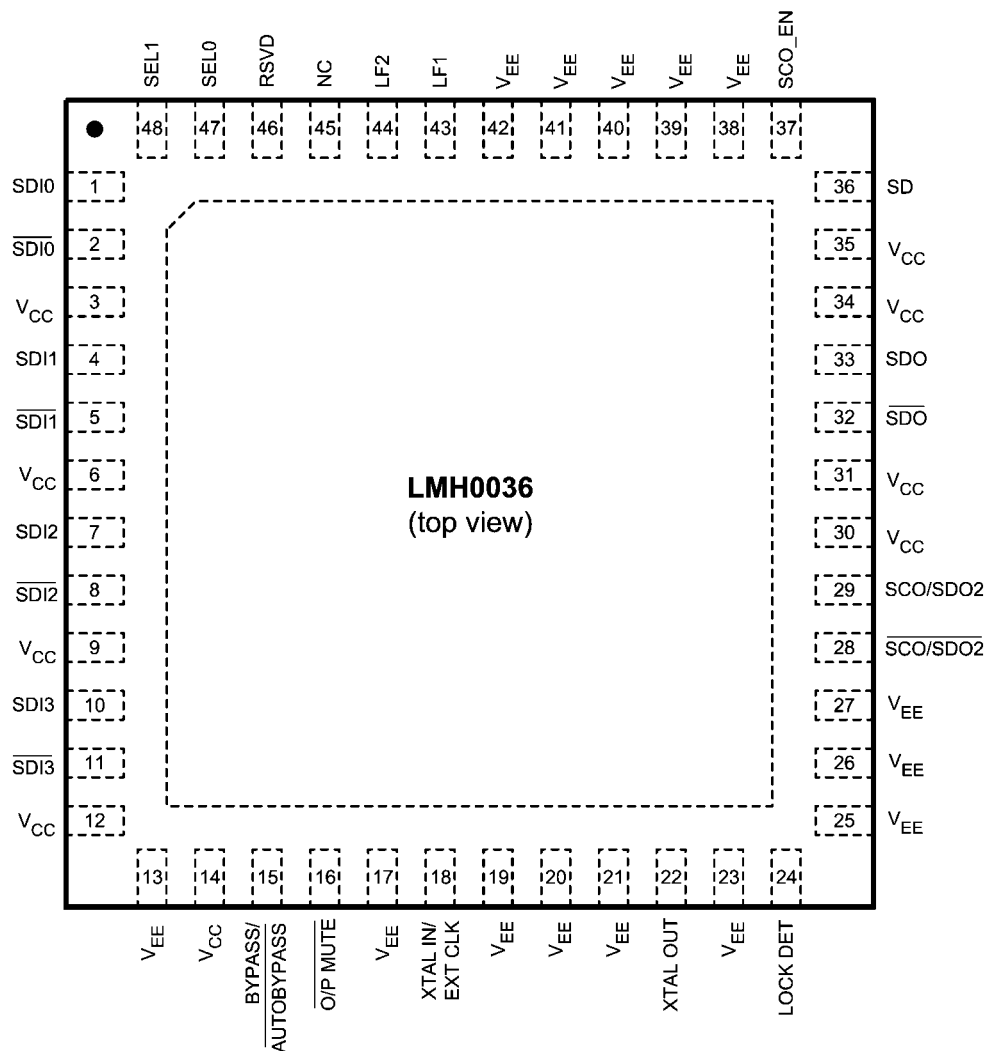
30003101

Block Diagram



30003103

Connection Diagram



30003102

The exposed die attach pad is the primary negative electrical terminal for this device. It must be connected to the negative power supply voltage.

48-Pin LLP
Order Number LMH0036SQ
See NS Package Number SQA48A

Pin Descriptions

Pin	Name	Description
1	SDI0	Data Input 0 True.
2	$\overline{\text{SDI0}}$	Data Input 0 Complement.
4	SDI1	Data Input 1 True.
5	$\overline{\text{SDI1}}$	Data Input 1 Complement.
7	SDI2	Data Input 2 True.
8	$\overline{\text{SDI2}}$	Data Input 2 Complement.
10	SDI3	Data Input 3 True.
11	$\overline{\text{SDI3}}$	Data Input 3 Complement.
15	BYPASS/AUTO BYPASS	Bypass/Auto Bypass mode select. Bypasses reclocking when high. This pin has an internal pulldown.
16	OUTPUT MUTE	Data and Clock Output Mute input. Mutes the output when low. This pin has an internal pullup.
18	XTAL IN/EXT CLK	Crystal or External Oscillator input.
22	XTAL OUT	Crystal Oscillator output.
24	LOCK DETECT	PLL Lock Detect output (active high).
28	$\overline{\text{SCO/SDO2}}$	Serial Clock or Serial Data Output 2 complement.
29	SCO/SDO2	Serial Clock or Serial Data Output 2 true.
32	$\overline{\text{SDO}}$	Data Output complement.
33	SDO	Data Output true.
36	SD	SD indicator output. Output is high when locked to 270 Mbps.
37	SCO_EN	Serial Clock or Serial Data 2 Output select. Sets second output to output the clock when high and the data when low. This pin has an internal pulldown.
43	LF1	Loop Filter.
44	LF2	Loop Filter.
45	NC	No Connect. Not bonded internally.
46	RSVD	Reserved. Do not connect or connect to ground.
47	SEL0	Data Input select input. This pin has an internal pulldown.
48	SEL1	Data Input select input. This pin has an internal pulldown.
3, 6, 12, 14, 30, 31, 34, 35	V_{CC}	Positive power supply input.
DAP, 13, 17, 19, 20, 21, 23, 25, 26, 27, 38, 39, 40, 41, 42	V_{EE}	Negative power supply input.

Absolute Maximum Ratings (Note 1)

It is anticipated that this device will not be offered in a military qualified version. If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage ($V_{CC}-V_{EE}$)	4.0V
Logic Supply Voltage (V_i)	$V_{EE}-0.15V$ to $V_{CC}+0.15V$

Logic Input Current (single input):

$$V_i = V_{EE}-0.15V \quad -5 \text{ mA}$$

$$V_i = V_{CC}+0.15V \quad +5 \text{ mA}$$

Logic Output Voltage (V_o)	$V_{EE}-0.15V$ to $V_{CC}+0.15V$
--------------------------------	----------------------------------

Logic Output Source/Sink Current $\pm 8 \text{ mA}$

Serial Data Input Voltage (V_{SDI}) V_{CC} to $V_{CC}-2.0V$

Serial Data Output Sink Current (I_{SDO}) 24 mA

Package Thermal Resistance

θ_{JA} 48-pin LLP	26.1°C/W
θ_{JC} 48-pin LLP	1.9°C/W
Storage Temp. Range	-65°C to +150°C
Junction Temperature	+150°C
Lead Temperature (Soldering 4 Sec)	+260°C (Pb-free)
ESD Rating (HBM)	8 kV
ESD Rating (MM)	400V
ESD Rating (CDM)	1250V

Recommended Operating Conditions

Supply Voltage ($V_{CC}-V_{EE}$)	3.3V $\pm 5\%$
Logic Input Voltage	V_{EE} to V_{CC}
Differential Serial Input Voltage	800 mV $\pm 10\%$
Serial Data or Clock Output Sink Current (I_{SO})	16 mA max.
Operating Free Air Temperature (T_A)	-40°C to +85°C

DC Electrical Characteristics

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified. (Notes 2, 3)

Symbol	Parameter	Conditions	Reference	Min	Typ	Max	Units
V_{IH}	Input Voltage High Level		Logic level inputs	2		V_{CC}	V
V_{IL}	Input Voltage Low Level			V_{EE}		0.8	V
I_{IH}	Input Current High Level	$V_{IH} = V_{CC}$			47	65	μA
I_{IL}	Input Current Low Level	$V_{IL} = V_{EE}$			-18	-25	μA
V_{OH}	Output Voltage High Level	$I_{OH} = -2 \text{ mA}$	All logic level outputs	2			V
V_{OL}	Output Voltage Low Level	$I_{OL} = +2 \text{ mA}$				$V_{EE} + 0.6$	V
V_{SDID}	Serial Input Voltage, Differential		SDI	200		1600	mV _{P-P}
V_{CMI}	Input Common Mode Voltage	$V_{SDID} = 200 \text{ mV}$	SDI	$V_{EE}+1.2$		$V_{CC}-0.2$	V
V_{SDOD}	Serial Output Voltage, Differential	100 Ω differential load	SDO, SCO	720	800	880	mV _{P-P}
V_{CMO}	Output Common Mode Voltage	100 Ω differential load	SDO, SCO		$V_{CC}-V_{SDOD}$		V
I_{CC}	Power Supply Current, 3.3V supply, Total	270 Mbps, NTSC color bar pattern			109		mA

AC Electrical Characteristics

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified. (Note 3)

Symbol	Parameter	Conditions	Reference	Min	Typ	Max	Units
BR _{SD}	Serial Data Rate	SMPTE 259M (C)	SDI, SDO		270		Mbps
TOL _{JIT}	Serial Input Jitter Tolerance	270 Mbps, (Notes 7, 8, 9)	SDI	>6			UI _{P-P}
TOL _{JIT}	Serial Input Jitter Tolerance	270 Mbps, (Notes 7, 8, 10)	SDI	>0.6			UI _{P-P}
t _{JIT}	Serial Data Output Jitter	270 Mbps, (Notes 8, 11)	SDO		0.02	0.08	UI _{P-P}
BW _{LOOP}	Loop Bandwidth	270 Mbps, <0.1dB Peaking			300		kHz
F _{CO}	Serial Clock Output Frequency	270 Mbps data rate	SCO		270		MHz
t _{JIT}	Serial Clock Output Jitter				2	3	ps _{RMS}
	Serial Clock Output Alignment with respect to Data Interval		SDO, SCO	40		60	%
	Serial Clock Output Duty Cycle		SCO	45		55	%
T _{ACQ}	Acquisition Time	(Notes 4, 6)				15	ms
t _r , t _f	Input rise/fall time	10%–90%	Logic inputs		1.5	3	ns
t _r , t _f	Input rise/fall time	20%–80%	SDI			1500	ps
t _r , t _f	Output rise/fall time	10%–90%	Logic outputs		1.5	3	ns
t _r , t _f	Output rise/fall time	20%–80%, (Note 5)	SCO, SDO		90	130	ps
F _{REF}	Reference Clock Frequency				27		MHz
F _{TOL}	Ref. Clock Freq. Tolerance				±50		ppm

Note 1: “Absolute Maximum Ratings” are those parameter values beyond which the life and operation of the device cannot be guaranteed. The stating herein of these maximums shall not be construed to imply that the device can or should be operated at or beyond these values. The table of “Electrical Characteristics” specifies acceptable device operating conditions.

Note 2: Current flow into device pins is defined as positive. Current flow out of device pins is defined as negative. All voltages are referenced to V_{EE} (equal to zero volts).

Note 3: Typical values are stated for: V_{CC} = +3.3V, T_A = +25°C.

Note 4: Specification is guaranteed by design.

Note 5: R_L = 100Ω differential.

Note 6: Measured from first SDI transition until Lock Detect (LD) output goes high (true).

Note 7: Peak-to-peak amplitude with sinusoidal modulation per SMPTE RP 184-1996 paragraph 4.1. The test data signal shall be color bars.

Note 8: This parameter is guaranteed by characterization over voltage and temperature limits.

Note 9: Refer to “A1” in Figure 1 of SMPTE RP 184-1996.

Note 10: Refer to “A2” in Figure 1 of SMPTE RP 184-1996.

Note 11: Serial Data Output Jitter is total output jitter with 0.2UI_{P-P} input jitter.

Device Description

The LMH0036 SD SDI Reclocker with 4:1 Input Multiplexer is used in many types of digital video signal processing equipment. The LMH0036 supports the SMPTE 259M (C) standard, with a corresponding serial data rate of 270 Mbps. DVB-ASI data at 270 Mbps may also be retimed. The LMH0036 retimes the serial data stream to suppress accumulated jitter. It provides two low-jitter, differential, serial data outputs. The second output may be selected to output either serial data or a low-jitter serial data-rate clock. Controls and indicators are: serial data-rate clock or second serial data output select, manual rate select input, SD indicator output, lock detect output, auto/manual data bypass and output mute.

Serial data inputs are CML and LVPECL compatible. Serial data and data-rate clock outputs are differential CML and produce LVPECL compatible levels. The output buffer design can drive AC or DC-coupled, terminated 100Ω differential loads. The differential output level is 800 mV_{P-P} ±10% into 100Ω AC or DC-coupled differential loads. Logic inputs and outputs are LVCMOS compatible.

The device package is a 48-pin LLP with an exposed die attach pad. The exposed die attach pad is electrically connected to device ground (V_{EE}) and is the primary negative electrical terminal for the device. This terminal must be connected to the negative power supply or circuit ground.

Serial Data Inputs, Serial Data and Clock Outputs

SERIAL DATA INPUT AND OUTPUTS

The differential serial data inputs, SDI0-SDI3, accept 270 Mbps serial digital video data. The serial data inputs are dif-

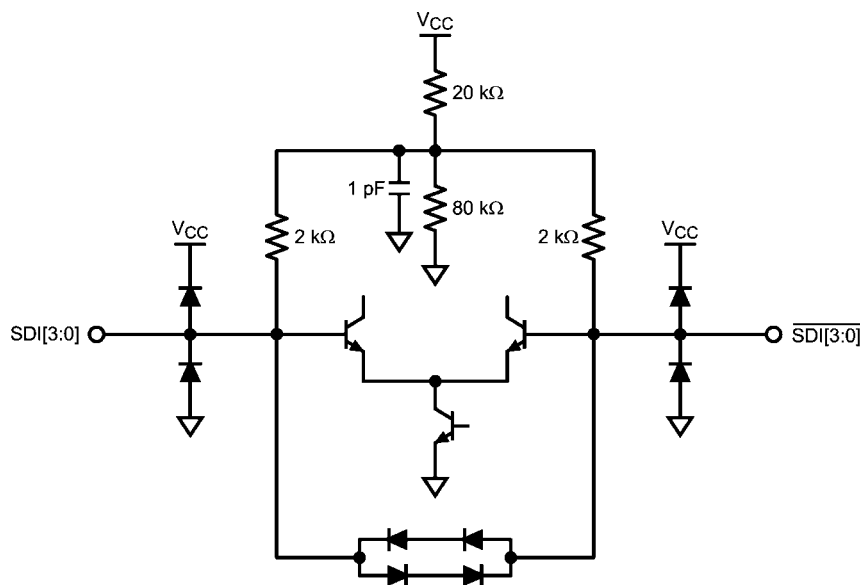
ferential LVPECL compatible. These inputs are intended to be DC interfaced to devices such as the LMH0074 adaptive cable equalizer. These inputs are not internally terminated or biased. The inputs may be AC-coupled if a suitable input bias voltage is provided.

The LMH0036 provides four independent, multiplexed data inputs. The active input channel is selected via the SEL0 and SEL1 pins, as shown in *Table 1*. *Figure 1* shows the equivalent input circuit for SDI[3:0] and $\overline{\text{SDI}}[3:0]$.

The LMH0036 has two, retimed, differential, serial data outputs, SDO and SCO/SDO2. These outputs provide low jitter, differential, retimed data to devices such as the LMH0001 or LMH0002 cable driver. Output SCO/SDO2 is multiplexed and can provide either a second serial data output or a serial data-rate clock output. *Figure 2* shows the equivalent output circuit for SDO, SDO, SCO/SDO2, and SCO/SDO2.

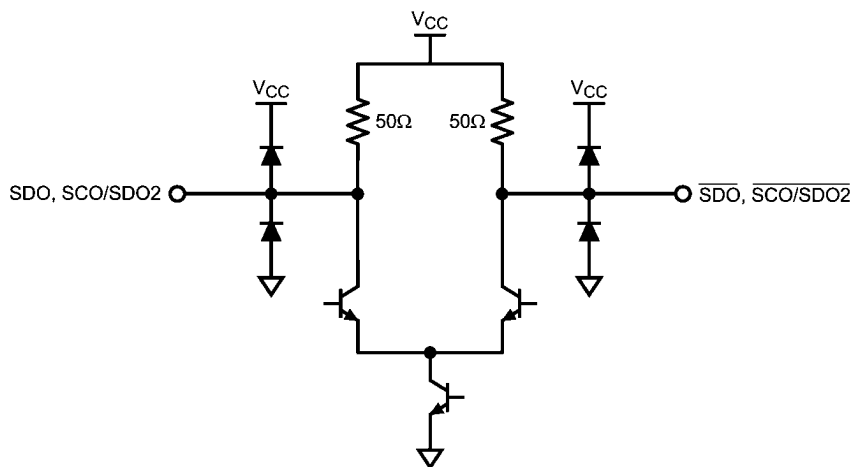
The SCO_EN input controls the operating mode for the SCO/SDO2 output. When the SCO_EN input is high the SCO/SDO2 output provides a serial data-rate clock. When SCO_EN is low, the SCO/SDO2 output provides retimed serial data.

Both differential serial data outputs, SDO and SCO/SDO2, are muted when the OUTPUT MUTE input is a logic low level. SCO/SDO2 also mutes when the Bypass mode is activated when this output is operating as the serial clock output. When muted, SDO and $\overline{\text{SDO}}$ (or SDO2 and $\overline{\text{SDO2}}$) will assume opposite differential output levels. The CML serial data outputs are differential LVPECL compatible. These outputs have internal 50Ω pull-ups and are suitable for driving AC or DC-coupled, 100Ω center-tapped, AC grounded or 100Ω uncenter-tapped, differentially terminated networks.



30003108

FIGURE 1. Equivalent SDI Input Circuit (SDI[3:0], $\overline{\text{SDI}}[3:0]$)



30003109

FIGURE 2. Equivalent SDO Output Circuit (SDO, $\overline{\text{SDO}}$, SCO/SDO2, $\overline{\text{SCO/SDO2}}$)

SERIAL DATA CLOCK/SERIAL DATA 2 OUTPUT

The Serial Data Clock/Serial Data 2 Output is controlled by the SCO_EN input and provides either a second retimed serial data output or a low jitter differential clock output appropriate to the serial data rate being processed. When operating as a serial clock output, the rising edge of the clock will be positioned within the corresponding serial data bit interval within 10% of the center of the data interval.

Differential output SCO/SDO2 functions as the second serial data output when the SCO_EN input is a logic-low level. This output functions as the serial data-rate clock output when the SCO_EN input is a logic-high level. The SCO_EN input has an internal pull-down device and the default state of SCO_EN is low (serial data output 2 enabled). SCO/SDO2 is muted when the OUTPUT MUTE input is a logic low level. When the Bypass mode is activated and this output is functioning as a serial clock output, the output will also be muted. If an unsupported data rate is used while in Auto Bypass mode with this output functioning as a serial clock output, the output is invalid.

Control Inputs and Indicator Outputs

SERIAL DATA INPUT SELECTOR

The Serial Data Input Selector (SEL [1:0]) allows the user to select the active input channel. Table 1 shows the input selected for a given state of SEL [1:0].

TABLE 1. Data Input Select Codes

SEL [1:0] Code	Selected Input
00	SDI0
01	SDI1
10	SDI2
11	SDI3

LOCK DETECT

The Lock Detect (LD) output, when high, indicates that data is being received and the PLL is locked. LD may be connected to the OUTPUT MUTE input to mute the data and clock outputs when no data signal is being received. Note that when the Bypass/Auto Bypass input is set high, Lock Detect will remain low. See Table 2.

OUTPUT MUTE

The OUTPUT MUTE input, when low, mutes the serial data and clock outputs. It may be connected to Lock Detect or externally driven to mute or un-mute the outputs. If OUTPUT MUTE is connected to LD, then the data and clock outputs are muted when the PLL is not locked. This function overrides the Bypass function: see Table 2. OUTPUT MUTE has an internal pull-up device to enable the output by default.

BYPASS/AUTO BYPASS

The Bypass/Auto Bypass input, when high, forces the device to output the data without reclocking it. When this input is low, the device automatically bypasses the reclocking function when the device is in an unlocked condition or the detected data rate is a rate which the device does not support. Note that when the Bypass/Auto Bypass input is set high, Lock Detect will remain low. See Table 2. BYPASS/AUTO BYPASS has an internal pull-down device.

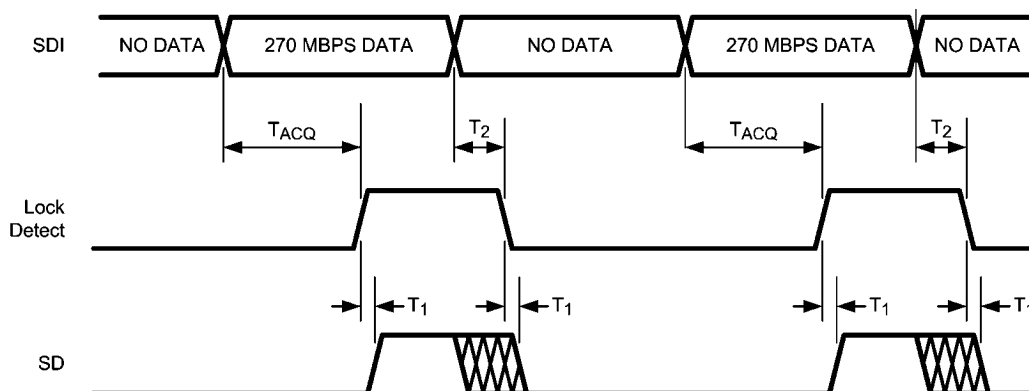
TABLE 2. Control Functionality

LOCK DETECT	OUTPUT MUTE	BYPASS/AUTO BYPASS	DEVICE STATUS
0	1	X	PLL unlocked, reclocker bypassed
1	1	0	PLL locked to supported data rate, reclocker not bypassed
X	0	X	Outputs muted
0	LOCK DETECT	X	Outputs muted
1	LOCK DETECT	0	PLL locked to supported data rate, reclocker not bypassed

SD

The SD output indicates that the LMH0036 is locked and processing SD data rates. It may be used to control another device such as the LMH0002 cable driver. When this output is high it indicates that the data rate is 270 Mbps. The SD output is a registered function and is only valid when the PLL

is locked and the Lock Detect output is high. The SD output is undefined for a short time after lock detect assertion or de-assertion due to a data change on the SDI input. See Figure 3 for a timing diagram showing the relationship between SDI, Lock Detect, and SD.



T_{ACQ} = Acquisition Time, defined in the AC Electrical Characteristics Table

T_1 = Time from Lock Detect assertion or deassertion until SD output is valid, typically 37ns (one 27 MHz clock period)

T_2 = Time from SDI input change until Lock Detect de-assertion, 1 ms maximum. SD output is not valid during this time.

30003105

FIGURE 3. SDI, Lock Detect, and SD Timing

SCO_EN

Input SCO_EN enables the SCO/SDO2 differential output to function either as a serial data-rate clock or second serial data output. SCO/SDO2 functions as a serial data-rate clock when SCO_EN is high. This pin has an internal pull-down device. The default state (low) enables the SCO/SDO2 output as a second serial data output.

CRYSTAL OR EXTERNAL CLOCK REFERENCE

The LMH0036 uses a 27 MHz crystal or external clock signal as a timing reference input. A 27 MHz parallel resonant crystal and load network may be connected to the XTAL IN/EXT CLK and XTAL OUT pins. Alternatively, a 27 MHz LVCMOS compatible clock signal may be input to XTAL IN/EXT CLK. Parameters for a suitable crystal are given in Table 3.

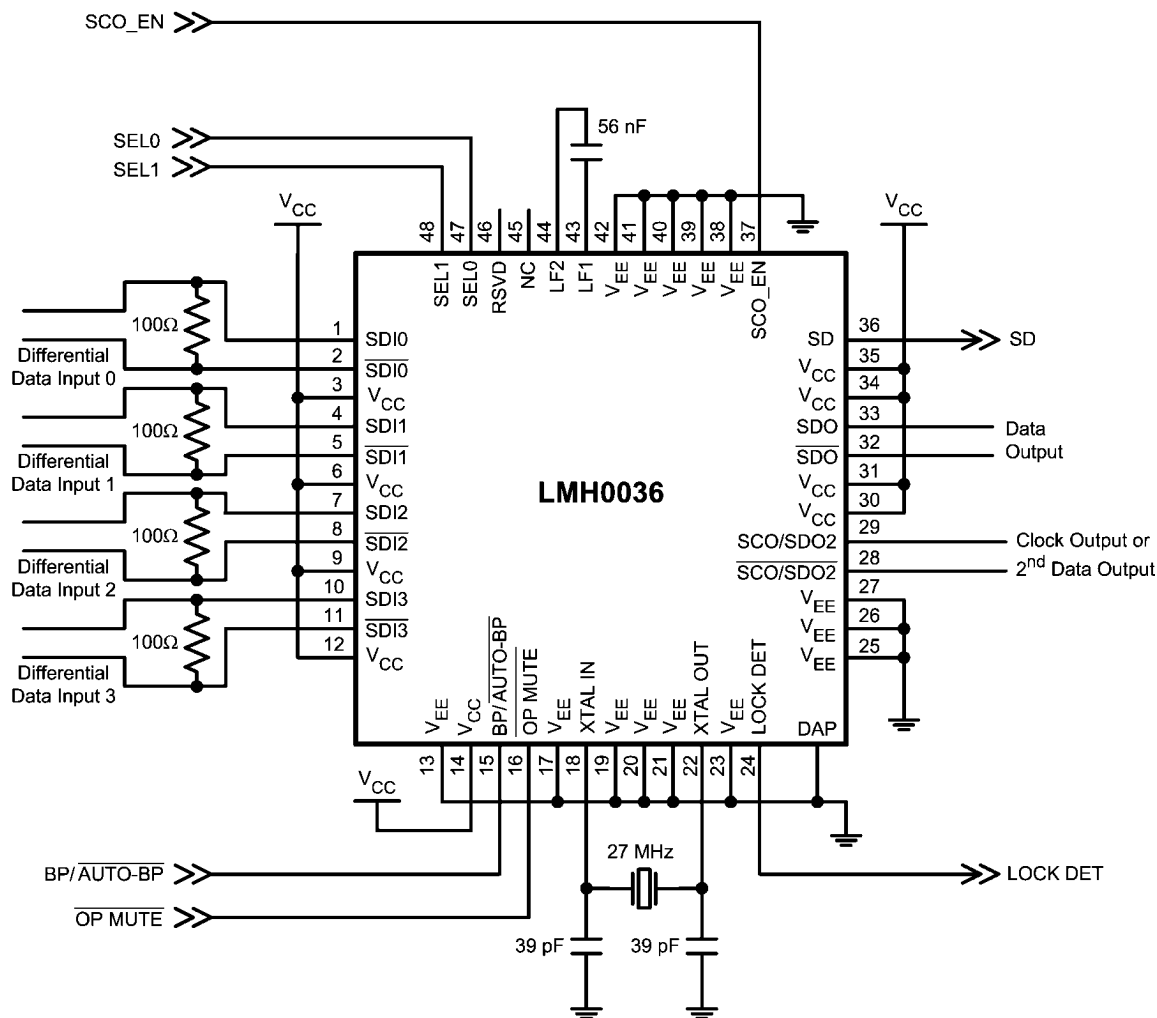
TABLE 3. Crystal Parameters

Parameter	Value
Frequency	27 MHz
Frequency Stability	±100 ppm @ recommended drive level

Parameter	Value
Operating Mode	Fundamental mode, Parallel Resonant
Load Capacitance	20 pF
Shunt Capacitance	7 pF
Series Resistance	40Ω max.
Recommended Drive Level	100 μW
Maximum Drive Level	500 μW
Operating Temperature Range	–10°C to +60°C

Application Information

Figure 4 shows a application circuit for the LMH0036.



30003104

FIGURE 4. Application Circuit

BYPASS/AUTO BYPASS has an internal pulldown to enable Auto Bypass mode by default. This pin may be pulled high to force the LMH0036 to bypass all data.

OUTPUT MUTE has an internal pullup to enable the outputs by default. This pin may be pulled low to mute the outputs.

The XTAL IN/EXT CLK and XTAL OUT pins are shown with a 27 MHz crystal and the proper loading. The crystal should match the parameters described in *Table 3*. Alternately, a 27MHz LVCMOS compatible clock signal may be input to XTAL IN/EXT CLK.

The active high LOCK DETECT output provides an indication that proper data is being received and the PLL is locked.

The SD output may be used to drive the SD/H $\overline{D}$ pin of an SDI cable driver (such as the LMH0002) in order to properly set the cable driver's edge rate for SMPTE compliance. It defaults to low when the LMH0036 is not locked.

SCO_EN has an internal pulldown to set the second output (SCO/SDO2) to output data. This pin may be pulled high to set the second output as a serial clock.

The external loop filter capacitor (between LF1 and LF2) should be 56 nF. This is the only supported value; the loop filter capacitor should not be changed.

SEL0 and SEL1 have internal pulldowns to select the SDI0 input by default.

The inputs are LVPECL compatible. The LMH0036 has a wide input common mode range and in most cases the input should be DC coupled. For DC coupling, the inputs must be kept within the common mode range specified in *DC Electrical Characteristics*.

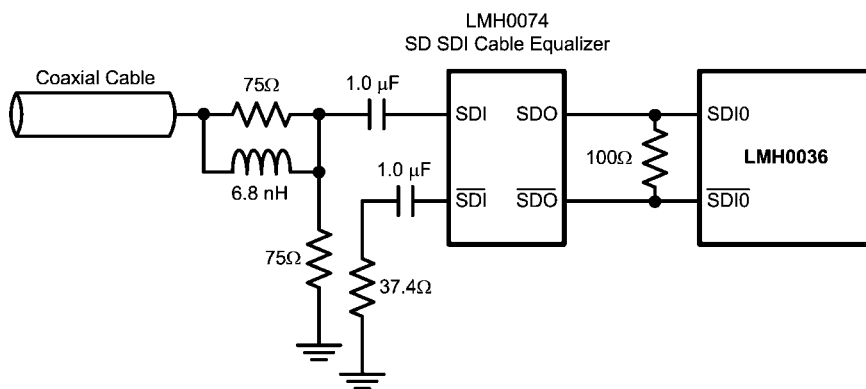
Figure 5 shows an example of a DC coupled interface between the LMH0074 cable equalizer and the LMH0036. The LMH0074 output common mode voltage and voltage swing are within the range of the input common mode voltage and voltage swing of the LMH0036. All that is required is a 100Ω differential termination as shown. The resistor should be placed as close as possible to the LMH0036 input. If desired, this network may be terminated with two 50Ω resistors and a center tap capacitor to ground in place of the single 100Ω resistor.

The outputs are LVPECL compatible. SDO is the primary data output and SCO/SDO2 is a second output that may be set as the serial clock or a second data output. Both outputs are always active. The LMH0036 output should be DC coupled to the input of the receiving device as long as the common mode ranges of both devices are compatible.

Figure 6 shows an example of a DC coupled interface between the LMH0036 and LMH0001 cable driver. All that is required is a 100Ω differential termination as shown. The re-

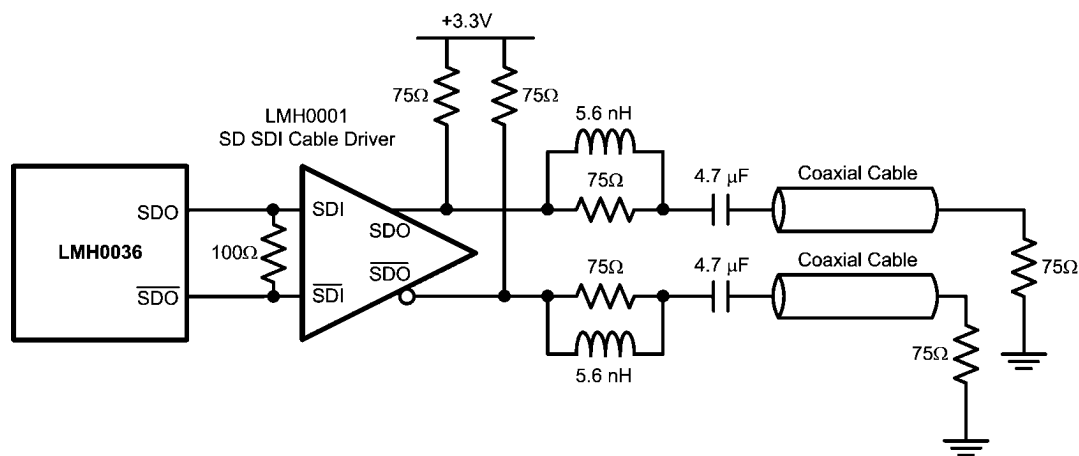
sistor should be placed as close to the LMH0302 input as possible. If desired, this network may be terminated with two 50Ω resistors and a center tap capacitor to ground in place of the single 100Ω resistor.

The LMH0036 has multiple ground connections, however; the primary ground connection is through the large exposed DAP. The DAP must be connected to ground for proper operation of the LMH0036.



30003106

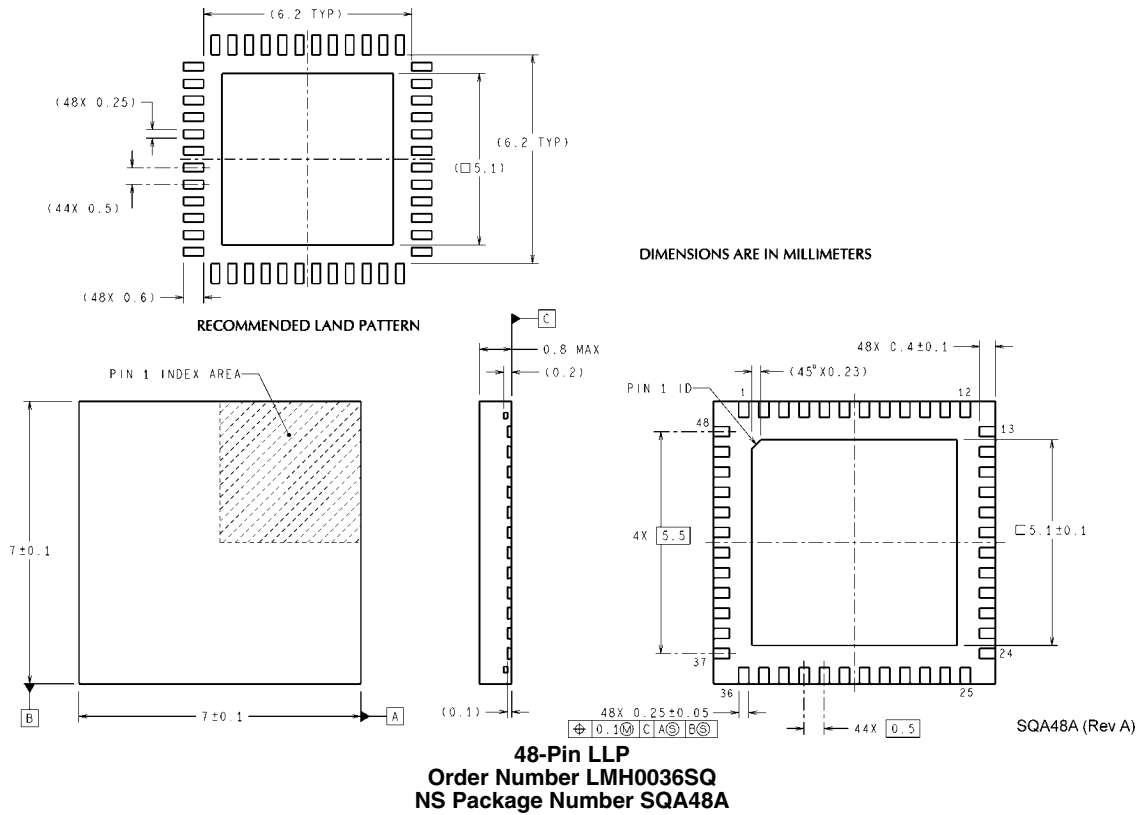
FIGURE 5. DC Input Interface



30003107

FIGURE 6. DC Output Interface

Physical Dimensions inches (millimeters) unless otherwise noted



Notes

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at:

Products		Design Support	
Amplifiers	www.national.com/amplifiers	WEBENCH	www.national.com/webench
Audio	www.national.com/audio	Analog University	www.national.com/AU
Clock Conditioners	www.national.com/timing	App Notes	www.national.com/appnotes
Data Converters	www.national.com/adc	Distributors	www.national.com/contacts
Displays	www.national.com/displays	Green Compliance	www.national.com/quality/green
Ethernet	www.national.com/ethernet	Packaging	www.national.com/packaging
Interface	www.national.com/interface	Quality and Reliability	www.national.com/quality
LVDS	www.national.com/lvds	Reference Designs	www.national.com/refdesigns
Power Management	www.national.com/power	Feedback	www.national.com/feedback
Switching Regulators	www.national.com/switchers		
LDOs	www.national.com/ldo		
LED Lighting	www.national.com/led		
PowerWise	www.national.com/powerwise		
Serial Digital Interface (SDI)	www.national.com/sdi		
Temperature Sensors	www.national.com/tempsensors		
Wireless (PLL/VCO)	www.national.com/wireless		

THE CONTENTS OF THIS DOCUMENT ARE PROVIDED IN CONNECTION WITH NATIONAL SEMICONDUCTOR CORPORATION ("NATIONAL") PRODUCTS. NATIONAL MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS PUBLICATION AND RESERVES THE RIGHT TO MAKE CHANGES TO SPECIFICATIONS AND PRODUCT DESCRIPTIONS AT ANY TIME WITHOUT NOTICE. NO LICENSE, WHETHER EXPRESS, IMPLIED, ARISING BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.

TESTING AND OTHER QUALITY CONTROLS ARE USED TO THE EXTENT NATIONAL DEEMS NECESSARY TO SUPPORT NATIONAL'S PRODUCT WARRANTY. EXCEPT WHERE MANDATED BY GOVERNMENT REQUIREMENTS, TESTING OF ALL PARAMETERS OF EACH PRODUCT IS NOT NECESSARILY PERFORMED. NATIONAL ASSUMES NO LIABILITY FOR APPLICATIONS ASSISTANCE OR BUYER PRODUCT DESIGN. BUYERS ARE RESPONSIBLE FOR THEIR PRODUCTS AND APPLICATIONS USING NATIONAL COMPONENTS. PRIOR TO USING OR DISTRIBUTING ANY PRODUCTS THAT INCLUDE NATIONAL COMPONENTS, BUYERS SHOULD PROVIDE ADEQUATE DESIGN, TESTING AND OPERATING SAFEGUARDS.

EXCEPT AS PROVIDED IN NATIONAL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, NATIONAL ASSUMES NO LIABILITY WHATSOEVER, AND NATIONAL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF NATIONAL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE CHIEF EXECUTIVE OFFICER AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

National Semiconductor and the National Semiconductor logo are registered trademarks of National Semiconductor Corporation. All other brand or product names may be trademarks or registered trademarks of their respective holders.

Copyright© 2008 National Semiconductor Corporation

For the most current product information visit us at www.national.com



**National Semiconductor
Americas Technical
Support Center**
Email: support@nsc.com
Tel: 1-800-272-9959

**National Semiconductor Europe
Technical Support Center**
Email: europe.support@nsc.com
German Tel: +49 (0) 180 5010 771
English Tel: +44 (0) 870 850 4288

**National Semiconductor Asia
Pacific Technical Support Center**
Email: ap.support@nsc.com

**National Semiconductor Japan
Technical Support Center**
Email: jpn.feedback@nsc.com