



# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

MAX9512

## 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.

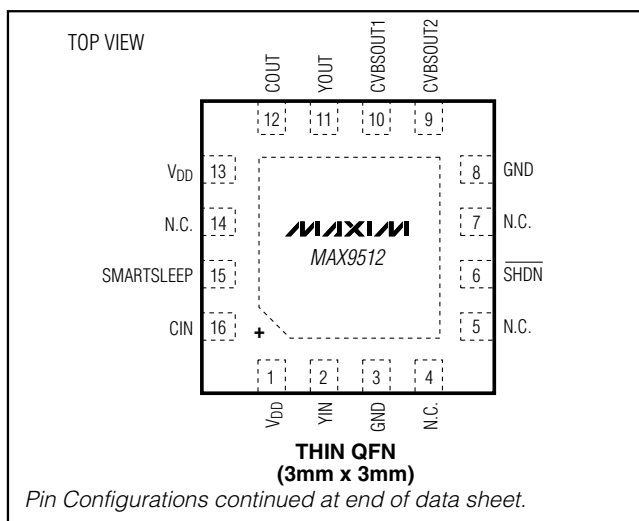
The SmartSleep circuitry intelligently reduces power consumption based on the presence of the input signal and the output loads. When the MAX9512 does not detect the presence of sync on luma, the supply current is reduced to less than 7μA. The device only enables a video amplifier when there is an active 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)
- Set-Top Boxes (STBs)
- Portable DVD Players
- Portable Applications

## Pin Configurations



## 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	—

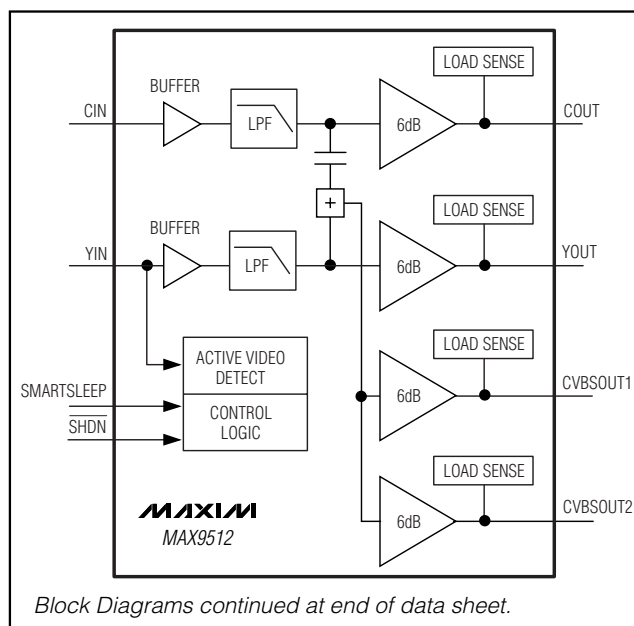
**Note:** All devices specified over the -40°C to +125°C operating temperature range.

+ Denotes lead-free package.

\* Future product—contact factory for availability.

\*\* EP = Exposed pad.

## Block Diagrams



# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

## ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND)

V <sub>DD</sub> .....	-0.3V to +4V
CIN, YIN, SMARTSLEEP, $\overline{\text{SHDN}}$ .....	-0.3V to +4V
Duration of COUT, YOUT, CVBSOUT1, CVBSOUT2	
Short Circuit to V <sub>DD</sub> or GND.....	Continuous
Continuous Input Current	
CIN, YIN, SMARTSLEEP, $\overline{\text{SHDN}}$ .....	±20mA

Continuous Power Dissipation (T<sub>A</sub> = +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<sub>DD</sub> = V $\overline{\text{SHDN}}$  = 3.3V, V<sub>SMARTSLEEP</sub> = GND = 0V. R<sub>L</sub> = No load. T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 1)

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

# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

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## ELECTRICAL CHARACTERISTICS (continued)

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

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

# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

## AC CHARACTERISTICS

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

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Color Subcarrier Output Voltage Swing		$V_{DD} = 2.7V$ , $Y_{IN} = 0.65V$ , $C_{IN} = 0.7V_{P-P}$		1.4			$V_{P-P}$
		$V_{DD} = 3.0V$ , $Y_{IN} = 0.75V$ , $C_{IN} = 0.9V_{P-P}$		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%

# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

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## AC CHARACTERISTICS (continued)

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

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
2T Bar Response		Bar time is 18 $\mu$ s, the beginning 2.5% and the ending 2.5% of the bar time are ignored, 2T = 200ns or 250ns		0.2		K%
2T Pulse-to-Bar K Rating		Bar time is 18 $\mu$ s, the beginning 2.5% and the ending 2.5% of the bar time are 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 $\leq$ f $\leq$ 5MHz, inputs are 1V <sub>p-p</sub>		10		ns
Interchannel Group Delay Distortion Error		Outputs are 2V <sub>p-p</sub>		2		ns
Peak Signal to RMS Noise		100kHz $\leq$ f $\leq$ 5MHz, inputs are 1V <sub>p-p</sub>		67		dB
Power-Supply Rejection Ratio		f = 100kHz, 200mV <sub>p-p</sub> , input referred		43		dB
Output Impedance		f = 5MHz		6		$\Omega$
Enable Time		YIN = 1V, output settled to within 1% of the final voltage, $R_L = 150\Omega$ to GND		13		$\mu$ s
Disable Time		YIN = 1V, output settled to within 1% of the final voltage, $R_L = 150\Omega$ to GND		1.1		$\mu$ s
<b>CROSSTALK</b>						
All Hostile Output Crosstalk		f = 4.43MHz		-71		dB
All Hostile Input Crosstalk		f = 4.43MHz, $\overline{SHDN} = GND$ , input termination resistors are 75 $\Omega$		-106		dB

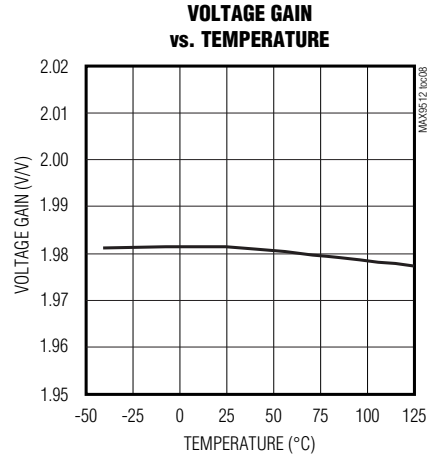
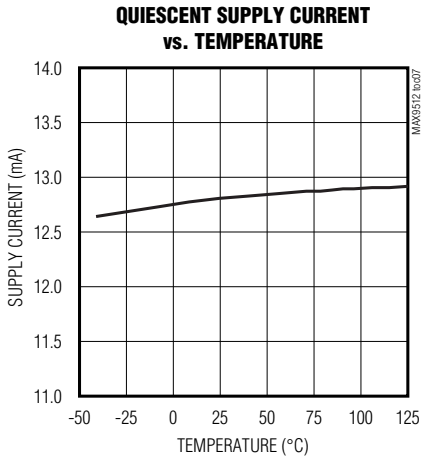
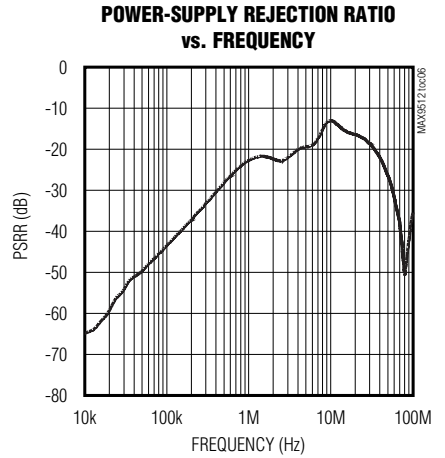
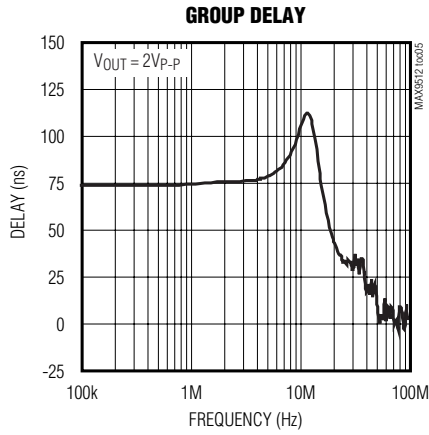
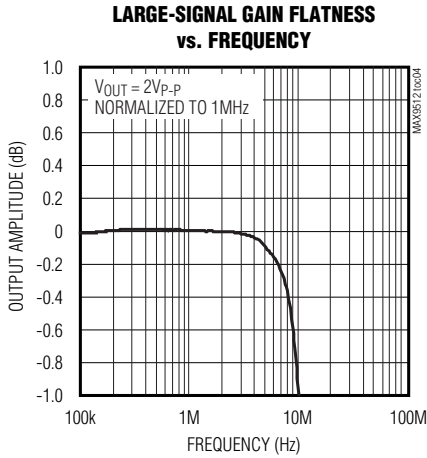
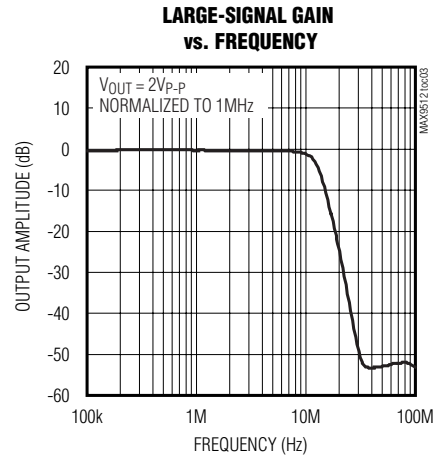
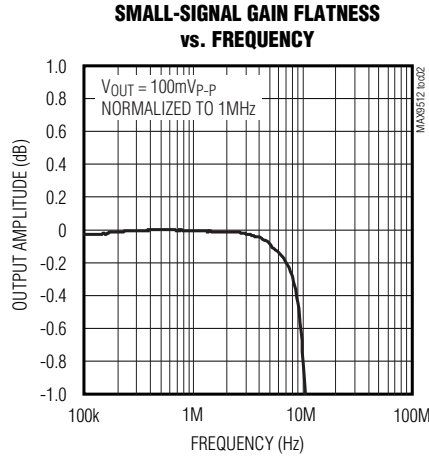
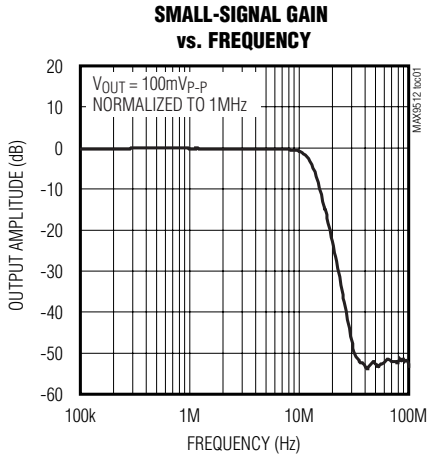
**Note 1:** All devices are 100% production tested at  $T_A = +25^\circ C$ . Specifications over temperature limits are guaranteed by design.

**Note 2:** Specified current is an average over time.

# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

## Typical Operating Characteristics

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

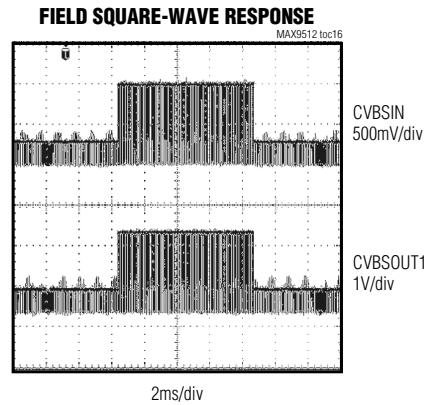
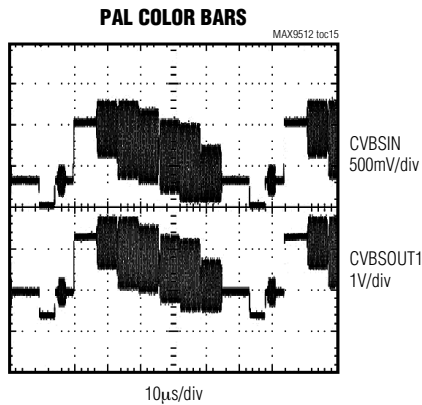
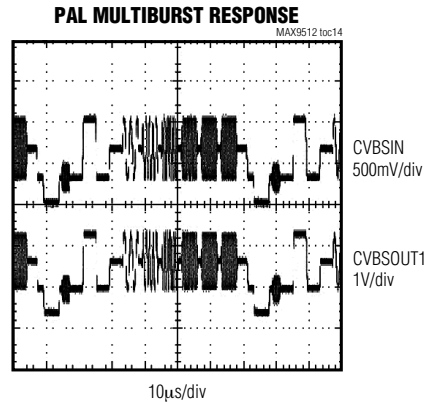
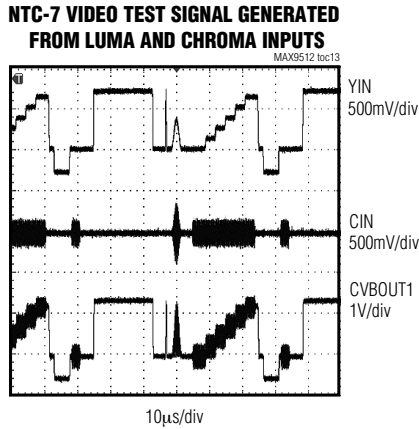
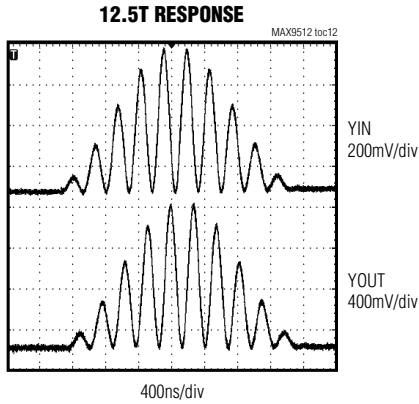
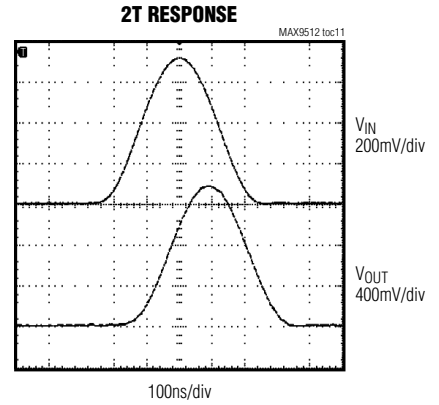
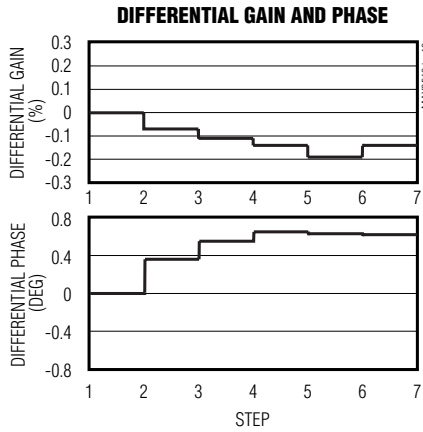
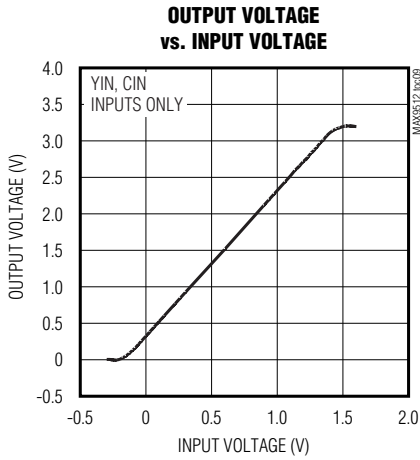


# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

MAX9512

## Typical Operating Characteristics (continued)

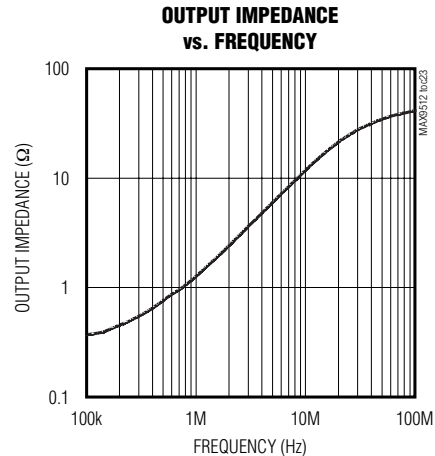
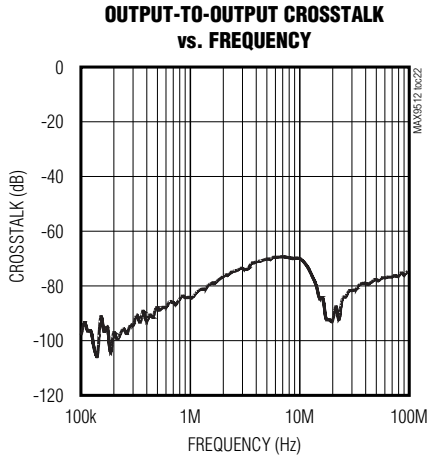
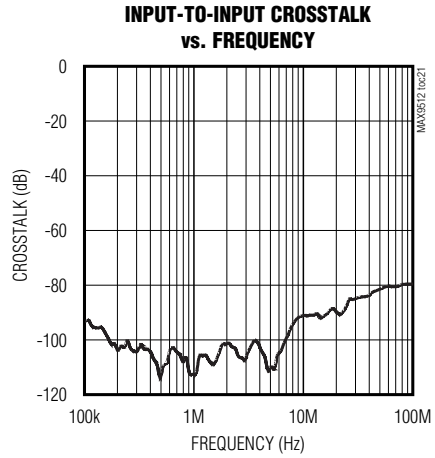
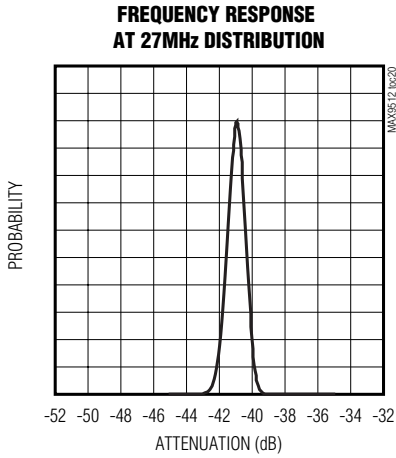
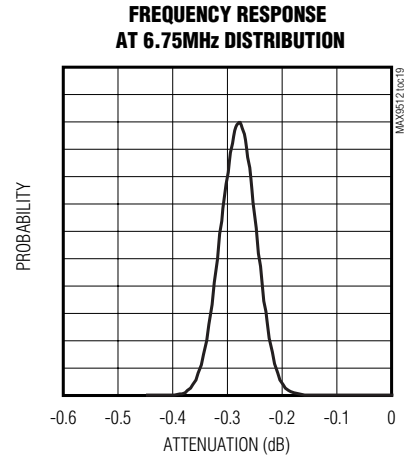
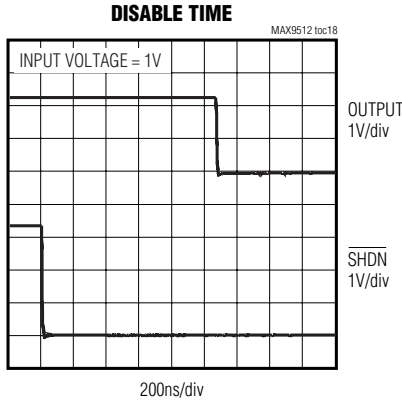
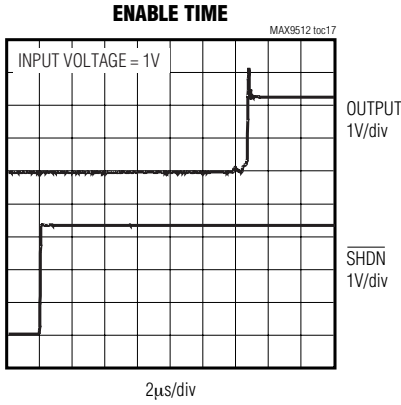
( $V_{DD} = V_{SHDN} = +3.3V$ ,  $V_{SMARTSLEEP} = GND = 0V$ . Video outputs have  $R_L = 150\Omega$  connected to GND.  $T_A = +25^\circ C$ , unless otherwise noted.)



# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

## Typical Operating Characteristics (continued)

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





# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

## Pin Description

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PIN		NAME	FUNCTION
TQFN	QSOP		
1, 13	3, 15	V <sub>DD</sub>	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	$\overline{\text{SHDN}}$	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.

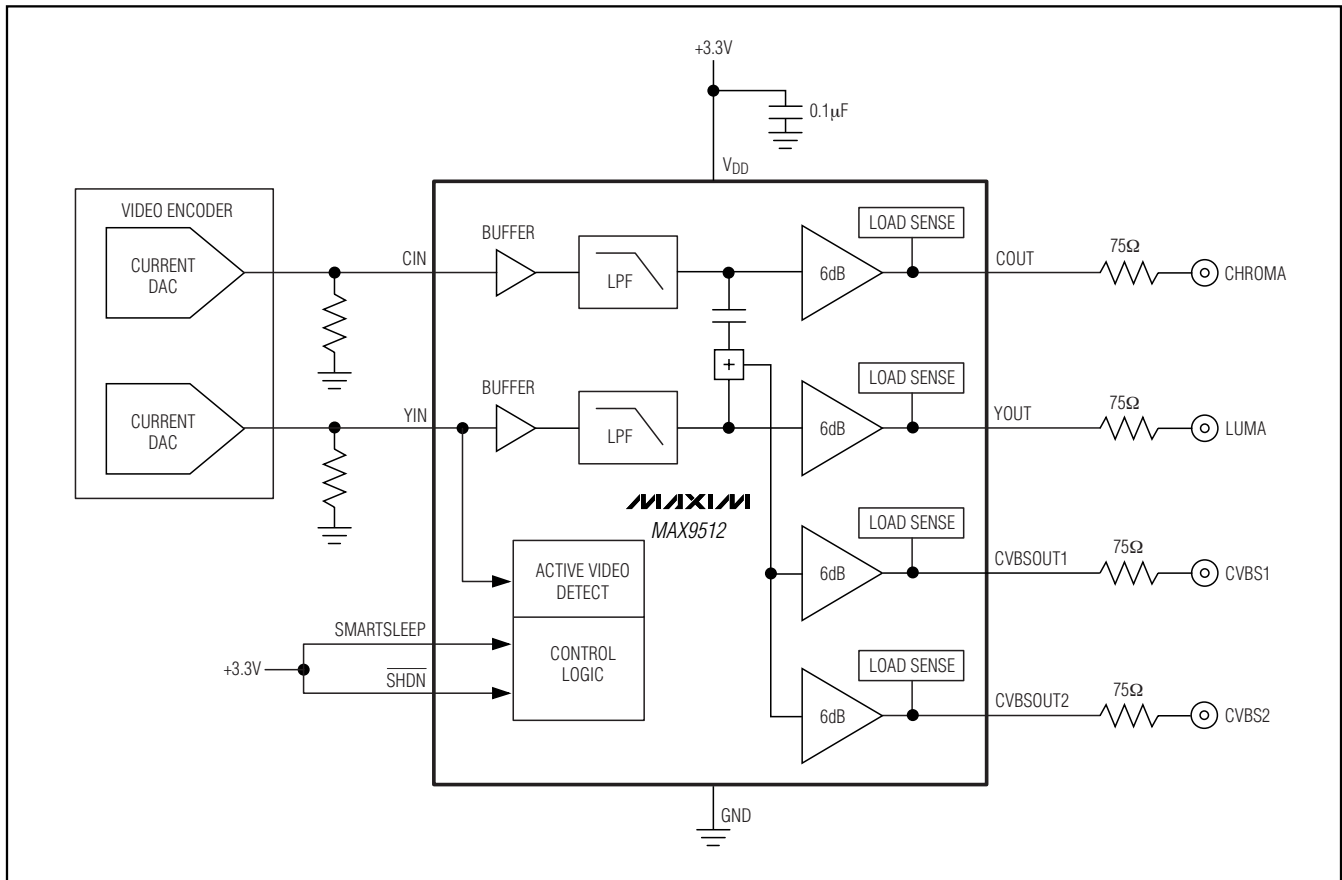


Figure 1. Typical Application Circuit for Portable Media Players

# 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 operational. 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.

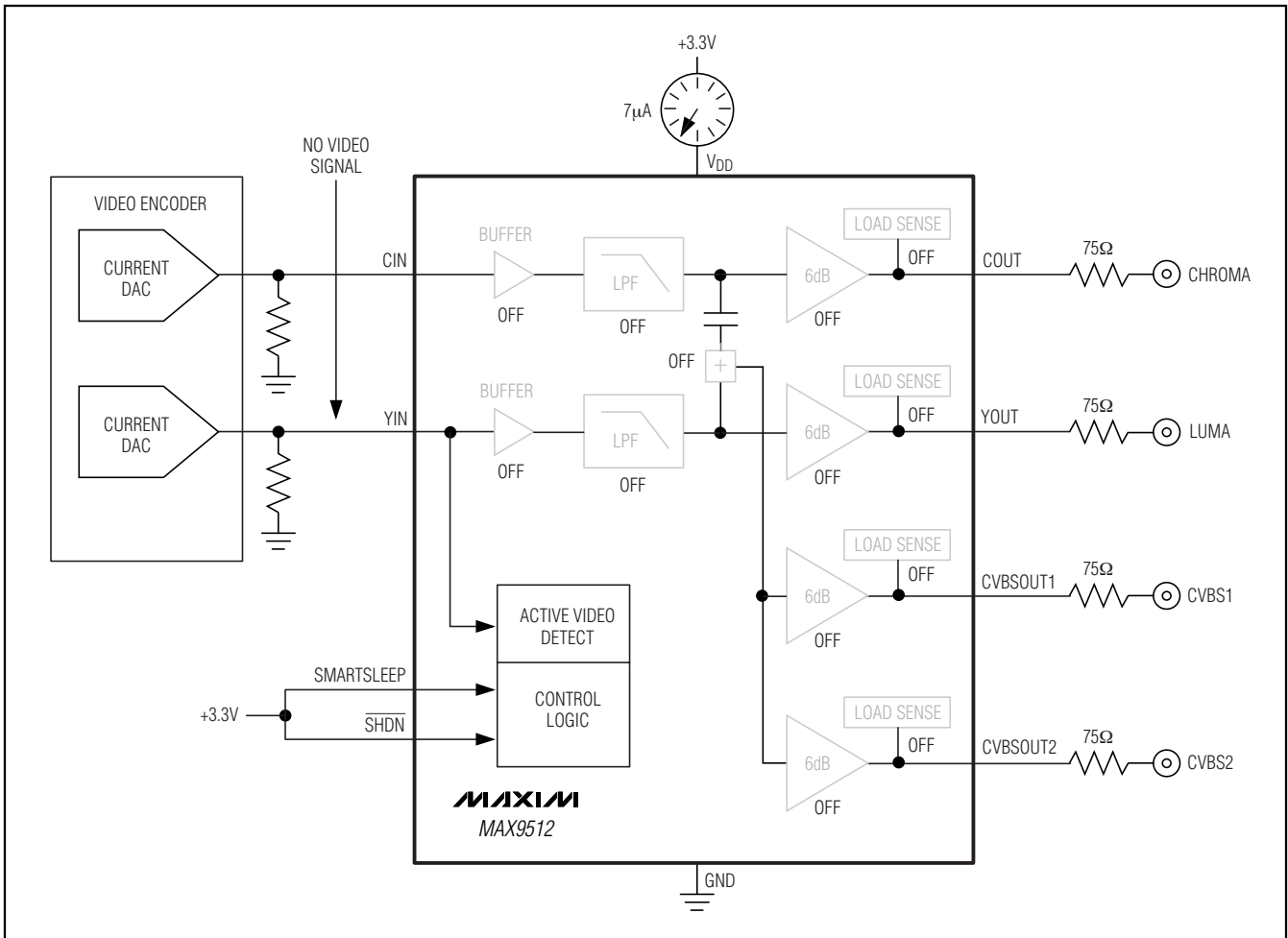


Figure 2. Standby Mode Operation

# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

## 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 14.3kHz 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 17 $\mu$ A.

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 15k $\Omega$  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 64 $\mu$ s), 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.

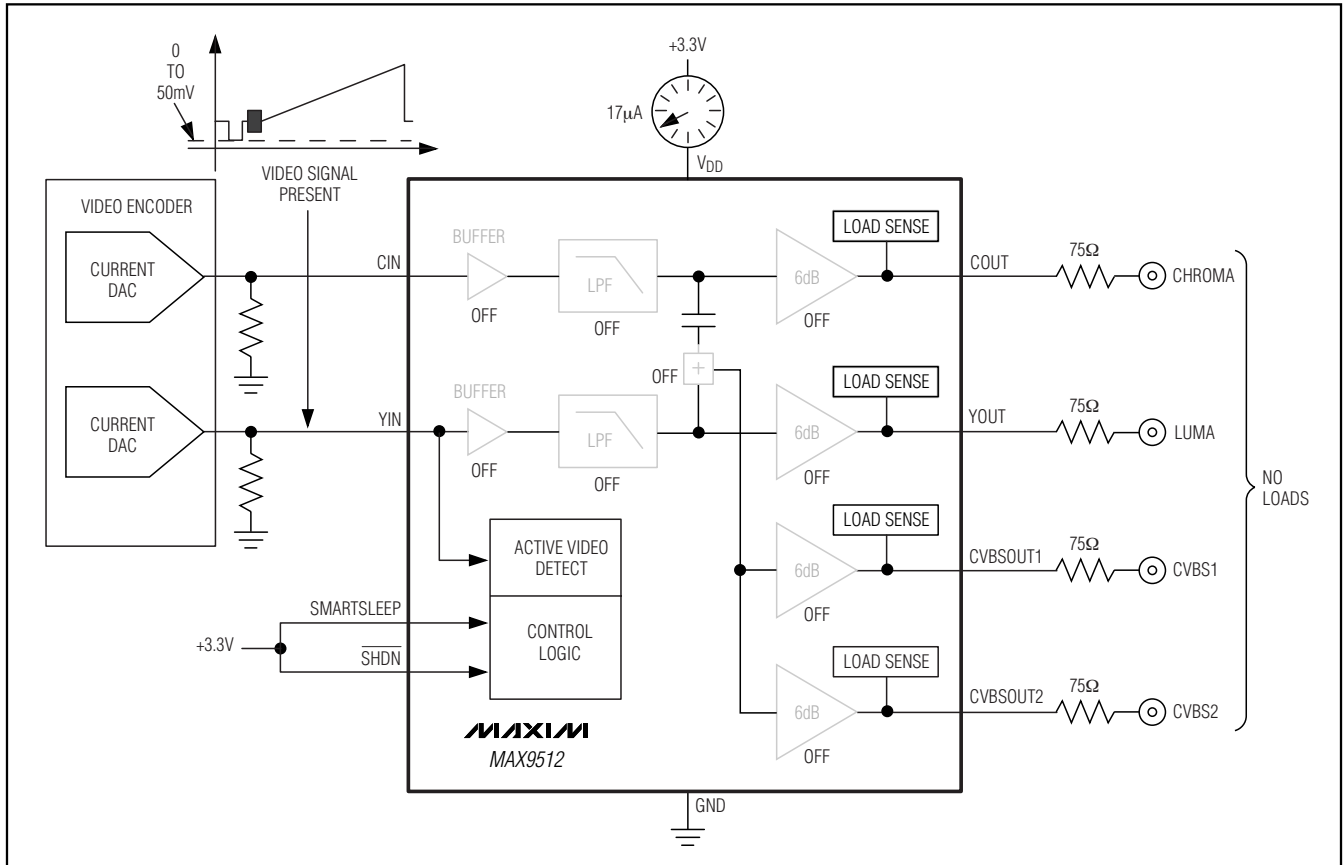


Figure 3. Active-Detect Mode with No Output Loads

# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

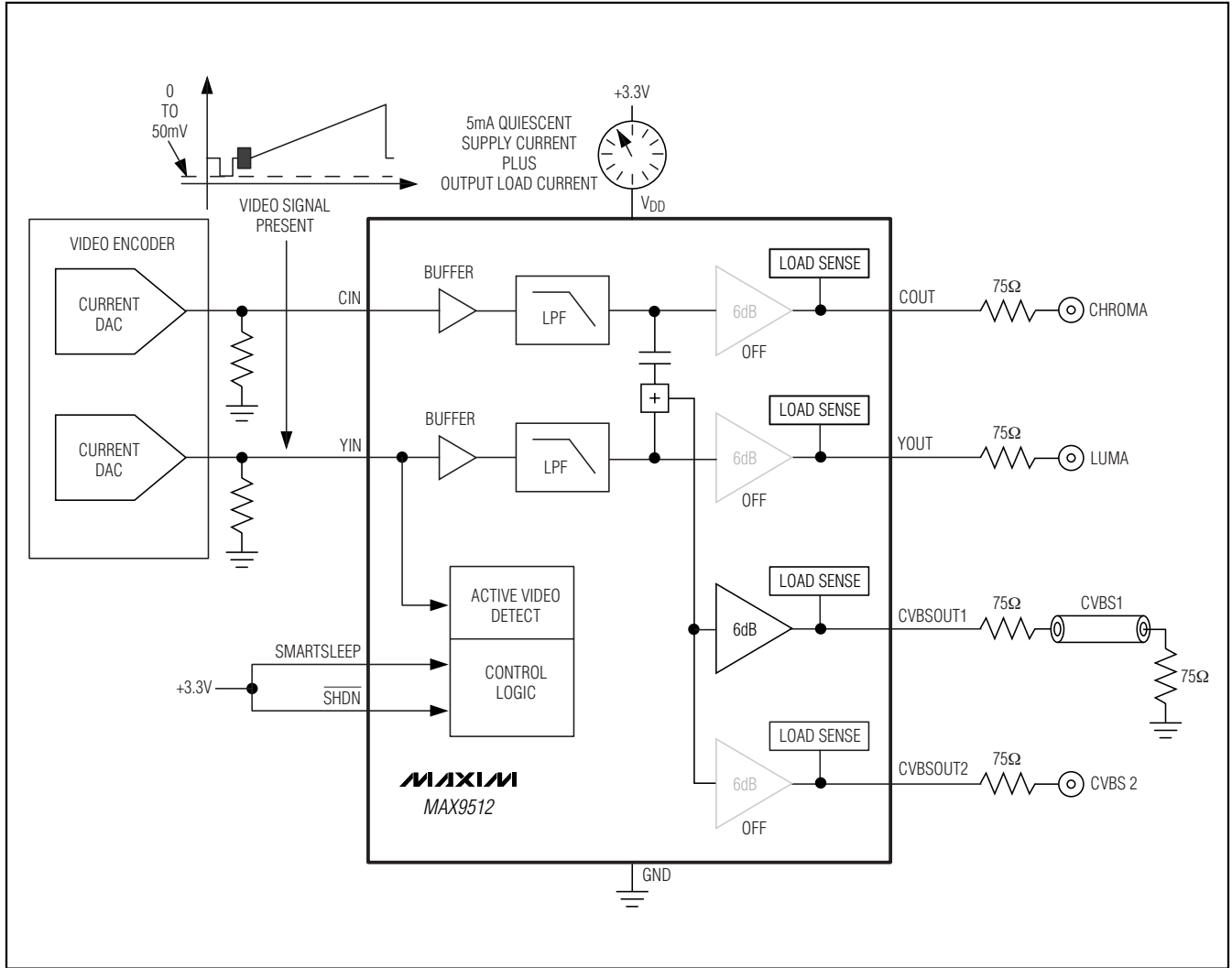


Figure 4. Full Operation Mode with CVBSOUT1 Loaded

# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

MAX9512

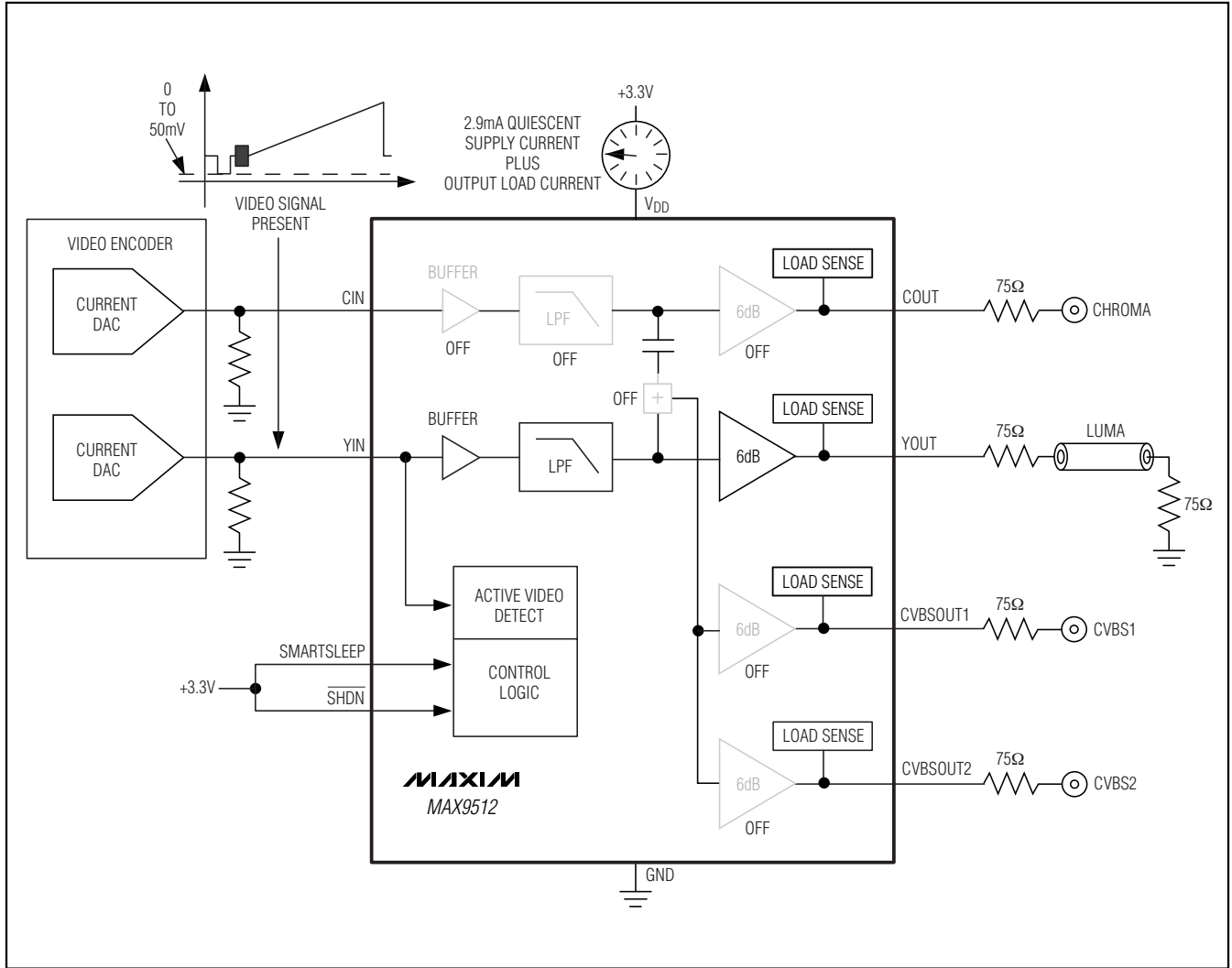


Figure 5. Full Operation Mode with YOUT Loaded

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## 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  $\overline{\text{SHDN}}$  is low, the MAX9512 draws less than 1 $\mu$ A supply current. All the amplifier outputs become high impedance. The effective output resistance at the video outputs is 28k $\Omega$ , 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 300 $\Omega$ . 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 37.5 $\Omega$ , the DAC must source 26.7mA when the output is 1V. If the output resistor is increased to 300 $\Omega$ , 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, 300 $\Omega$  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.

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## 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 220 $\mu$ F or greater to keep the highpass filter formed by the 150 $\Omega$  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. SmartSleep only works with DC-coupled loads.

## 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 0.1 $\mu$ F capacitor. Place all external components as close to the device as possible.

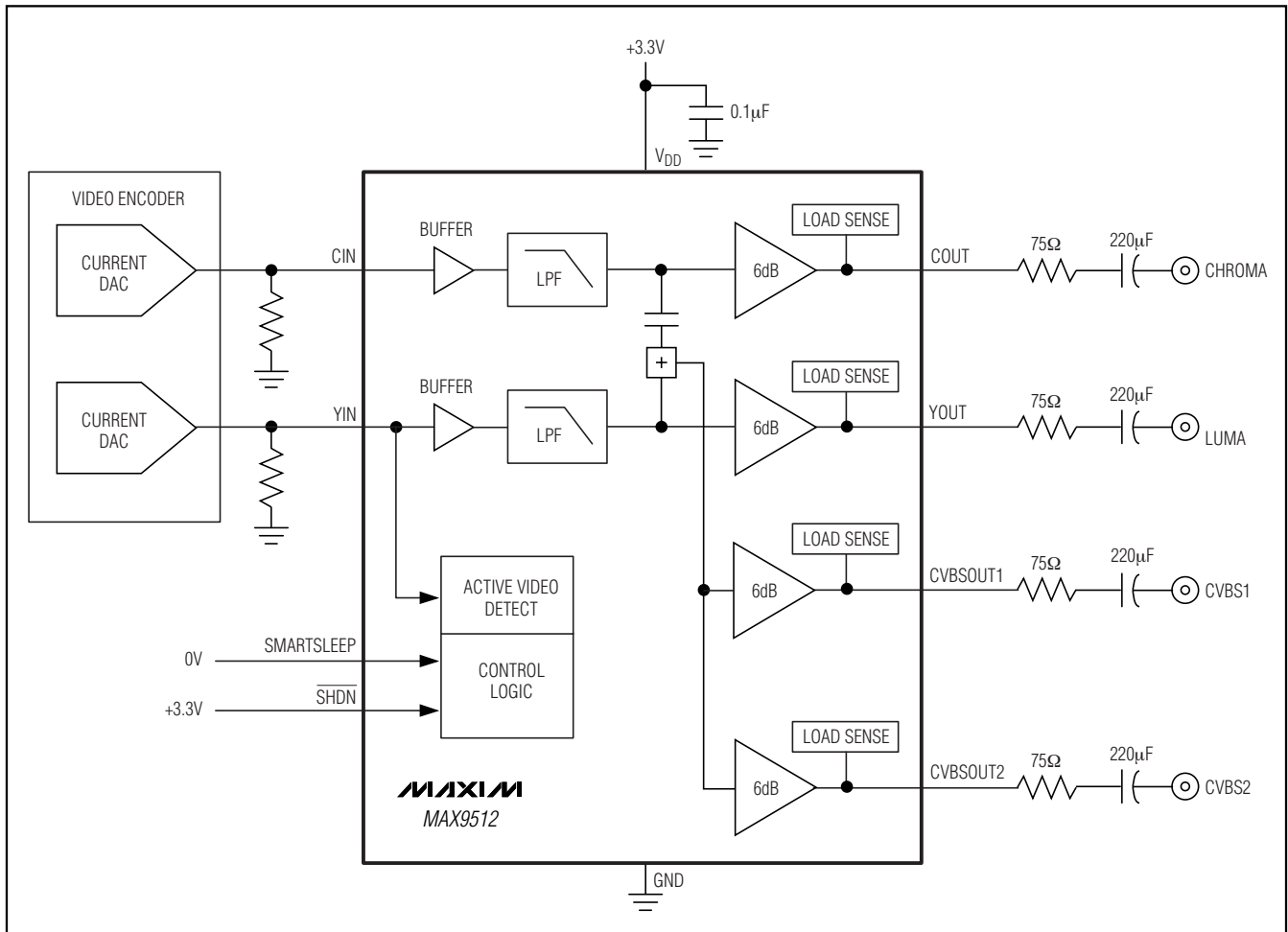
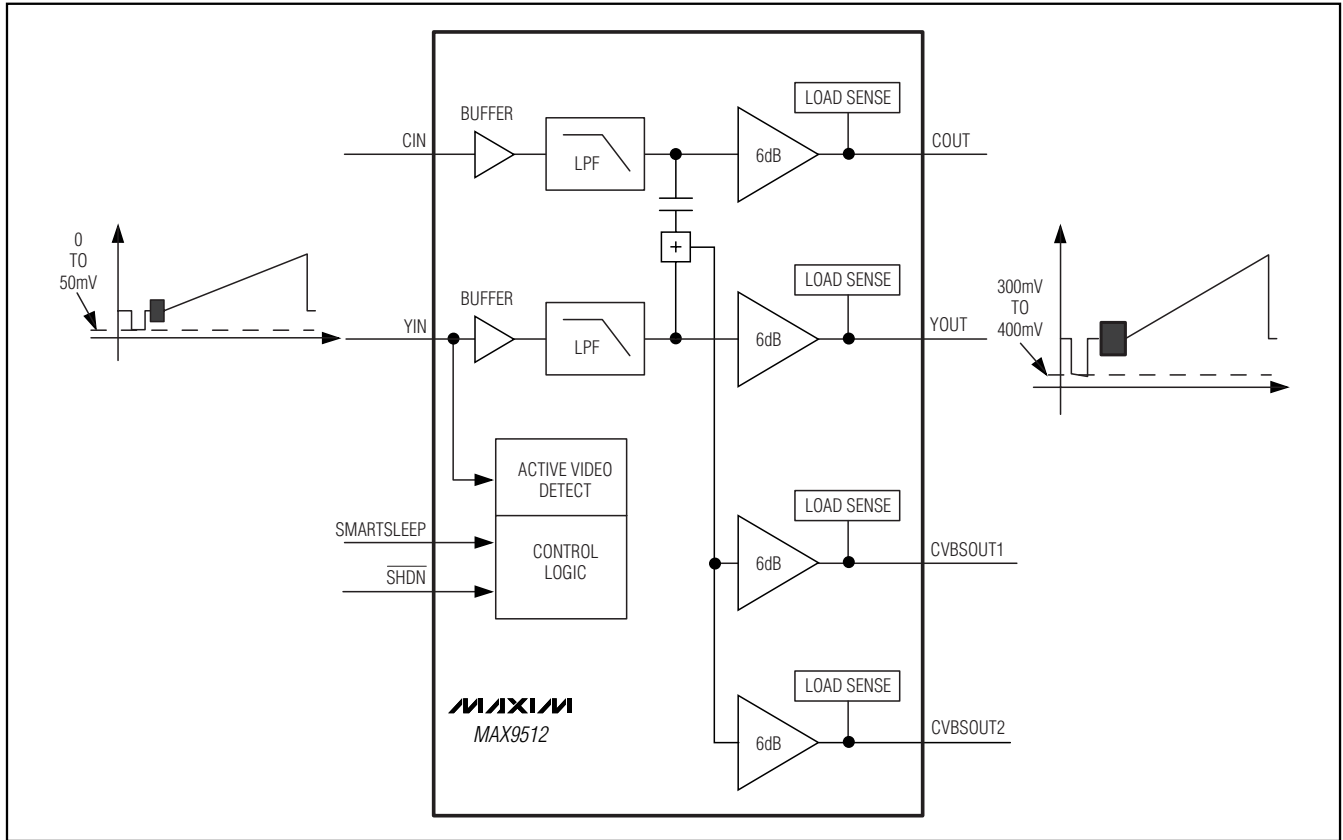


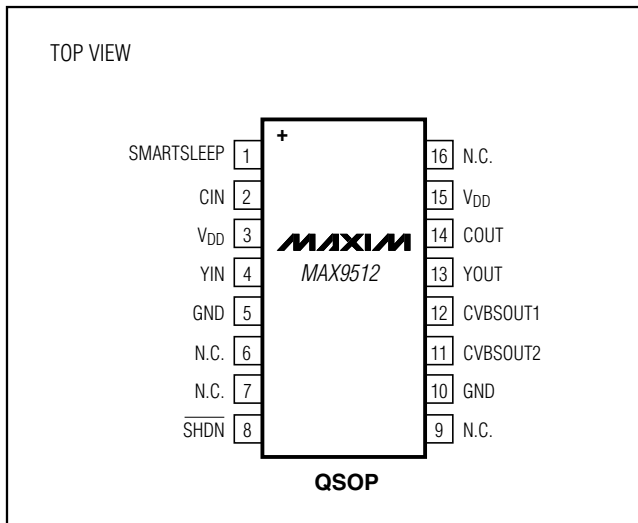
Figure 6. AC-Coupling at the Outputs

# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

## Block Diagrams (continued)



## Pin Configurations (continued)



## Chip Information

PROCESS: BiCMOS

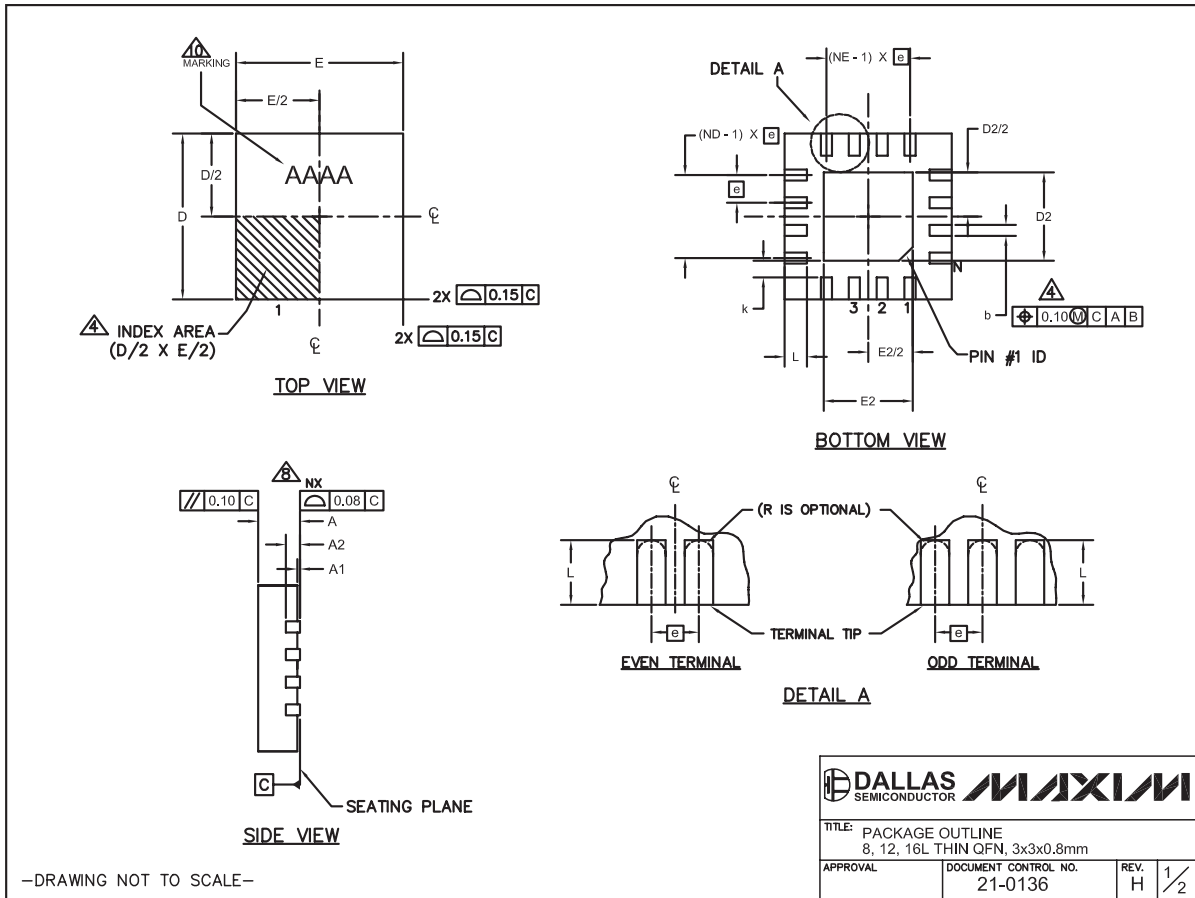


# Video Filter Amplifier with SmartSleep and Y/C Mixer Circuit

## 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](http://www.maxim-ic.com/packages).)

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## Package Information (continued)

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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
	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
T1233-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1
T1233-3	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1
T1233-4	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1
T1633-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2
T1633-2	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2
T1633F-3	0.65	0.80	0.95	0.65	0.80	0.95	0.225 x 45°	WEED-2
T1633FH-3	0.65	0.80	0.95	0.65	0.80	0.95	0.225 x 45°	WEED-2
T1633-4	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2

**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-

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

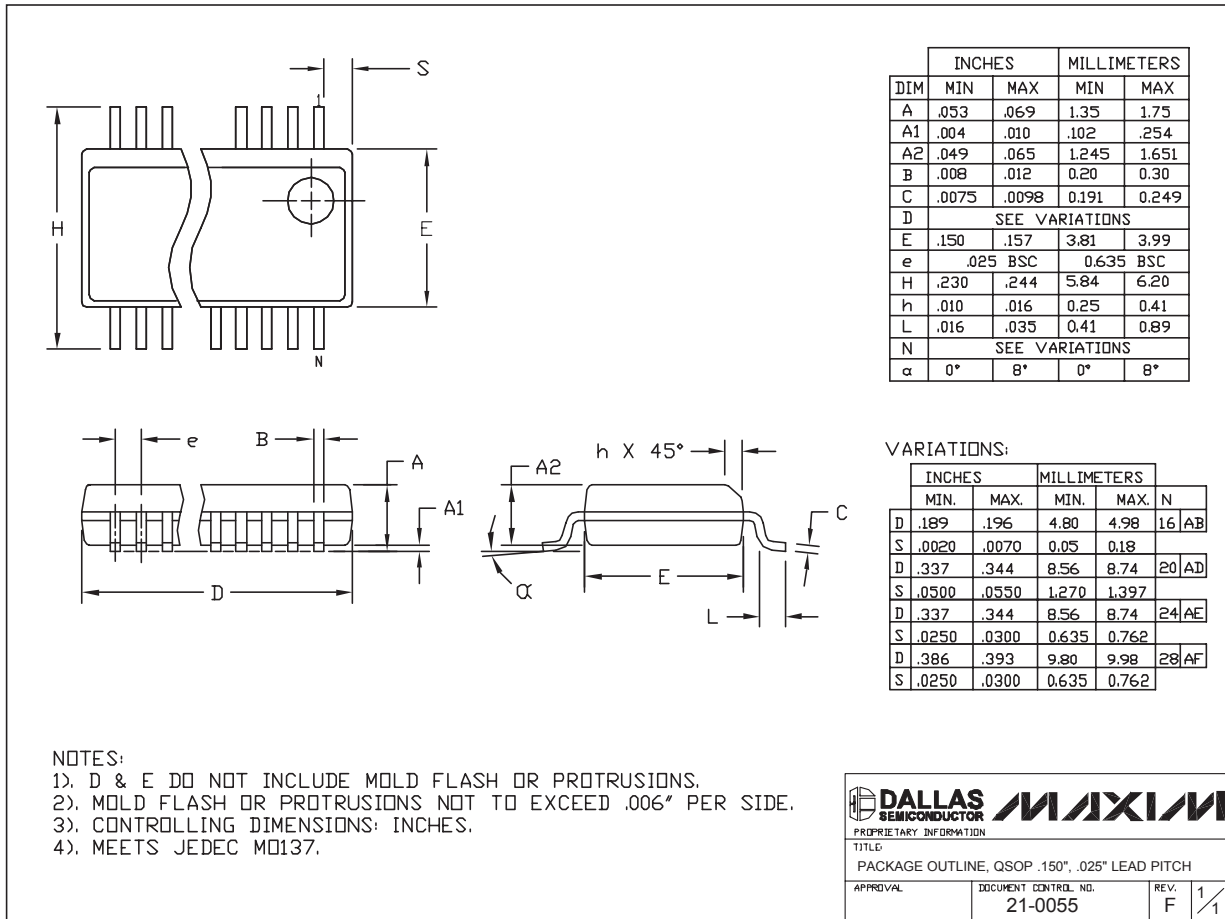
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QSOP-EFS



## Revision History

Pages changed at Rev 1: 1, 2, 5-8, 10-16, 19

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