19-0535; Rev 0; 5/06

Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

General Description

The MAX9512 video filter amplifier with SmartSleep™ and Y/C mixer is ideal for portable media players (PMPs), portable DVD players, and set-top boxes (STBs). The inputs can be directly connected to the digital-to-analog converter (DAC) outputs. The dual reconstruction filters remove high-frequency signals above 6.75MHz. The Y/C-to-CVBS mixer creates a composite video signal from luma and chroma. The four amplifiers each have 6dB of gain. The outputs can be DC-coupled to a load of 75Ω, which is equivalent to two video loads, or AC-coupled to a load of 150Ω.

The SmartSleep circuitry intelligently reduces power consumption based on the presence of the input signal and the output loads. When the MAX9512 does not detect the presence of sync on luma, the supply current is reduced to less than 7µA. The device only enables a video amplifier when there is an active video input signal and an attached load. The video amplifier remains on while a load is connected. If the load is disconnected, the video amplifier is turned off.

The MAX9512 operates from a 2.7V to 3.6V single supply and is offered in a small, 16-pin TQFN (3mm x 3mm) package. The device is specified over the -40°C to +125°C automotive temperature range.

Applications

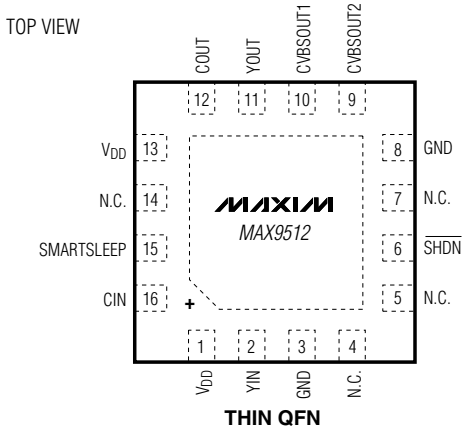
Portable Media Players (PMPs)

Portable DVD Players

Set-Top Boxes (STBs)

Portable Applications

Pin Configurations



THIN QFN (3mm x 3mm)

Pin Configurations continued at end of data sheet.

SmartSleep is a trademark of Maxim Integrated Products, Inc.

Features

- **SmartSleep Feature Detects Input Signal and Output Load Status to Reduce Power Consumption**
- **Dual Standard-Definition Video Reconstruction Filters with 6.75MHz Passband**
- **Luma and Chroma Inputs**
- **Y/C-to-CVBS Mixer**
- **Luma, Chroma, and Two Composite Outputs**
- **Supports Two Video Loads at Each Output (DC-Coupled)**
- **2.7V to 3.6V Single-Supply Operation**

Ordering Information

PART	PIN-PACKAGE	PKG CODE	TOP MARK
MAX9512ATE+	16 TQFN-EP** (3mm x 3mm)	T1633-4	AEN
MAX9512AEE+*	16 QSOP	E16-4	—

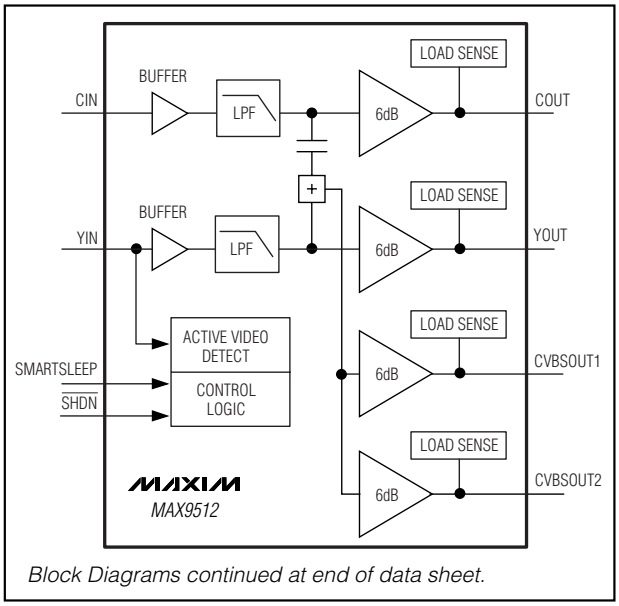
Note: *All devices specified over the -40°C to +125°C operating temperature range.*

+Denotes lead-free package.

**Future product—contact factory for availability.*

***EP = Exposed pad.*

Block Diagrams



Block Diagrams continued at end of data sheet.

Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND)
V_{DD} .....-0.3V to +4V
CIN, YIN, SMARTSLEEP, $\overline{SHDN}$.....-0.3V to +4V
Duration of COUT, YOUT, CVBSOUT1, CVBSOUT2 Short Circuit to V_{DD} or GND.....Continuous
Continuous Input Current (CIN, YIN, SMARTSLEEP, $\overline{SHDN}$).....±20mA

Continuous Power Dissipation (T_A = +70°C)
16-Pin TQFN (derate 15.6mW/°C above +70°C) 1250mW
16-Pin QSOP (derate 8.3mW/°C above +70°C).....667mW
Operating Temperature Range .....-40°C to +125°C
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_{DD} = $V_{\overline{SHDN}}$ = 3.3V, $V_{SMARTSLEEP}$ = GND = 0V. R_L = No load. T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS			MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{DD}	Guaranteed by PSRR			2.7		3.6	V
Supply Current	I_{DD}	YIN = 0.3V, CIN = 0.6V				13	16	mA
		SMARTSLEEP = V_{DD}, YIN has no active video signal				7	14	µA
		SMARTSLEEP = V_{DD}, YIN has a black-burst video signal with sync tip at GND (Note 2)				17		
Shutdown Supply Current	I_{SHDN}	$V_{\overline{SHDN}}$ = GND				0.01	10	µA
SMARTSLEEP CHARACTERISTICS								
Minimum Line Frequency		YIN			14.3			kHz
Sync Slice Level		YIN			4.1		5.2	% V_{DD}
Output Load Detect Threshold		R_L to GND, sync pulse present					200	Ω
DC CHARACTERISTICS								
Input-Voltage Range	V_{IN}	CIN, YIN, guaranteed by output voltage swing	2.7V < V_{DD} < 3.6V		0		1.05	V
			3.0V < V_{DD} < 3.6V		0		1.2	
Input Current	I_{IN}	CIN = YIN = 0V				2	5	µA
Input Resistance	R_{IN}	CIN, YIN				20		MΩ
DC Voltage Gain	A_V	R_L = 150Ω to V_{DD} / 2	0V ≤ V_{IN} ≤ 1.05V, V_{DD} = 2.7V	T_A = -40°C to +85°C	5.7	6	6.3	dB
				T_A = -40°C to +125°C	5.6		6.3	
			0V ≤ V_{IN} ≤ 1.2V, V_{DD} = 3.0V	T_A = -40°C to +85°C	5.7	6	6.3	
				T_A = -40°C to +125°C	5.6		6.3	

ELECTRICAL CHARACTERISTICS (continued)

(V_{DD} = $V_{\overline{SHDN}}$ = 3.3V, $V_{SMARTSLEEP}$ = GND = 0V. R_L = No load. T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DC Gain Matching		0V ≤ V_{IN} ≤ 1.05V, V_{DD} = 2.7V		-0.2	0	+0.2	dB
		0V ≤ V_{IN} ≤ 1.2V, V_{DD} = 3.0V		-0.2	0	+0.2	
Output Level		CIN = YIN = 0V, R_L = 150Ω to GND		0.188	0.3	0.400	V
Output Voltage Swing		Measured at output, V_{DD} = 2.7V, 0V ≤ V_{IN} ≤ 1.05V, R_L = 150Ω to -0.2V	T_A = -40°C to +85°C	2.027	2.1	2.163	V_{P-P}
			T_A = -40°C to +125°C	2.006		2.163	
		Measured at output, V_{DD} = 2.7V, 0V ≤ V_{IN} ≤ 1.05V, R_L = 150Ω to V_{DD} / 2		2.027	2.1	2.163	
		Measured at output, V_{DD} = 3V, 0V ≤ V_{IN} ≤ 1.2V, R_L = 150Ω to -0.2V	T_A = -40°C to +85°C	2.316	2.4	2.472	
			T_A = -40°C to +125°C	2.292		2.472	
		Measured at output, V_{DD} = 3V, 0V ≤ V_{IN} ≤ 1.2V, R_L = 150Ω to V_{DD} / 2		2.316	2.4	2.472	
		Measured at output, V_{DD} = 3.135V, 0V ≤ V_{IN} ≤ 1.05V, R_L = 75Ω to -0.2V		2.027	2.1	2.163	
Output Resistance	R_{OUT}	V_{OUT} = 1.3V, -5mA ≤ I_{LOAD} ≤ +5mA			0.47		Ω
Power-Supply Rejection Ratio	PSRR	2.7V ≤ V_{DD} ≤ 3.6V, input referred, R_L = 150Ω to GND		48			dB
Output Shutdown Impedance					28		kΩ
LOGIC INPUTS (SMARTSLEEP, $\overline{SHDN}$)							
Logic-Low Threshold	V_{IL}					0.3 x V_{DD}	V
Logic-High Threshold	V_{IH}			0.7 x V_{DD}			V
Logic Input Current	I_{IL}/I_{IH}	V_I = 0V or V_{DD}			0.01	10	µA

Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

AC CHARACTERISTICS

(V_{DD} = $V_{\overline{SHDN}}$ = +3.3V, $V_{SMARTSLEEP}$ = GND = 0V, R_L = 150Ω to GND. T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Color Subcarrier Output Voltage Swing		V_{DD} = 2.7V, YIN = 0.65V, CIN = 0.7V_{P-P}			1.4		V_{P-P}
		V_{DD} = 3.0V, YIN = 0.75V, CIN = 0.9V_{P-P}			1.8		
Mixer HPF -3dB Frequency					300		kHz
Standard-Definition Reconstruction Filter		Inputs are 1V_{P-P}, Reference frequency is 1MHz	f = 5.5MHz		-0.1		dB
			f = 6.75MHz	-1	-0.3	+1	
			f = 11MHz		-3		
			f = 27MHz	-33	-41		
Differential Gain	DG	DC-coupled output, 5-step modulated staircase	f = 3.58MHz or 4.43MHz		0.2		%
		AC-coupled output, 5-step modulated staircase	f = 3.58MHz or 4.43MHz		0.4		
Differential Phase	DP	DC-coupled output, 5-step modulated staircase	f = 3.58MHz		0.62		degrees
			f = 4.43MHz		0.75		
		AC-coupled output, 5-step modulated staircase	f = 3.58MHz		0.78		
			f = 4.43MHz		1.01		
2T Pulse Response		2T = 200ns or 250ns			0.2		K%

AC CHARACTERISTICS (continued)

(V_{DD} = $V_{\overline{SHDN}}$ = +3.3V, $V_{SMARTSLEEP}$ = GND = 0V, R_L = 150Ω to GND. T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
2T Bar Response		Bar time is 18µs, the beginning 2.5% and the ending 2.5% of the bar time is ignored, 2T = 200ns or 250ns		0.2		K%
2T Pulse-to-Bar K Rating		Bar time is 18µs, the beginning 2.5% and the ending 2.5% of the bar time is ignored, 2T = 200ns or 250ns		0.3		K%
Nonlinearity		5-step staircase		0.1		%
Interchannel Timing Error		Difference in time between the 50% point of the output signals, YOUT to COUT		0.2		ns
Group Delay Distortion		100kHz ≤ f ≤ 5MHz, inputs are $1V_{P-P}$		10		ns
Interchannel Group Delay Distortion Error		Outputs are $2V_{P-P}$		2		ns
Peak Signal to RMS Noise		100kHz ≤ f ≤ 5MHz, inputs are $1V_{P-P}$		67		dB
Power-Supply Rejection Ratio		f = 100kHz, $200mV_{P-P}$, input referred		43		dB
Output Impedance		f = 5MHz		6		Ω
Enable Time		YIN = 1V, output settled to within 1% of the final voltage, R_L = 150Ω to GND		13		µs
Disable Time		YIN = 1V, output settled to within 1% of the final voltage, R_L = 150Ω to GND		1.1		µs
CROSSTALK						
All Hostile Output Crosstalk		f = 4.43MHz		-71		dB
All Hostile Input Crosstalk		f = 4.43MHz, $\overline{SHDN}$ = GND, input termination resistors are 75Ω		-106		dB

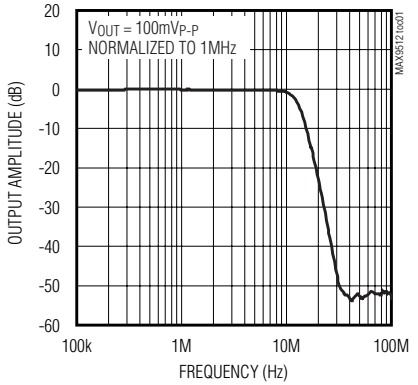
Note 1: All devices are 100% production tested at T_A = +25°C. Specifications over temperature limits are guaranteed by design.
Note 2: Specified current is an average over time.

Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

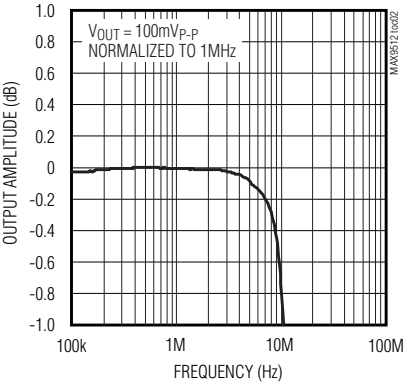
Typical Operating Characteristics

(V_{DD} = $\overline{SHDN}$ = +3.3V, $V_{SMARTSLEEP}$ = GND = 0V. Video outputs have R_L = 150Ω connected to GND. T_A = +25°C, unless otherwise noted.)

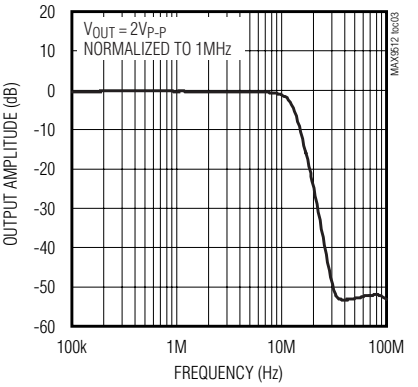
SMALL-SIGNAL GAIN vs. FREQUENCY



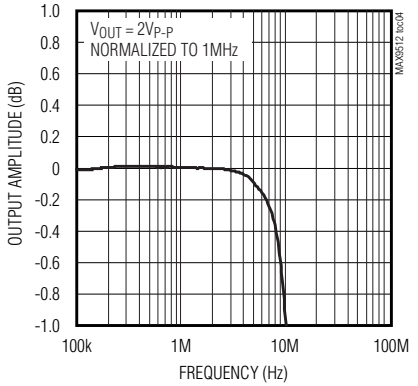
SMALL-SIGNAL GAIN FLATNESS vs. FREQUENCY



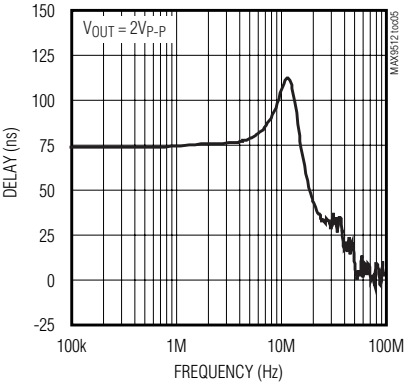
LARGE-SIGNAL GAIN vs. FREQUENCY



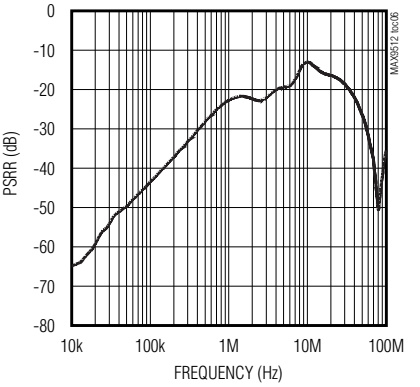
LARGE-SIGNAL GAIN FLATNESS vs. FREQUENCY



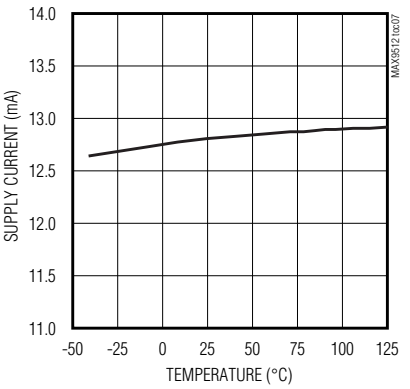
GROUP DELAY



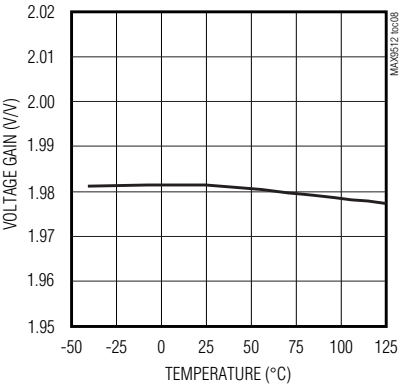
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



QUIESCENT SUPPLY CURRENT vs. TEMPERATURE



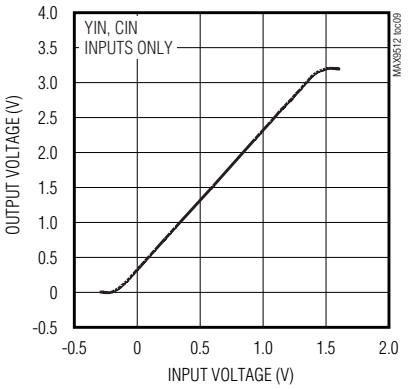
VOLTAGE GAIN vs. TEMPERATURE



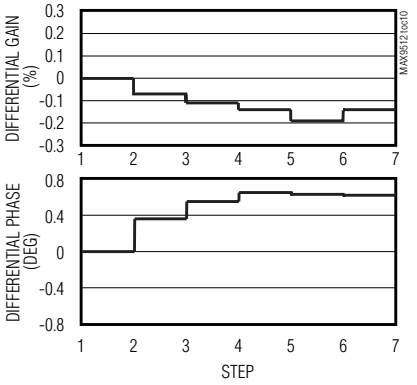
Typical Operating Characteristics (continued)

(V_{DD} = $\overline{SHDN}$ = +3.3V, $V_{SMARTSLEEP}$ = GND = 0V. Video outputs have R_L = 150Ω connected to GND. T_A = +25°C, unless otherwise noted.)

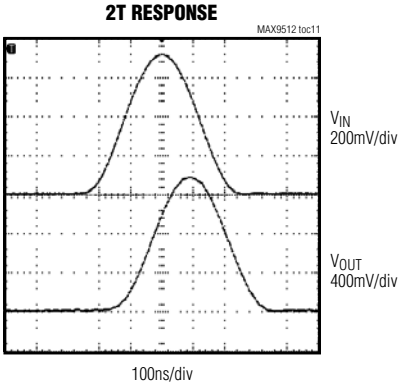
OUTPUT VOLTAGE vs. INPUT VOLTAGE



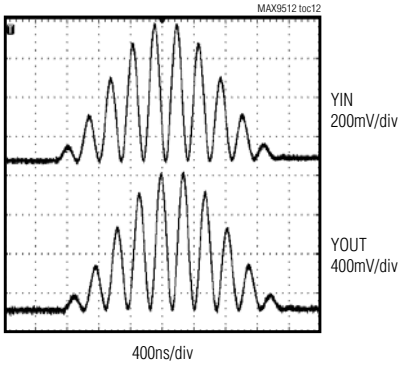
DIFFERENTIAL GAIN AND PHASE



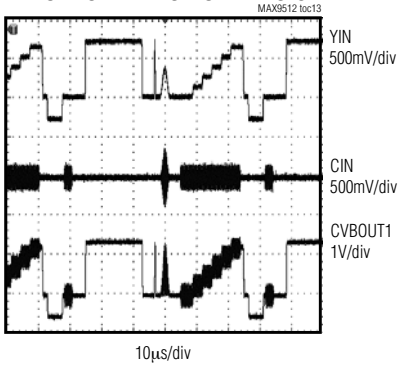
2T RESPONSE



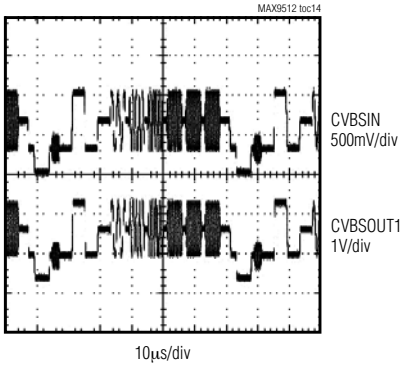
12.5T RESPONSE



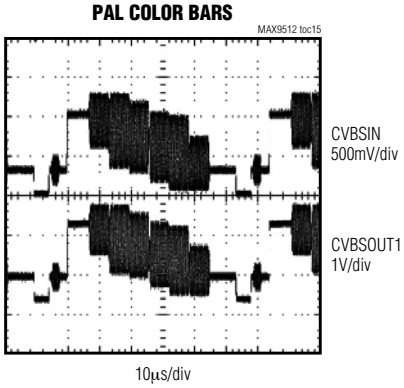
NTC-7 VIDEO TEST SIGNAL GENERATED FROM LUMA AND CHROMA INPUTS



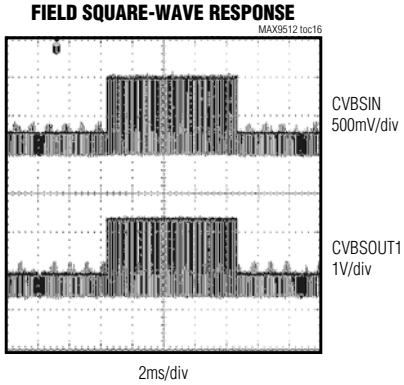
PAL MULTIBURST RESPONSE



PAL COLOR BARS



FIELD SQUARE-WAVE RESPONSE

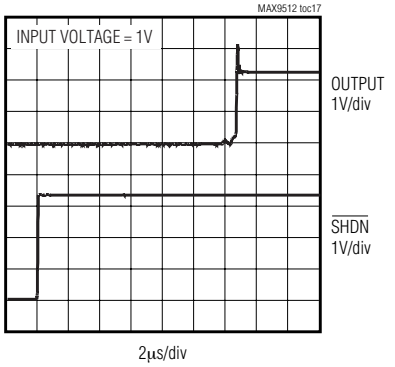


Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

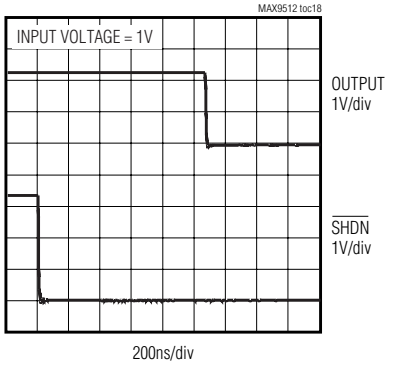
Typical Operating Characteristics (continued)

(V_{DD} = $\overline{SHDN}$ = +3.3V, $V_{SMARTSLEEP}$ = GND = 0V. Video outputs have R_L = 150Ω connected to GND. T_A = +25°C, unless otherwise noted.)

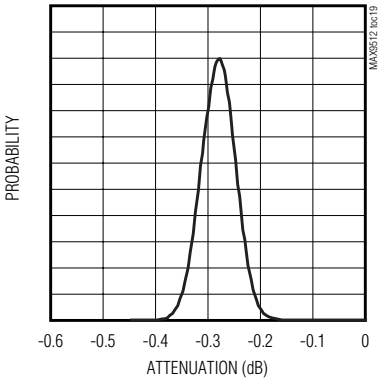
ENABLE TIME



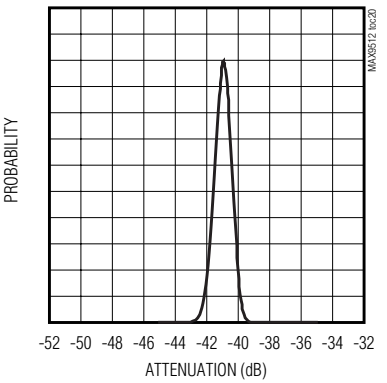
DISABLE TIME



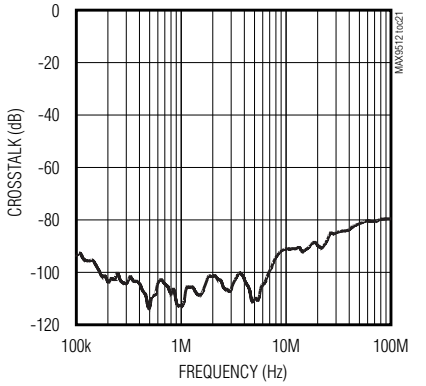
FREQUENCY RESPONSE AT 6.75MHz DISTRIBUTION



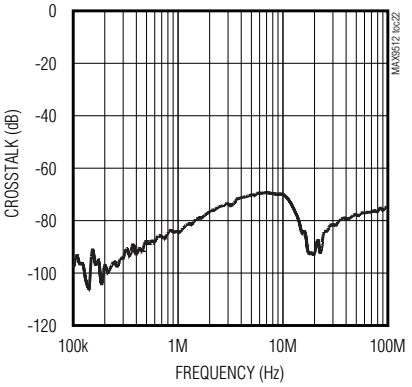
FREQUENCY RESPONSE AT 27MHz DISTRIBUTION



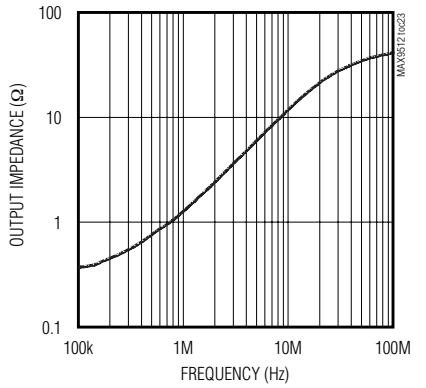
INPUT-TO-INPUT CROSSTALK vs. FREQUENCY



OUTPUT-TO-OUTPUT CROSSTALK vs. FREQUENCY



OUTPUT IMPEDANCE vs. FREQUENCY



Pin Description

PIN		NAME	FUNCTION
TQFN	QSOP		
1, 13	3, 15	V_{DD}	Power Supply. Bypass with a 0.1µF capacitor to GND.
2	4	YIN	Luma Video Input. Directly connect this input to the video DAC output.
3, 8	5, 10	GND	Ground
4, 5, 7, 14	6, 7, 9, 16	N.C.	No Connection. Connect to GND.
6	8	$\overline{SHDN}$	Active-Low Shutdown Logic Input. Connect to logic low to place device in shutdown. Connect to logic high for normal operation.
9	11	CVBSOUT2	CVBS Output 2
10	12	CVBSOUT1	CVBS Output 1
11	13	YOUT	Luma Video Output
12	14	COUT	Chroma Video Output
15	1	SMARTSLEEP	SmartSleep Logic Input. Connect to logic high to activate SmartSleep operation.
16	2	CIN	Chroma Video Input. Directly connect this input to the video DAC output.
EP	—	EP	Exposed Pad. Connect EP to GND. EP is also internally connected to GND.

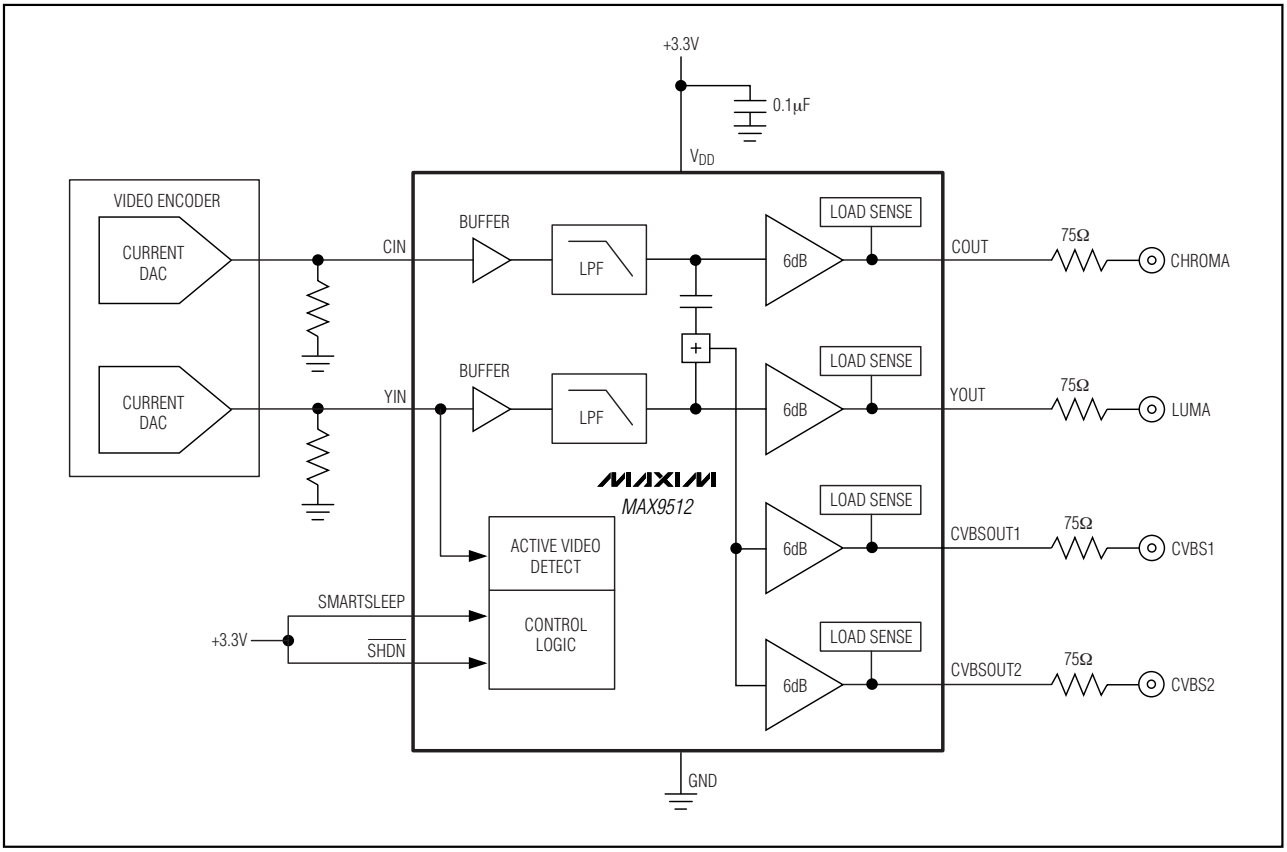


Figure 1. Typical Application Circuit for Portable Media Players

Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

Detailed Description

In the Typical Application Circuit (Figure 1), the current DACs on a video encoder generate luma and chroma video signals. The MAX9512 filters those signals and then adds them together to create the composite video signal. The output amplifiers drive the video connectors through a 75Ω back termination resistor.

SmartSleep Feature

The SmartSleep feature is activated when the SMARTSLEEP input is connected to logic high. The SmartSleep feature provides intelligent power management by selectively disabling the filters and output amplifiers based on the presence of a luma video signal or loads attached to the outputs. If the SmartSleep feature is not activated and the part is not in shutdown, the filters and output amplifiers completely turn on, regardless of whether there is a video signal at the YIN input and whether there are loads connected at the outputs.

SmartSleep only works with DC-coupled loads.

Standby Mode

In standby mode, the filters and output amplifiers are off and only the active video detect circuit is active. Quiescent current consumption is approximately 7µA (Figure 2). The active video detect circuit checks if sync is present on the YIN signal. If no sync is detected the device remains in standby mode.

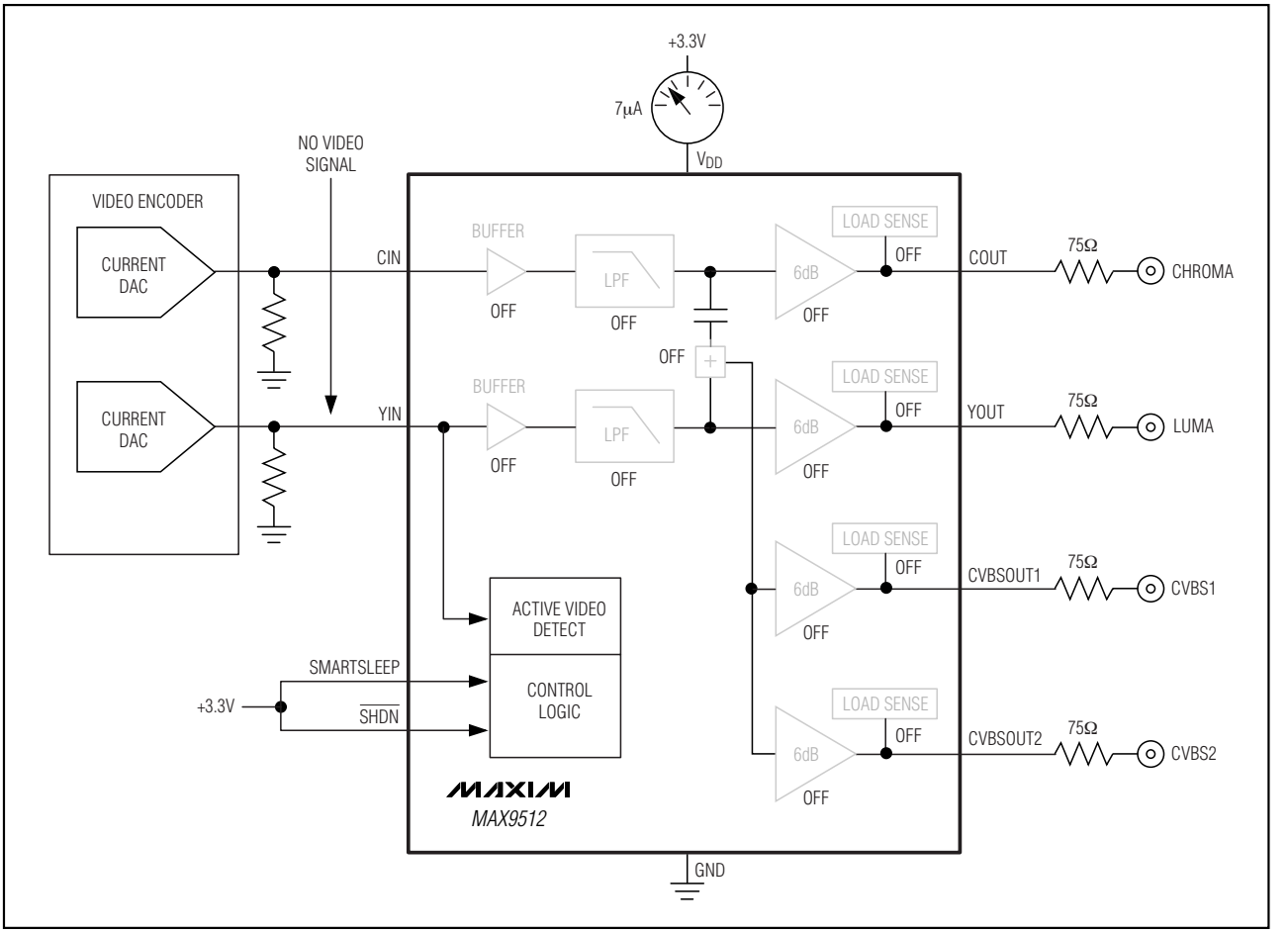


Figure 2. Standby Mode Operation

Active-Detect Mode

The active video detect circuit slices the YIN signal at 4.7% of the power supply (155mV for a 3.3V supply). If the transitions occur at a rate of 14kHz or higher, then a video signal is present. When the MAX9512 detects a video signal with sync at the YIN input, the control logic enters the active-detect mode and enables the load sense circuitry (Figure 3). The supply current is typically 17µA.

If an output load is not connected to any amplifier, the MAX9512 remains in active-detect mode. Eight times per second, each load-sense circuit checks for a load by connecting an internal 15kΩ pullup resistor to the output for 1ms. If the output is pulled up, then no load is present. If the output stays low, a load is connected.

Full-Operation Mode

If a load is connected to an output, the corresponding filter and amplifier turn on and remain on until the output load is disconnected. In full-operation mode, SmartSleep intelligently reduces the supply current based on the input signal presence and output loading. Figures 4 and 5 show which portions of the MAX9512 turn on and which remain off with different load configurations. In Figure 4, both filters and the Y/C mixer turn on to generate the composite video signal for the amplifier connected to CVBSOUT1. In Figure 5, only the luma filter turns on, and the Y/C mixer stays off.

When an amplifier is on, it continually checks if the load has been disconnected by detecting if the amplifier output is sourcing current during a horizontal line time. If no sourcing current is detected within one horizontal line time (approximately 64µs), the load has been disconnected and the amplifier returns to active-detect mode. If, at any time, the input video signal is removed, the MAX9512 returns to standby mode.

If the SmartSleep feature is not activated and the part is not in shutdown, then the filters and amplifiers completely turn on, regardless of whether there is a video signal at the CVBSIN input and whether there are loads connected at the outputs.

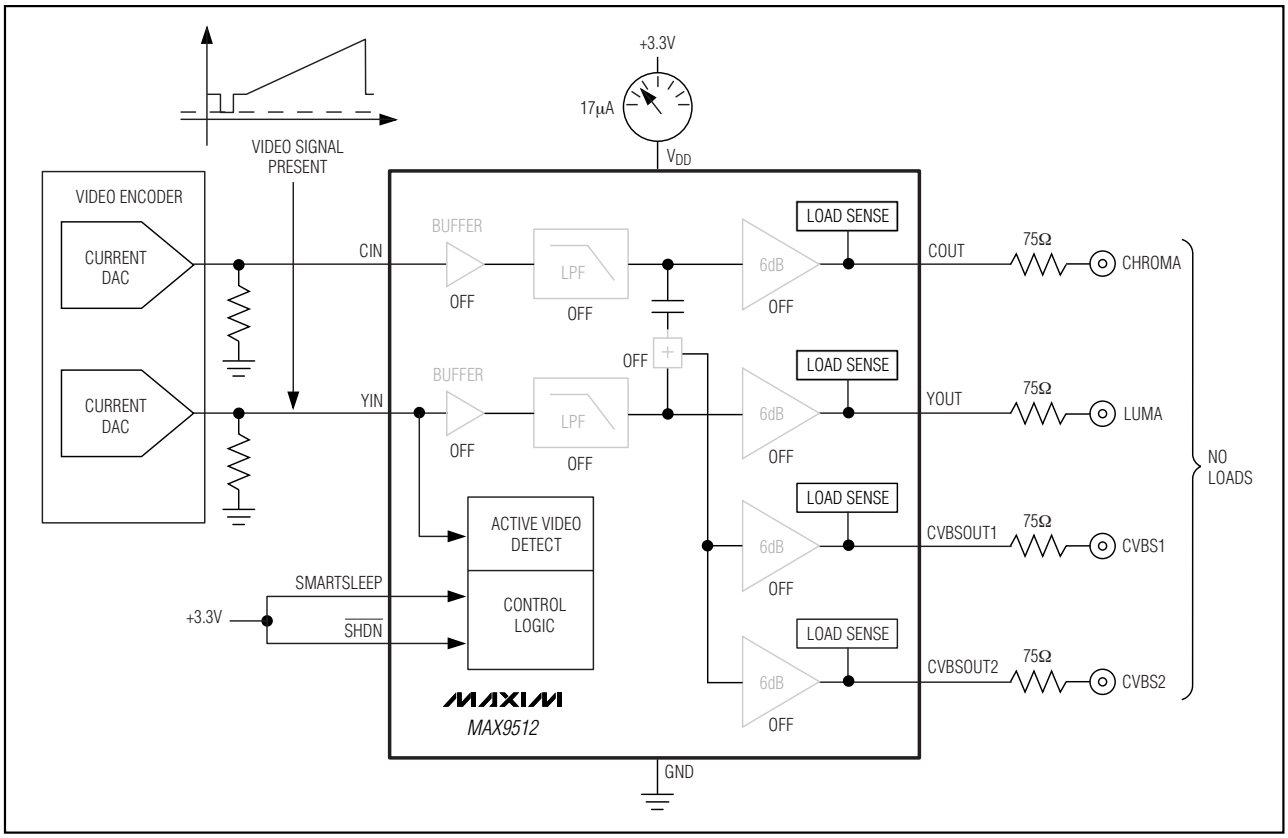


Figure 3. Active-Detect Mode with No Output Loads

Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

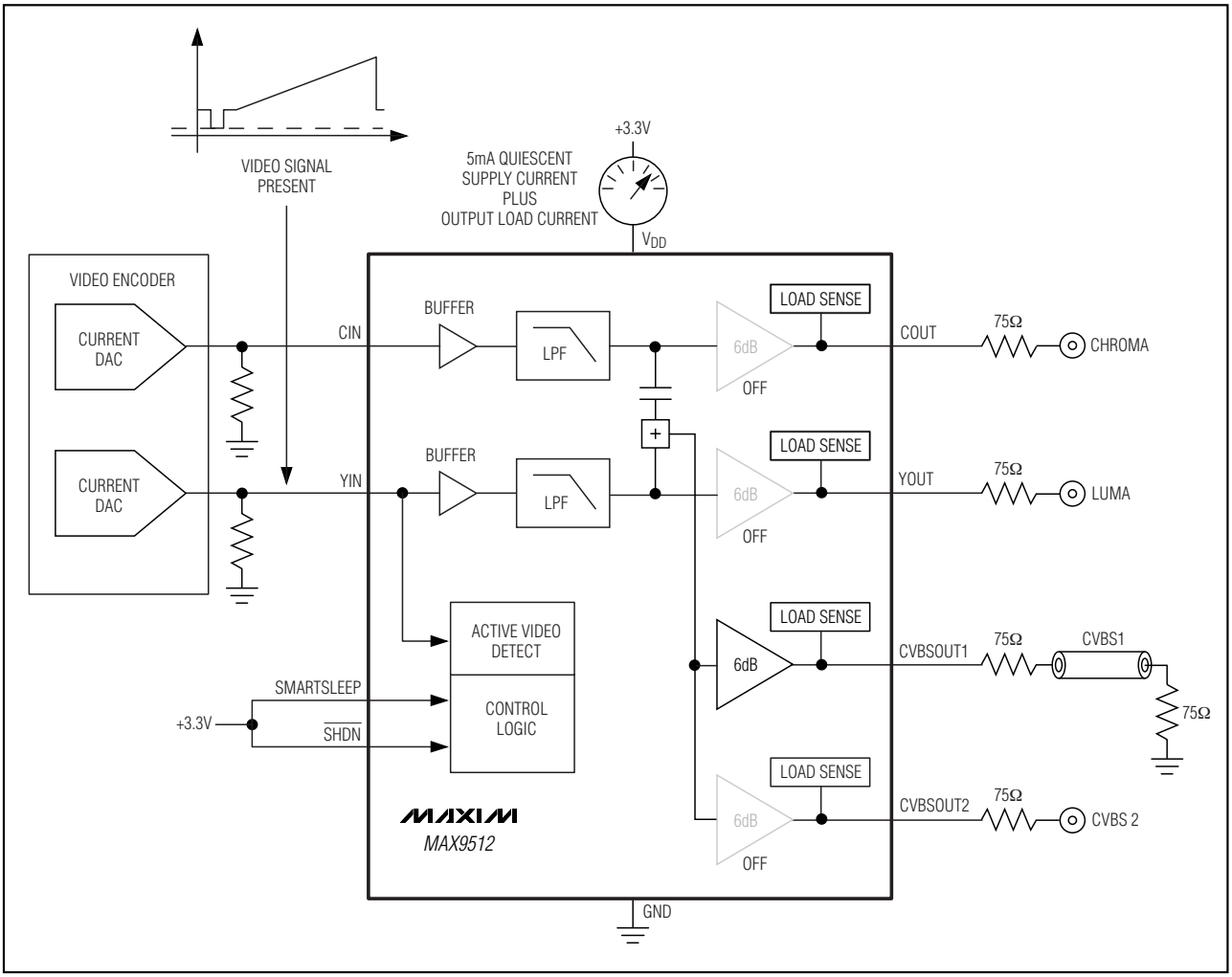


Figure 4. Full Operation Mode with CVBSOUT1 Loaded

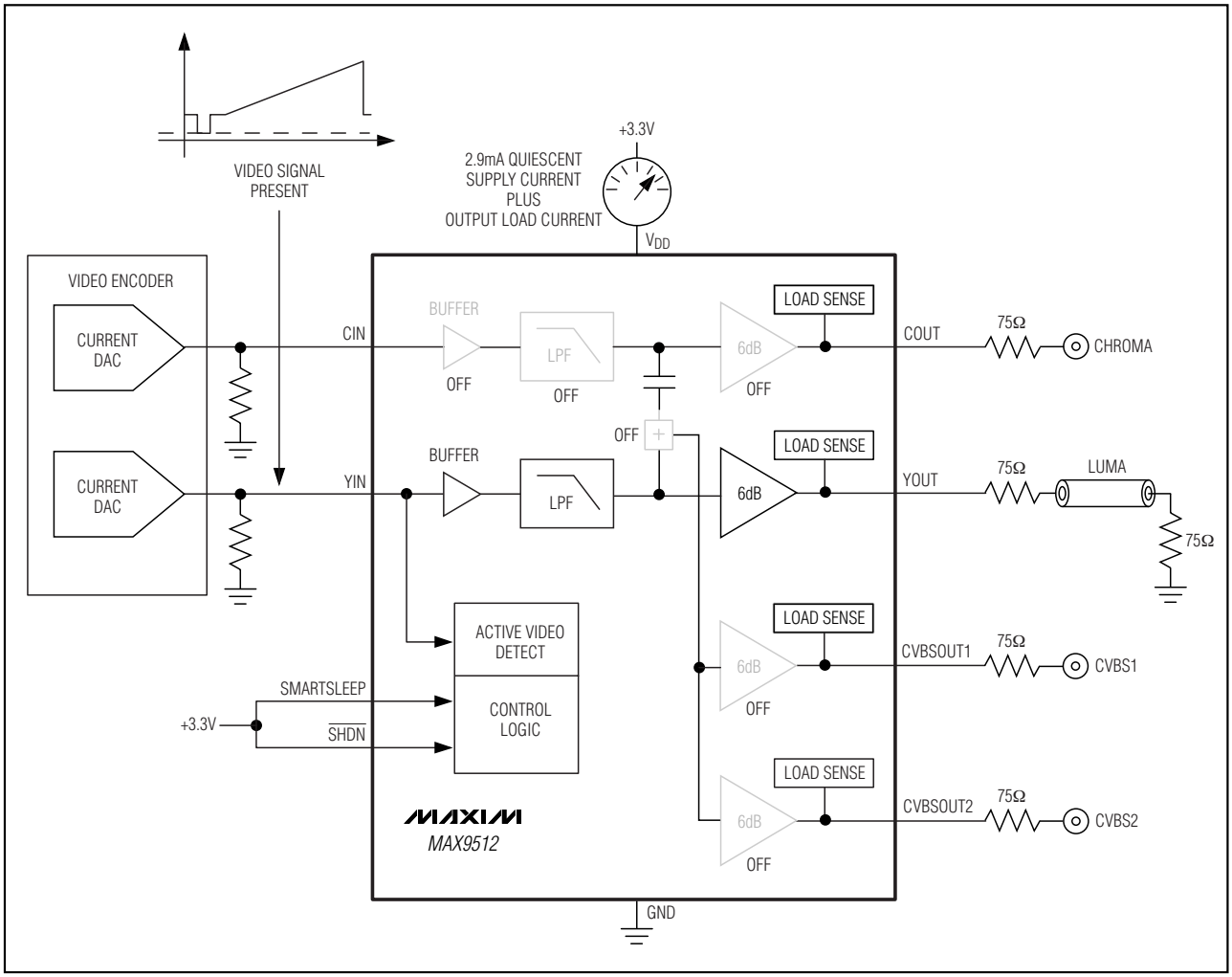


Figure 5. Full Operation Mode with YOUT Loaded

Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

Inputs

The MAX9512 video inputs YIN and CIN should be directly connected to the output of the video current DAC. DC-coupling ensures that the input signals are ground referenced such that the sync tip of the luma signal is within 50mV of ground and the blank level of the chroma signal is between 0.5V and 0.65V.

Video Reconstruction Filter

The MAX9512 filter passband is 6.75MHz, which makes the device suitable for the higher bandwidth video signals from a DVD chip. Broadcast video signals actually require less bandwidth because of channel limitations: NTSC signals have 4.2MHz bandwidth, and PAL signals have 5MHz bandwidth. Video signals from a DVD player are not channel limited; therefore, the bandwidth of DVD video signals can push right against the Nyquist limit of 6.75MHz. (Recommendation ITU-R BT.601-5 specifies 13.5MHz as the sampling rate for standard-definition video). Therefore, the maximum bandwidth of the signal is 6.75MHz. To ease the filtering requirements, most modern video systems oversample by two times; clocking the video current DAC at 27MHz.

Y/C Mixer

The Y/C mixer adds the luma and chroma signals together to create a composite video signal. Since chroma is a phase modulated carrier at 3.58MHz for NTSC and 4.43MHz for PAL, the chroma signal is AC-coupled into the Y/C mixer so that the variation in blank level from one video source to another video source does not affect the DC bias of the composite video signal. The highpass corner frequency of the chroma AC-coupling circuit is 300kHz.

Outputs

The video output amplifiers can both source and sink load current, allowing output loads to be DC- or AC-coupled. The amplifier output stage needs about 300mV of headroom from either supply rail. The MAX9512 has an internal level shift circuit that positions the sync tip at approximately 300mV at the output. The blank level of the chroma output is positioned at approximately 1.3V if the blank level of the chroma input signal is 0.5V. The blank level of the chroma output is positioned at approximately 1.5V if the blank level of the chroma input signal is 0.6V.

If the supply voltage is greater than 3.135V (5% below a 3.3V supply), each amplifier can drive two DC-coupled video loads to ground. If the supply is less than 3.135V, each amplifier can drive only one DC-coupled or AC-coupled video load.

Shutdown

When $\overline{SHDN}$ is low, the MAX9512 draws less than 1µA supply current. All the amplifier outputs become high impedance. The effective output resistance at the video outputs is 28kΩ, due to the internal feedback resistors to ground.

Applications Information

Reducing Power Consumption in the Video DACs

YIN and CIN have high-impedance input buffers and can work with source resistances as high as 300Ω. To reduce power dissipation in the video DACs, the DAC output resistor can be scaled up in value. The reference resistor that sets the reference current inside the video DACs must also be similarly scaled up. For instance, if the output resistor is 37.5Ω, the DAC must source 26.7mA when the output is 1V. If the output resistor is increased to 300Ω, the DAC only needs to source 3.33mA when the output is 1V.

There is parasitic capacitance from the DAC output to ground. That capacitance in parallel with the DAC output resistor forms a pole that can potentially roll off the frequency response of the video signal. For example, 300Ω in parallel with 50pF creates a pole at 10.6MHz. To minimize this capacitance, reduce the area of the signal trace attached to the DAC output as much as possible, and place the MAX9512 as close to the video DAC outputs as possible.

AC-Coupling the Outputs

The outputs can be AC-coupled since the output stage can source and sink current as shown in Figure 6. Coupling capacitors should be 220µF or greater to keep the highpass filter formed by the 150Ω equivalent resistance of the video transmission line to a corner frequency of 4.8Hz or below. The frame rate of PAL systems is 25Hz, and the frame rate of NTSC systems is 30Hz. The corner frequency should be well below the frame rate.

Power-Supply Bypassing and Ground

The MAX9512 operates from a single-supply voltage down to 2.7V, allowing for low-power operation. Bypass V_{DD} to GND with a 0.1µF capacitor. Place all external components as close to the device as possible.

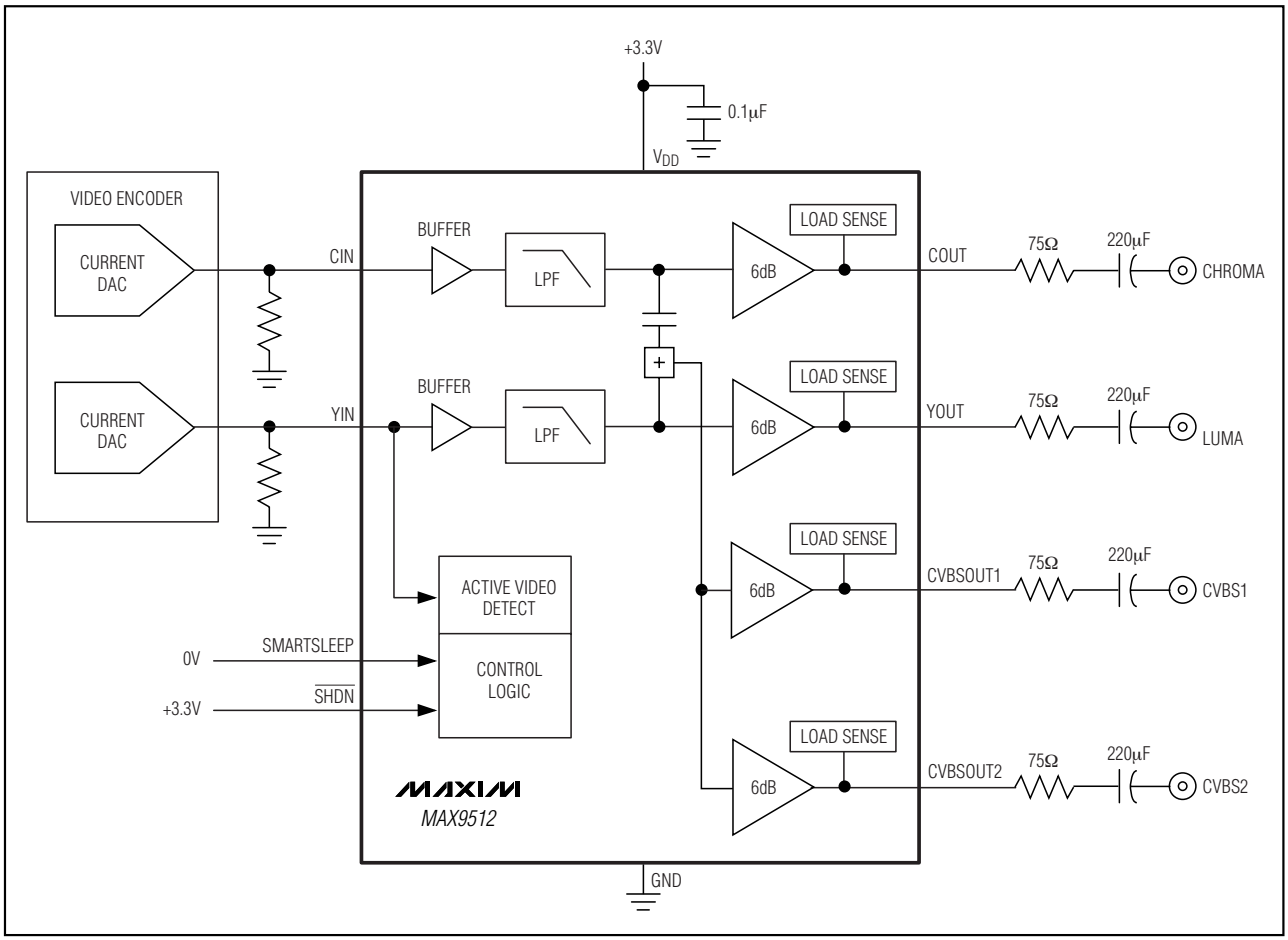
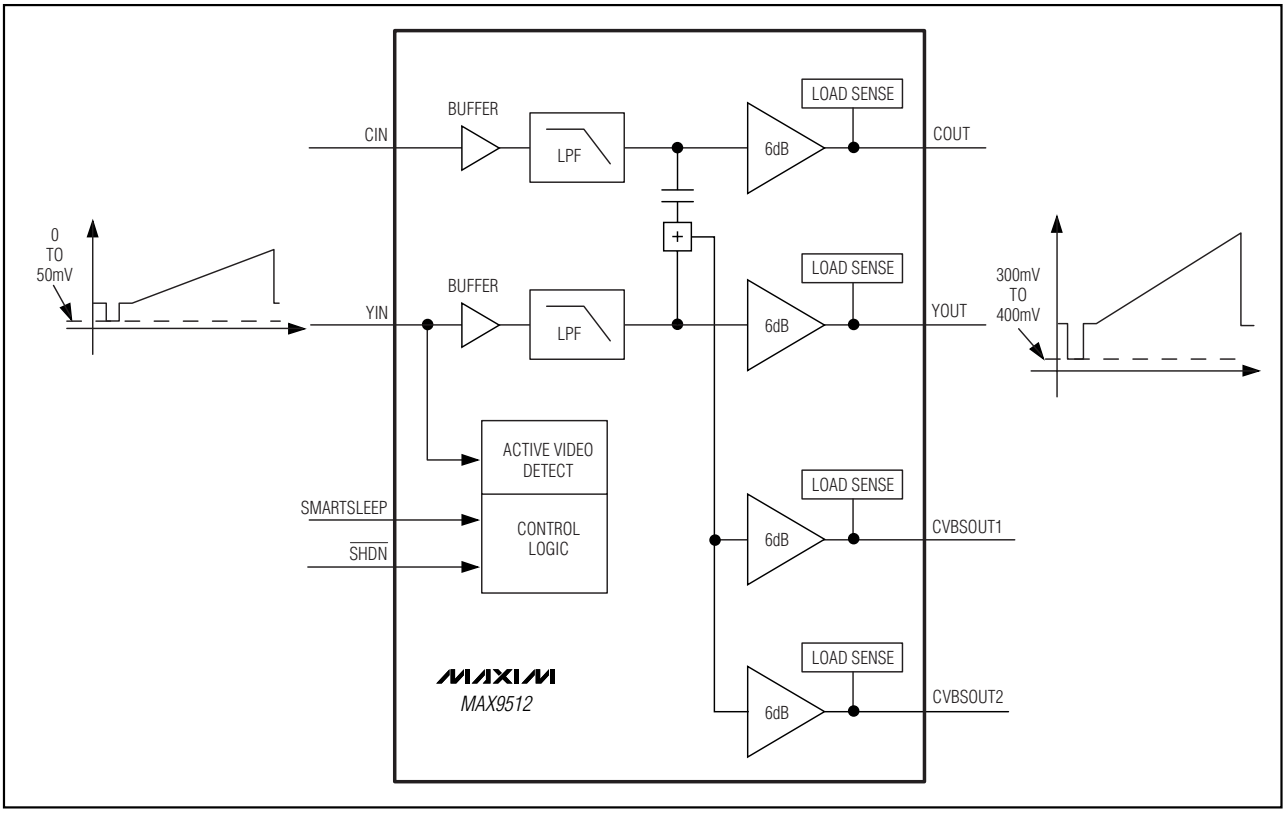


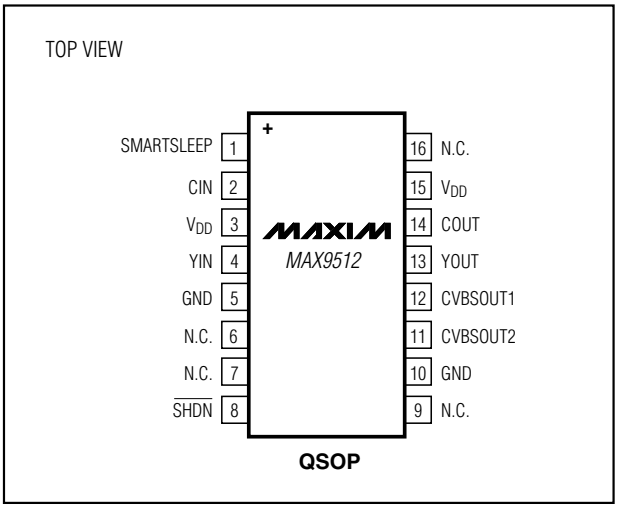
Figure 6. AC-Coupling at the Outputs

Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

Block Diagrams (continued)



Pin Configurations (continued)



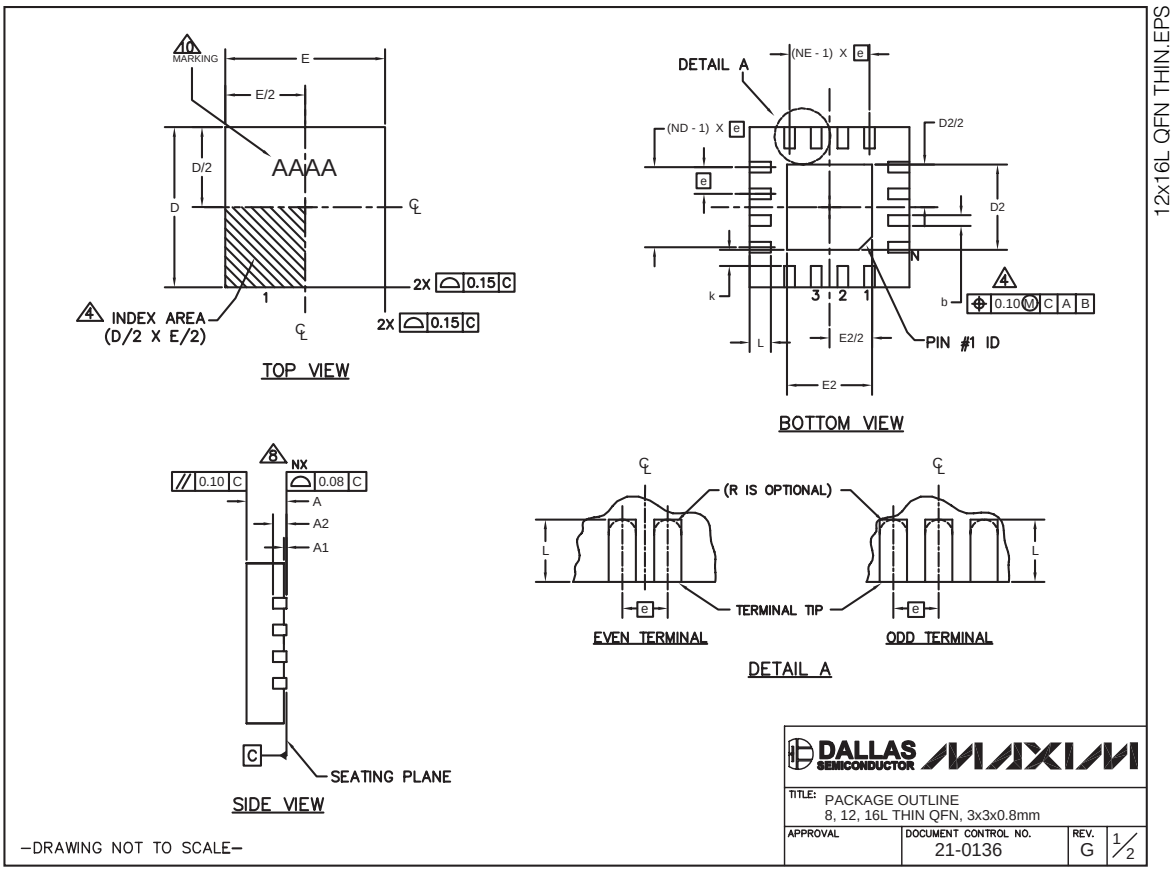
Chip Information

PROCESS: BiCMOS

Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

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**.)



Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

Package Information (continued)

(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**.)

PKG	8L 3x3			12L 3x3			16L 3x3		
REF.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80
b	0.25	0.30	0.35	0.20	0.25	0.30	0.20	0.25	0.30
D	2.90	3.00	3.10	2.90	3.00	3.10	2.90	3.00	3.10
E	2.90	3.00	3.10	2.90	3.00	3.10	2.90	3.00	3.10
e	0.65 BSC.			0.50 BSC.			0.50 BSC.		
L	0.35	0.55	0.75	0.45	0.55	0.65	0.30	0.40	0.50
N	8			12			16		
ND	2			3			4		
NE	2			3			4		
A1	0	0.02	0.05	0	0.02	0.05	0	0.02	0.05
A2	0.20 REF			0.20 REF			0.20 REF		
k	0.25	-	-	0.25	-	-	0.25	-	-

EXPOSED PAD VARIATIONS									
PKG. CODES	D2			E2			PIN ID	JEDEC	DOWN BONDS ALLOWED
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.			
TQ833-1	0.25	0.70	1.25	0.25	0.70	1.25	0.35 x 45°	WEEC	NO
T1233-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	NO
T1233-3	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	YES
T1233-4	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	YES
T1633-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	NO
T1633-2	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	YES
T1633F-3	0.65	0.80	0.95	0.65	0.80	0.95	0.225 x 45°	WEED-2	N/A
T1633FH-3	0.65	0.80	0.95	0.65	0.80	0.95	0.225 x 45°	WEED-2	N/A
T1633-4	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	NO

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.20 mm AND 0.25 mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220 REVISION C.
10. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
11. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.

—DRAWING NOT TO SCALE—

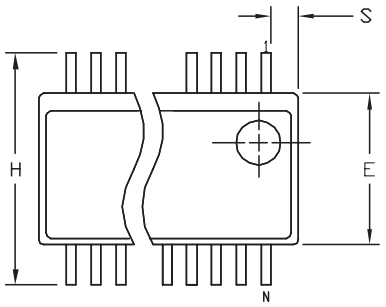
DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE 8, 12, 16L THIN QFN, 3x3x0.8mm			
APPROVAL	DOCUMENT CONTROL NO. 21-0136	REV. G	2/2

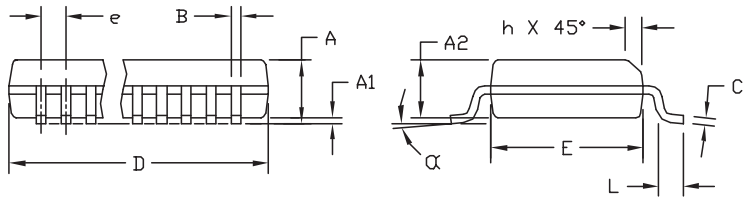
Package Information (continued)

(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**.)

QSOP.EPS



	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	.053	.069	1.35	1.75
A1	.004	.010	.102	.254
A2	.049	.065	1.245	1.651
B	.008	.012	0.20	0.30
C	.0075	.0098	0.191	0.249
D	SEE VARIATIONS			
E	.150	.157	3.81	3.99
e	.025 BSC		0.635 BSC	
H	.230	.244	5.84	6.20
h	.010	.016	0.25	0.41
L	.016	.035	0.41	0.89
N	SEE VARIATIONS			
α	0°	8°	0°	8°



VARIATIONS:

	INCHES		MILLIMETERS			
	MIN.	MAX.	MIN.	MAX.	N	
D	.189	.196	4.80	4.98	16	AB
S	.0020	.0070	0.05	0.18		
D	.337	.344	8.56	8.74	20	AD
S	.0500	.0550	1.270	1.397		
D	.337	.344	8.56	8.74	24	AE
S	.0250	.0300	0.635	0.762		
D	.386	.393	9.80	9.98	28	AF
S	.0250	.0300	0.635	0.762		

NOTES:
1). D & E DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
2). MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .006" PER SIDE.
3). CONTROLLING DIMENSIONS: INCHES.
4). MEETS JEDEC MO137.

DALLAS SEMICONDUCTOR MAXIM
PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, QSOP .150", .025" LEAD PITCH

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0055	F	1/1