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19-3216; Rev 0; 1/08

EVALUATION KIT AVAILABLE

Adaptive Equalizer for Video Over Twisted Pair

General Description

The MAX7474 adaptive equalizer recovers losses incurred in the transmission of a composite video (CVBS) signal over unshielded twisted-pair (UTP) cable. The device fully recovers losses for cable lengths of up to 300m and greatly improves signal quality for cable lengths of up to 600m. The device automatically adapts to all cable lengths for CVBS signals with color burst and allows fixed-equalization settings for video signals without burst. The MAX7474 is optimized to provide compensation for losses that occur when transmitting composite video signals over UTP cables such as Category 5e. The device compensates for low frequency and chroma band losses. The MAX7474 is compatible with NTSC and PAL standards.

The MAX7474 accepts differential input and provides a single-ended output. The output is capable of driving two AC- or DC-coupled standard 150Ω video loads. The output back-porch DC level is adjustable with an externally applied DC voltage at the BPLVL input. The device also features loss-of-sync (LOS) and loss-of-burst (LOB) logic outputs.

The MAX7474 is available in a 16-pin SSOP package and is fully specified over the extended (-40°C to +85°C) temperature range.

Applications

Security Video Systems

Video Switching Systems

Home Automation

Features

- **Automatically Equalizes Up to 600m (Fully Recovers Losses Up to 300m) of UTP Cable Carrying CVBS**
- **Automatic Switchover to Fixed Equalization for CVBS Without Color Burst**
- **Integrated Video Driver with Adjustable Back-Porch Clamp Level**
- **LOS and LOB Output**
- **NTSC and PAL Compatible**
- **16-Pin SSOP Package**

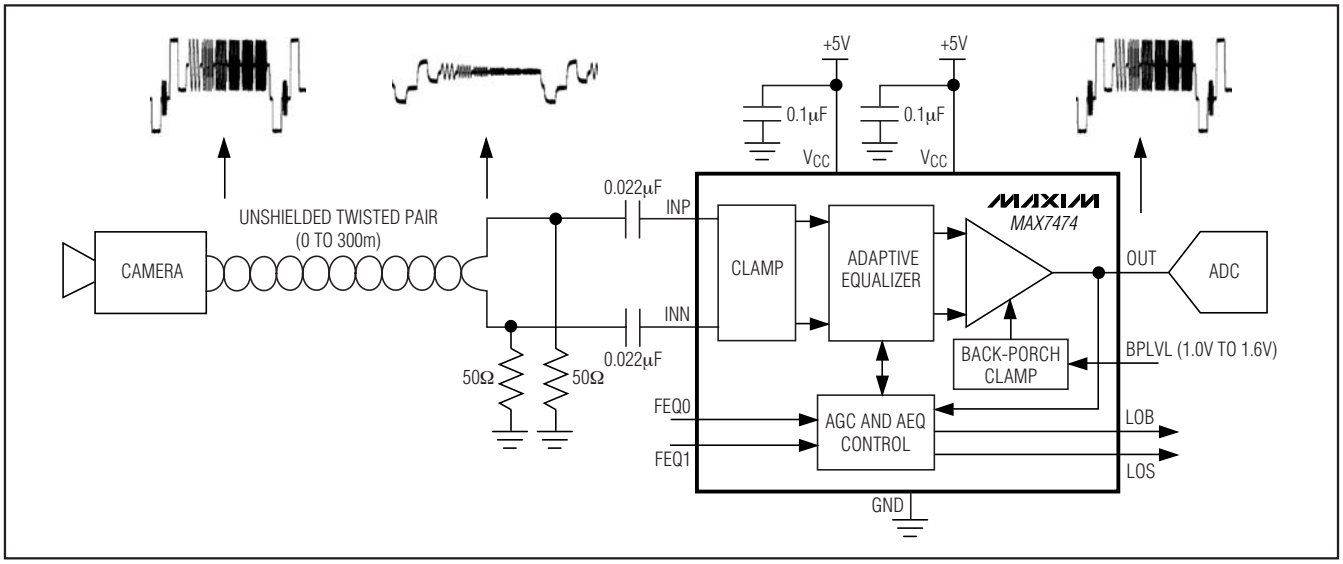
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	PKG CODE
MAX7474EAE+	-40°C to +85°C	16 SSOP (5.3mm x 6.2mm)	A16+2

+Denotes a lead-free package.

Pin Configuration and Typical Application Circuit appear at end of data sheet.

Functional Diagram



Adaptive Equalizer for Video Over Twisted Pair

ABSOLUTE MAXIMUM RATINGS

V_{CC} to GND .....-0.3V to +6V
All Other Pins to GND.....-0.3V to (min of 6V or V_{CC} + 0.3V)
Maximum Continuous Current into Any Input or Output .....±50mA
Continuous Power Dissipation (T_A = +70°C)
16-Pin SSOP (derate 7.1mW/°C above +70°C) 571.4mW
Operating Temperature Range .....-40°C to +85°C
Maximum Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{CC} = +4.75V to +5.25V, R_L = 150Ω (AC-coupled), FEQ1 = GND, FEQ0 = GND, V_{BPLVL} = 1.4V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Differential Input Operating Voltage	$V_{IN-DIFF}$	AC-coupled, measured from sync tip to 100% white level (Note 1)			1.0		V_{P-P}
Maximum Differential Input Operating Voltage		AC-coupled, measured from sync tip to 100% white level		2.4			V_{P-P}
Output Voltage	V_{OUT}	Measured from sync tip to 100% white level			1.0		V_{P-P}
Output Sync Accuracy	V_{SYNC_OUT}	$210mV_{P-P} < V_{SYNC\_IN-DIFF} < 600mV_{P-P}$		263	293	323	mV_{P-P}
Output Burst Accuracy	V_{BURST_OUT}	$76mV_{P-P} < V_{BURST\_IN-DIFF} < 300mV_{P-P}$, f_{SC} = 3.58MHz		242	293	344	mV_{P-P}
Differential Phase	DP				0.3		Degrees
Differential Gain	DG				0.3		%
Clamp Settling Time	t_{CLAMP}	Output blank level settles to < 5 IRE of final value from an initial 100 IRE input error			9	30	H Lines
Back-Porch Level Input Operating Range	V_{BPLVL}			1.0		1.6	V
Output Blank Level Accuracy	ΔV_{OUT-BL}	(Note 2)				±55	mV
Line-Time Distortion	LTD	18µs, 100 IRE bar, DC-coupled output			1.2		%
LOS Threshold	V_{LOS}	Measured differentially between INP and INN (Note 3)			40		mV_{P-P}
LOB Threshold	V_{LOB}	Measured at OUT with maximum equalizer gain (Note 4)			80		mV_{P-P}
Equalizer Response Time	t_{EQ}	Within ±10% of final value of the combined AGC and AEQ gain from minimum to maximum			16,384		H Lines
OUT Leakage Current	I_{LEAK}	LOS mode, OUT is three-stated			±0.01	±10	µA
Fixed Equalizer Gain	A_{FEQ}	f_{SC} = 3.58MHz	FEQ1 = GND, FEQ0 = GND	-1.5	0	+1.5	dB
			FEQ1 = GND, FEQ0 = V_{CC}	2.5	4.5	6.5	
			FEQ1 = V_{CC}, FEQ0 = GND	8.5	10.5	12.5	

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +4.75V to +5.25V, R_L = 150Ω (AC-coupled), FEQ1 = GND, FEQ0 = GND, V_{BPLVL} = 1.4V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DIGITAL INPUTS (FEQ0, FEQ1)							
Input High Voltage	V_{IH}			0.7 x V_{CC}			V
Input Low Voltage	V_{IL}					0.3 x V_{CC}	V
Input Leakage Current		Digital inputs = 0 or V_{CC}			±0.01	±10	µA
Input Capacitance	C_{IN}				15		pF
DIGITAL OUTPUTS (LOS, LOB)							
Output Low Voltage	V_{OL}	I_{SINK} = 500µA				0.4	V
Output High Voltage	V_{OH}	I_{SOURCE} = 500µA		V_{CC} - 0.4			V
POWER SUPPLY							
Supply Voltage Range	V_{CC}			4.75	5.0	5.25	V
Supply Current	I_{CC}	No load	Normal mode		47	59	mA
			LOS mode		24		
DC Power-Supply Rejection Ratio	PSRR	20log($\Delta V_{CC}/\Delta V_{OUT\text{-}BlackLevel}$), black video input with no color burst			65		dB

Note 1: $V_{IN\text{-}DIFF} = V_{INP} - V_{INN}$.

Note 2: $V_{OUT\text{-}BL} = V_{BPLVL} + \Delta V_{OUT\text{-}BL}$.

Note 3: LOS is high when the input video sync amplitude goes below V_{LOS} for 32 consecutive horizontal lines. LOS goes low when the input video sync amplitude exceeds V_{LOS} for 32 consecutive horizontal lines.

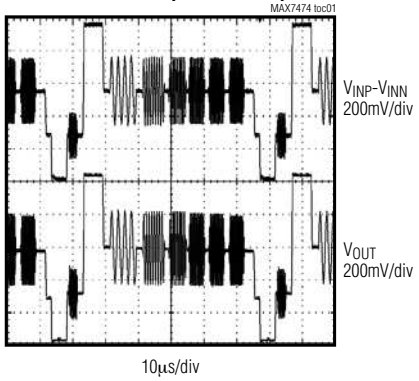
Note 4: LOB is high when the output color burst amplitude goes below V_{LOB} for 32 consecutive horizontal lines when at maximum equalizer gain. LOB goes low when the output color burst amplitude exceeds V_{LOB} for 32 consecutive horizontal lines.

Adaptive Equalizer for Video Over Twisted Pair

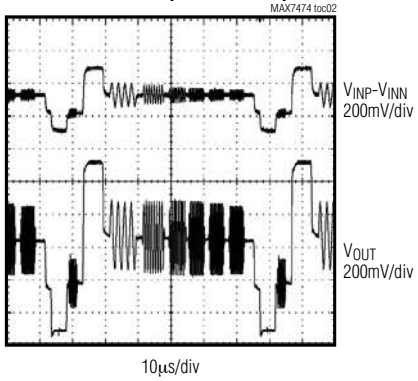
Typical Operating Characteristics

(V_{CC} = 5V, R_L = high impedance, f_{SC} = 3.58MHz, Category 5e cable with active driver, T_A = +25°C.)

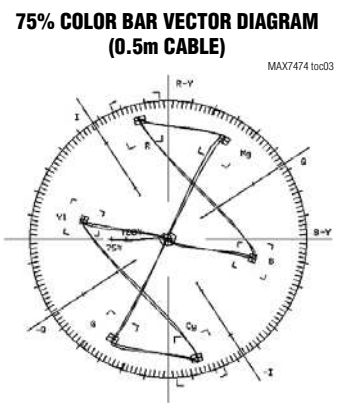
MULTIBURST (0.5m CABLE)



MULTIBURST (300m CABLE)

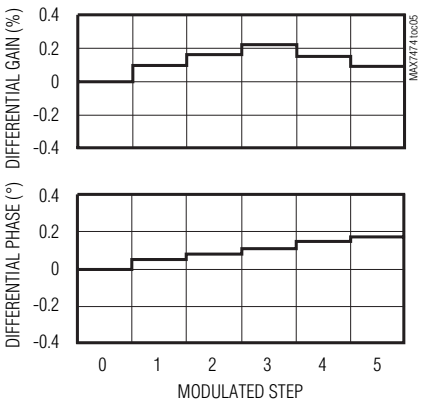


75% COLOR BAR VECTOR DIAGRAM (0.5m CABLE)

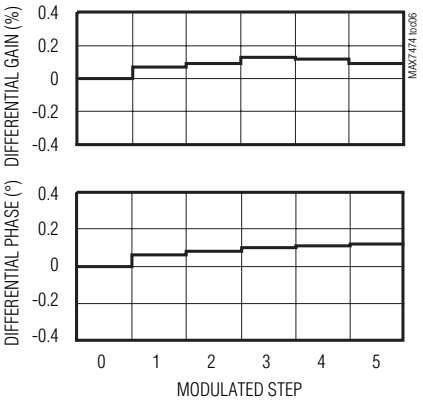


75% COLOR BAR VECTOR DIAGRAM (300m CABLE)

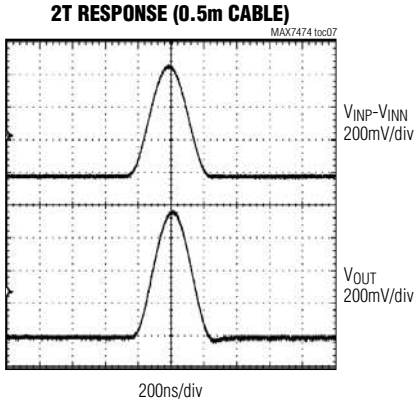
DIFFERENTIAL GAIN AND PHASE (0.5m CABLE)



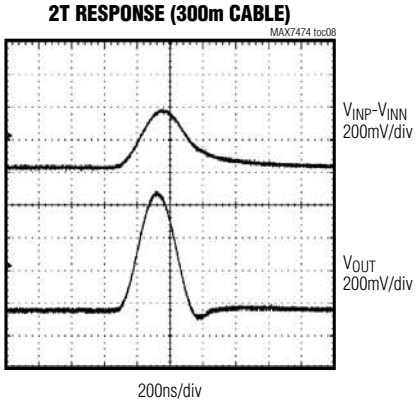
DIFFERENTIAL GAIN AND PHASE (300m CABLE)



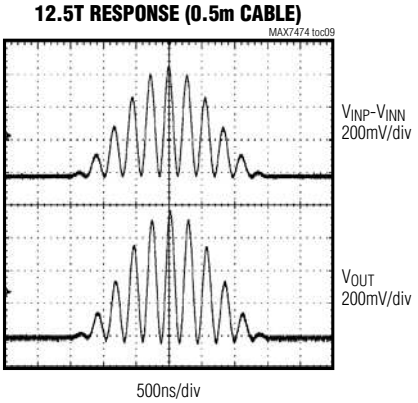
2T RESPONSE (0.5m CABLE)



2T RESPONSE (300m CABLE)



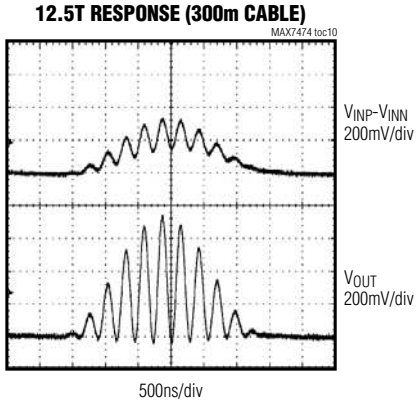
12.5T RESPONSE (0.5m CABLE)



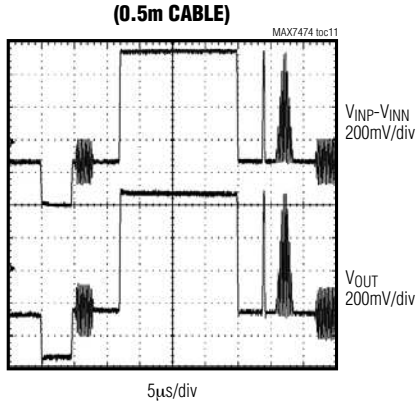
Typical Operating Characteristics (continued)

(V_{CC} = 5V, R_L = high impedance, f_{SC} = 3.58MHz, Category 5e cable with active driver, T_A = +25°C.)

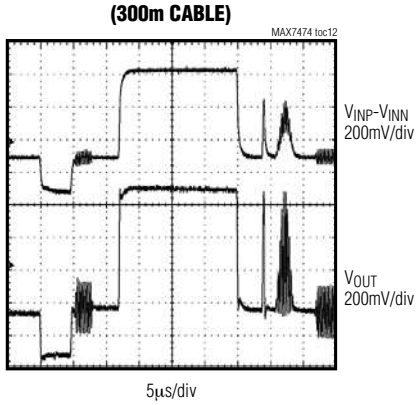
12.5T RESPONSE (300m CABLE)



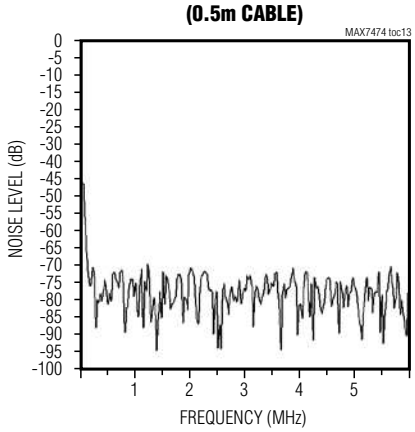
18µs LINE-TIME DISTORTION (0.5m CABLE)



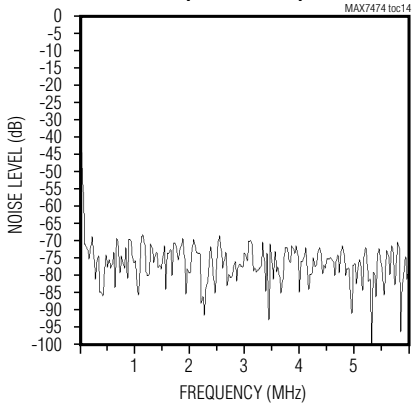
18µs LINE-TIME DISTORTION (300m CABLE)



NOISE SPECTRUM (0.5m CABLE)



NOISE SPECTRUM (300m CABLE)



Adaptive Equalizer for Video Over Twisted Pair

Pin Description

PIN	NAME	FUNCTION
1, 2, 3, 5, 10, 13	GND	Ground. Connect all GND terminals together.
4, 9	V_{CC}	Power-Supply Input. Connect a +4.75V to +5.25V supply to V_{CC}. Connect both V_{CC} inputs together. Bypass each V_{CC} input with a 0.1µF capacitor to GND as close as possible to the device.
6	LOB	Loss-of-Burst Logic Output. LOB goes high when the output color burst goes below the LOB threshold (V_{LOB}) for 32 consecutive horizontal lines when the equalizer is at its maximum gain. LOB goes low when the output color burst exceeds V_{LOB} for 32 consecutive horizontal lines. When LOB is active, the device enters the fixed equalization mode. LOB is valid only when LOS is low.
7	BPLVL	Back-Porch Level Input. The voltage applied to BPLVL sets the output back-porch voltage level.
8	OUT	Composite Video Output
11	FEQ0	Fixed-Cable Equalization inputs. FEQ0 and FEQ1 set the fixed equalization level. See Table 1.
12	FEQ1	
14	INP	Noninverted Video Input. AC-couple video signal with a 0.022µF capacitor.
15	INN	Inverted Video Input. AC-couple video signal with a 0.022µF capacitor.
16	LOS	Loss-of-Sync Logic Output. LOS goes high when the input sync amplitude goes below the loss-of-sync threshold (V_{LOS}) for 32 consecutive horizontal lines. LOS is pulled low when the input sync amplitude exceeds V_{LOS} for 32 consecutive horizontal lines. When LOS is active, the output enters a high-impedance state.

Detailed Description

The MAX7474 compensates for cable losses that occur when transmitting a composite video signal over unshielded twisted-pair cable (see the *Typical Application Circuit*). The device automatically adapts to cable length by monitoring the sync and color-burst amplitudes of the color video signal at the output (OUT) and adjusting the gains accordingly. Video signals without burst are automatically detected and a user-selectable fixed equalization is applied to the signal. The MAX7474 provides full equalization up to 300m of Category 5e cable and greatly improves performance up to 600m.

The MAX7474 accepts differential video input signals in NTSC or PAL standards. The MAX7474 includes an output unity-gain video driver and adjustable back-porch DC level. The device also features LOS and LOB logic outputs.

Video Input

The MAX7474 accepts a differential video input with a maximum $2.4V_{P-P}$ voltage swing. A twisted-pair cable carries the differential video signal to the positive (INP) and negative (INN) inputs, which are AC-coupled with 0.022µF capacitors. Each input is internally clamped to a DC level (see the *Input Clamp* section).

Input Clamp

The MAX7474 clamps the sync tip of the input signal to internally set DC levels effectively correcting, on a line-by-line basis, any shift in the sync-tip level of the input video signal. The sync-tip of the positive video input signal (V_{INP}) is clamped to typically 2.0V and the negative video input signal (V_{INN}) is clamped to typically 3.2V. The input clamp enables capacitive coupling of the input, permitting a large common-mode DC difference between the line driver (camera) and the device.

Adaptive Equalizer

The adaptive equalizer in the MAX7474 provides the appropriate inverse frequency response needed to compensate for UTP cable loss. The equalizer adjusts the low-frequency amplitude and chroma amplitude of the input CVBS signal. The low-frequency component of the CVBS is adjusted according to the feedback information obtained from the internal automatic gain-control (AGC) circuit, which monitors the sync pulse amplitude of the output signal (see the *Automatic Gain Control (AGC)* section). The chroma gain of the video signal is adjusted according to the feedback information obtained from the internal automatic equalization control circuit, which monitors the color-burst amplitude of the output signal (see the *Automatic Equalization Control (AEQ)* section).

The chroma gain for the MAX7474 is automatically adjusted between 0dB and +12dB, while the low-frequency gain is automatically adjusted between -6dB and +3.6dB, providing full equalization for cable losses that can occur when using up to 300m of UTP cable to transmit CVBS signal with color burst.

Automatic Gain Control (AGC)

The automatic gain control circuit corrects low-frequency signal losses such that the output signal obtains a nominal sync level (V_{SYNC_OUT}) of 293mV. Differential input sync pulse amplitude in the 210mV_{P-P} and 600mV_{P-P} range is automatically adjusted to the nominal output sync level (V_{SYNC_OUT}).

If the sync is lost for 32 consecutive horizontal lines, the LOS output goes high and OUT is set to a high-impedance state.

Automatic Equalization Control (AEQ)

The automatic equalization control circuit corrects the chroma signal attenuation such that the output-signal burst amplitude is 293mV (subcarrier frequency, f_{SC} = 3.58MHz or 4.43MHz). Differential input color-burst amplitude in the 76mV_{P-P} and 300mV_{P-P} range is automatically adjusted to the nominal output color-burst level (V_{BURST_OUT}).

The AGC and AEQ equalization take approximately 1s (16,384 lines) to change from the lowest gain to the highest gain. During this time, the chroma amplitude is gradually increased from minimum to maximum.

Fixed Equalization Mode (LOB Is High)

If the color-burst amplitude at the output of the MAX7474 (OUT) is less than 80mV_{P-P} with the equalizer gain set to maximum for 32 consecutive horizontal lines, the loss-of-burst output (LOB) goes high. LOB returns low when color bursts with amplitude greater than 80mV_{P-P} are present at OUT for 32 consecutive horizontal lines.

For applications where the input signal has no color burst, or the input burst amplitude is lower than the LOB threshold voltage (V_{LOB}), the MAX7474 asserts LOB and automatically applies a user-defined fixed equalization set by logic inputs FEQ1 and FEQ0 (see Table 1).

Table 1. Fixed Equalization Level Settings

PART	FEQ1	FEQ0	TYP (dB)	CABLE LENGTH RANGE (m)
MAX7474	GND	GND	0	0 to 75
	GND	V_{CC}	4.5	75 to 225
	V_{CC}	X	10.5	≥ 225

X = V_{CC} or GND.

When using cable lengths greater than 75m, set the fixed equalization level according to Table 1, or higher, to ensure the device comes out of the fixed equalization mode. If the fixed equalization is set to a lower gain setting than specified in Table 1, the amplitude of the color-burst signal at the output may remain smaller than the LOB threshold (V_{LOB}) of 80mV_{P-P}, keeping the device in LOB mode (see the *Automatic Equalization Control (AEQ)* section). If the conditions in Table 1 are not met, set FEQ1 to high to ensure the device always comes out of LOB mode for longer cable lengths.

Output Video Driver

The MAX7474 features a single-ended video output driver with 0dB gain. The typical output voltage swing of the output driver is 1.2V_{P-P}. The output driver is capable of driving two AC-coupled or DC-coupled 150Ω video loads. The output back-porch DC level is set by an internal back-porch clamp circuit (see the *Back-Porch Clamp* section). OUT enters a high-impedance state when sync is lost for 32 consecutive horizontal lines, asserting LOS.

Back-Porch Clamp

The MAX7474 features a back-porch clamp to set the output blanking level. This clamp shifts the DC level of the video signal so that the back-porch level is approximately equal to the voltage level on the BPLVL input. The voltage range allowed at the BPLVL input is 1V to 1.6V.

Applications Information

Differential UTP Input Interface

Applications with differential input interface require proper input voltage levels, termination, and AC-coupling (Figure 1). The maximum differential input voltage swing allowed is 2.4V. Use active drivers to drive the cable as shown in Figure 1. For Category 5e cables, the proper termination resistance is 50Ω to ground at INN and INP inputs. Apply a 0.022µF coupling capacitor at each input.

Output Interface

The video output is capable of driving an AC-coupled or DC-coupled load. Use a 220µF or larger coupling capacitor for AC-coupling. Figure 1 shows applications with AC- and DC-coupled output interface.

Security Systems Application

Security systems typically consist of many cameras that are viewed and recorded on a relatively smaller number

Adaptive Equalizer for Video Over Twisted Pair

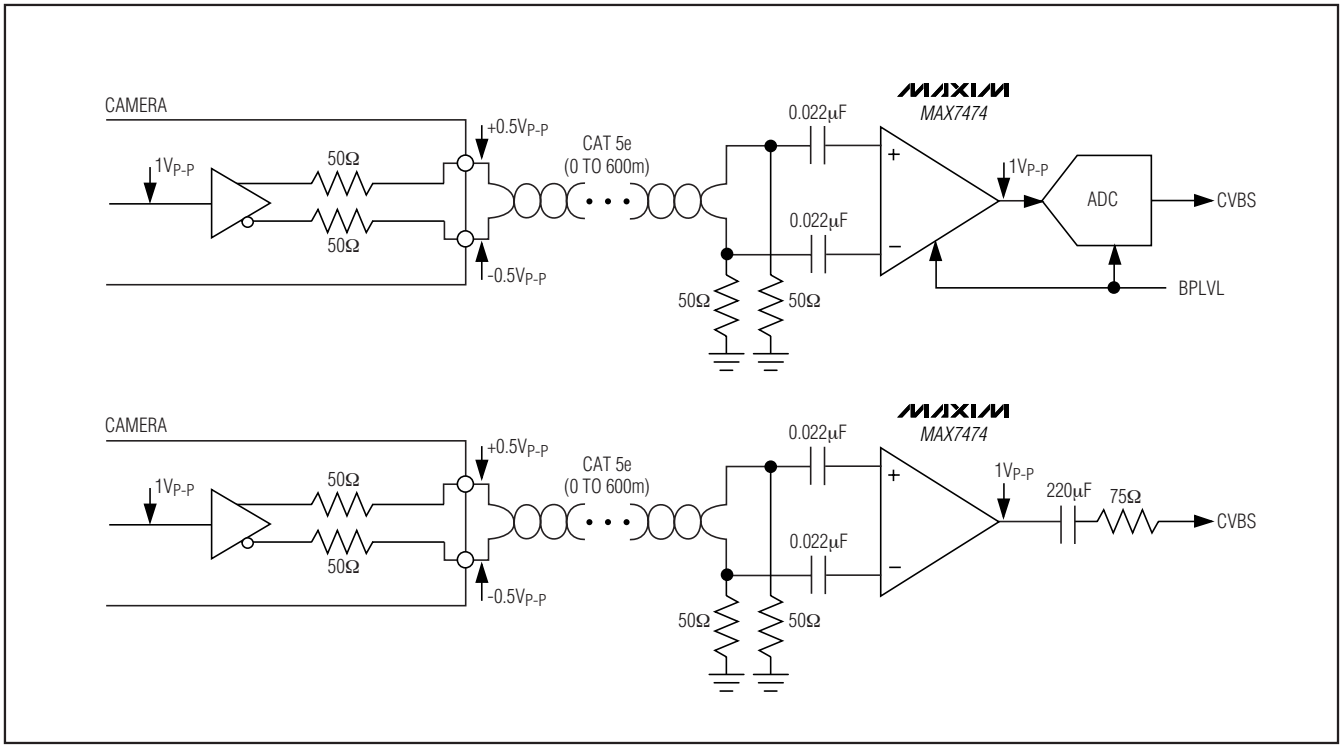


Figure 1. Typical Input and Output Connections

of monitors or recording devices. Cabling is a significant part of a CCTV installation cost. Low-cost unshielded twisted-pair (UTP) cable has increasingly replaced coaxial cable in security systems. Most cameras and switchers use single-channel coax connectors, and therefore require some type of single-ended-to-differential video conversion such as active drivers. Active cable compensation is required for longer cable lengths. Active compensation can occur on the receive side, camera side, or both. The MAX7474 provides active compensation on the receive side that is superior to balun, or active fixed cable equalization.

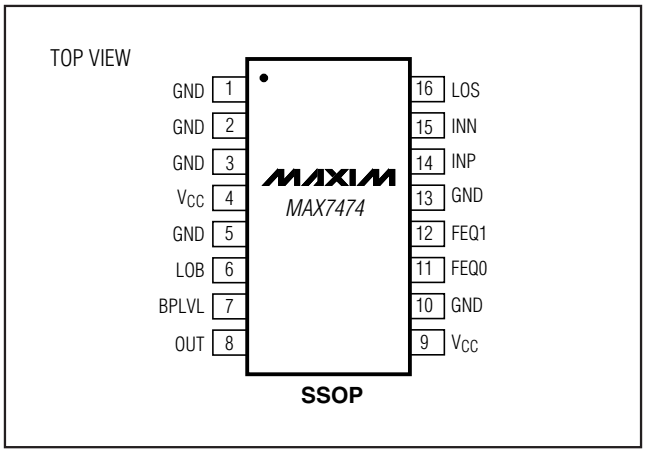
Power Supply, Grounding, and Layout

The MAX7474 operates from a +4.75V to +5.25V single supply. Connect both V_{CC} inputs together and bypass each one with a 0.1µF capacitor to GND. Connect the 0.1µF capacitors as close as possible to the device to minimize the loop formed when the bypass capacitor is connected to the device, thus avoiding additional inductance that could resonate with the capacitor. For optimum performance, use a ground plane and keep the input and output traces away from each other.

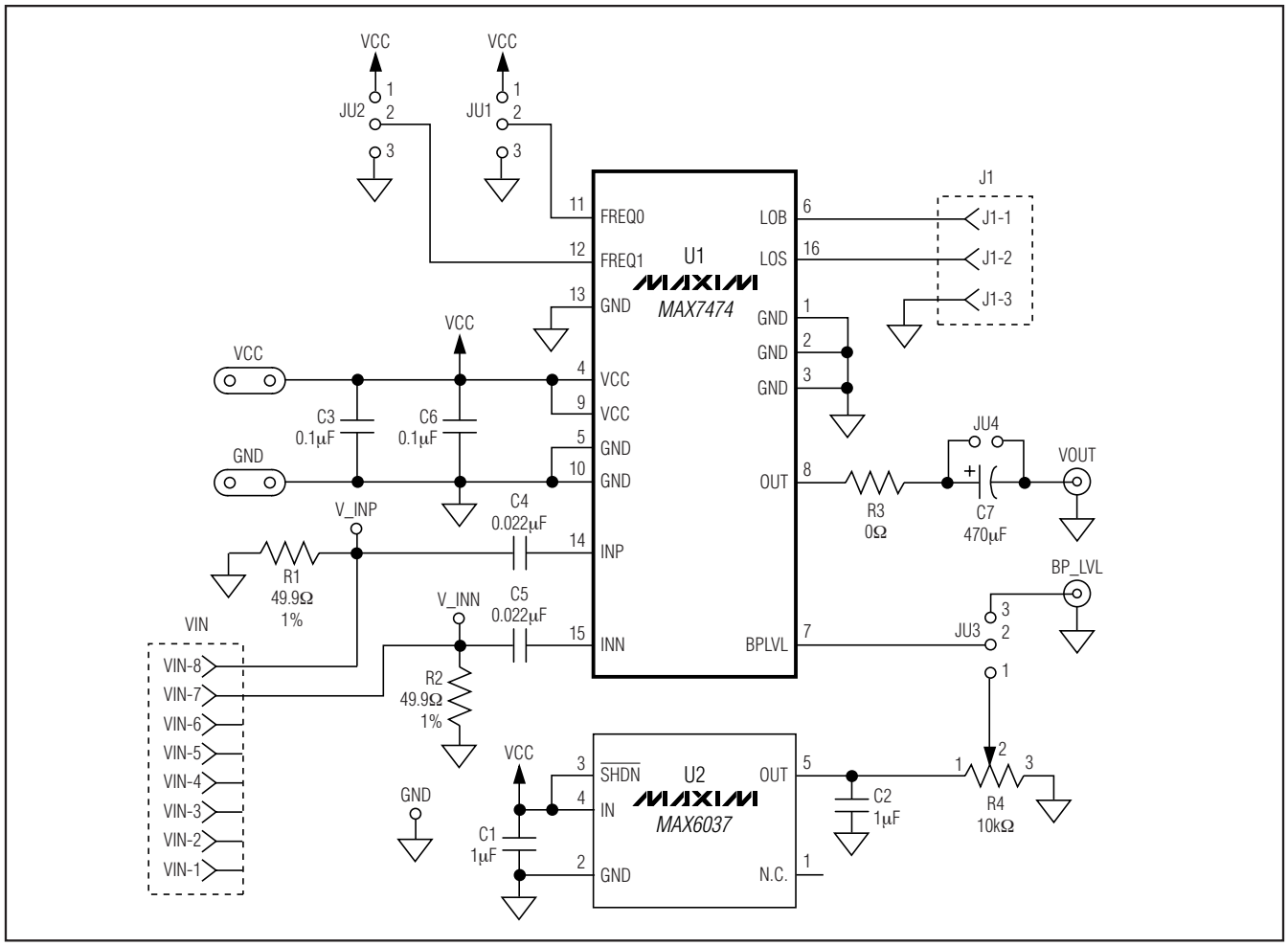
Chip Information

PROCESS: BiCMOS

Pin Configuration



Typical Application Circuit

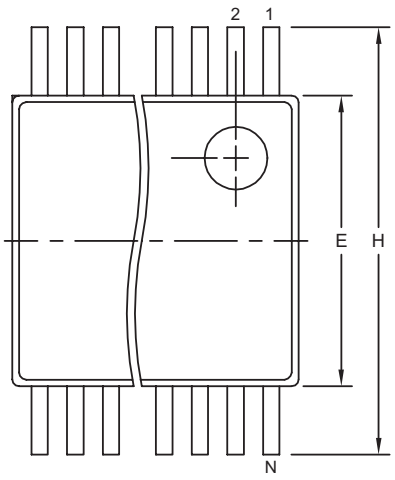


Adaptive Equalizer for Video Over Twisted Pair

Package Information

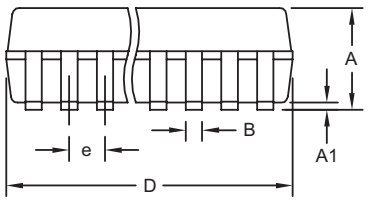
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

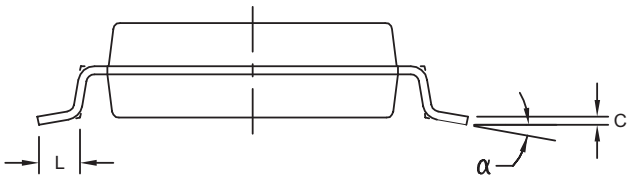
SSOP EPS



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.068	0.078	1.73	1.99
A1	0.002	0.008	0.05	0.21
B	0.010	0.015	0.25	0.38
C	0.004	0.008	0.09	0.20
D	SEE VARIATIONS			
E	0.205	0.212	5.20	5.38
e	0.0256 BSC		0.65 BSC	
H	0.301	0.311	7.65	7.90
L	0.025	0.037	0.63	0.95
α	0∞	8∞	0∞	8∞

	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX	N
D	0.239	0.249	6.07	6.33	14L
D	0.239	0.249	6.07	6.33	16L
D	0.278	0.289	7.07	7.33	20L
D	0.317	0.328	8.07	8.33	24L
D	0.397	0.407	10.07	10.33	28L





NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15 MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO150.
5. LEADS TO BE COPLANAR WITHIN 0.10 MM.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, SSOP, 5.3 MM

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