4-channel Video Amplifier with 1-CVBS and 3-1080p Full-HD Filters

Features

- 1-SDTV Video Filter Support CVBS
- 3-HDTV Video Filter Support Y'Pb'Pr'-1080p, R'G'B' or VGA/SVGA/XGA
- Optimized 6th-order Butterworth Video reconstruction filter：
  CVBS Channel: -3dB at 9MHz
  HD Channel: -3dB ≥ 72MHz
- Support Multiple Input Biasing:
  - Provide 80-mV Level-Shift when DC-Coupled
  - Transparent Input Clamping when AC-Coupled
  - Support External DC Biasing when AC-Coupled
- Very Low Quiescent Current: 38.3 mA(at 3.3V, Typical)
- 6dB Gain(2V/V), Rail TO Rail Output
- AC- or DC-Coupled Output Driving Dual Video Loads (75Ω)
- Wide Power Supply: +3.0V to +5.5V Single Supply
- Robust ESD Protection:
  - Robust 8kV – HBM and 2kV – CDM ESD Rating
- Green Product, MSOP-10-EP 和 TSSOP-14 Package

Applications

- Video Signal Amplification
- Set-Top Box Video Driver
- PVR、DVD Player Video Buffer
- Video Buffer for Portable or USB-Powered Video Devices
- HDTV

Description

TPF144 is a specially designed for consumer applications, high-performance, low-cost video reconstruction filter, it combine excellent video performance and low power consumption perfectly. It incorporates one standard-definition (CVBS) and three high-definition (HD) filter channels. All filters feature sixth-order Butterworth characteristics that are useful as digital-to-analog converter (DAC) reconstruction filters or as analog-to-digital converter (ADC) anti-aliasing filters. The HD filters can be bypassed to support filters. The HD filters can be bypassed to support 1080p60 video or up to quad extended graphics array (QXGA) RGB video.

As part of the TP144 flexibility, the input can be configured for ac- or dc-coupled inputs. The 84-mV output level shift allows for a full sync dynamic range at the output with 0-V input. The ac-coupled modes include a transparent sync-tip clamp option for composite video (CVBS), Y', and G'B'R' signals. AC- coupled biasing for C'/P'B/P'R channels can easily be achieved by adding an external resistor to VS+.

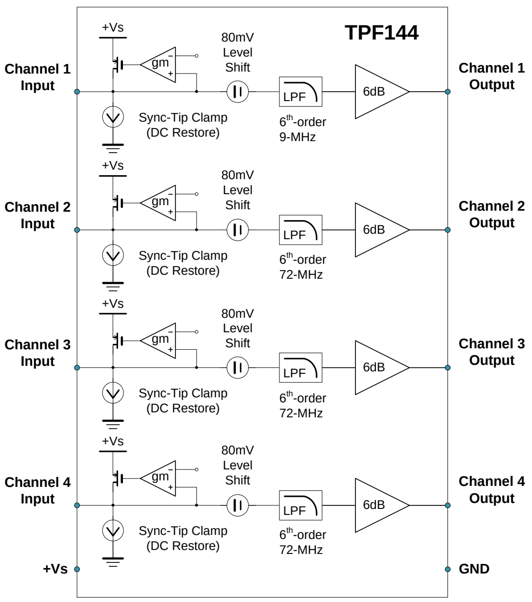
The TP144 rail-to-rail output stage with 6-dB gain allows for both ac and dc line driving. The ability to drive two lines, or 75-Ω loads, allows for maximum flexibility as a video line driver. The 38.3-mA total quiescent current at 3.3 V makes it an excellent choice for power-sensitive video applications.

TPF144 is available in MSOP-10 package (TPF144-V) and TSSOP-14 package (TPF144-T). Its operation temperature range is from −40°C to +85°C.

Related Resources

AN-1201: Application notes of TPF1xx

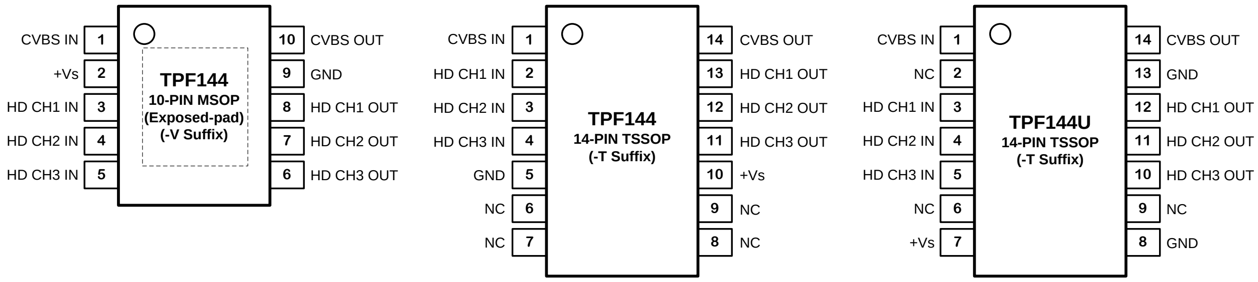
Function Block



Order Information

Order Number	Operating Temperature Range	Package	Marking Information	Transport Media, Quantity
TPF144-VR	-40 to 85°C	MSOP-10-EP	TPF144	Tape and Reel, 3000
TPF144-TR	-40 to 85°C	TSSOP-14	TPF144	Tape and Reel, 3000
TPF144U-TR	-40 to 85°C	TSSOP-14	TPF144U	Tape and Reel, 3000

Pin configuration (Top View)



Pin Functions

Pin Number			Pin Name	Function
1	1	1	CVBS IN	SD Video Input, Channel 1
3	2	3	HD CH1 IN	HD Video Input, Channel 2
4	3	4	HD CH2 IN	HD Video Input, Channel 3
5	4	5	HD CH3 IN	HD Video Input, Channel 4
2	10	7	$+V_S$	Positive Power Supply
	6,7,8,9	2, 6, 9	NC	No Connection
9	5	8,13	GND	Ground
6	11	10	HD CH3 OUT	HD Filtered Output, Channel 4
7	12	11	HD CH2 OUT	HD Filtered Output, Channel 3
8	13	12	HD CH1 OUT	HD Filtered Output, Channel 2
10	14	14	CVBS OUT	SD Filtered Output, Channel 1

Absolute Maximum Ratings*

Parameters		Value	Units
Power Supply, V_{DD} to GND		6.0	V
V_{IN}	Input Voltage	V_{DD} + 0.3V to GND - 0.3V	
I_O	Output Current	65	I_O
T_J	Maximum Junction Temperature	150	T_J
T_A	Operating Temperature Range	–45 to 85	T_A
T_{STG}	Storage Temperature Range	–65 to 150	T_{STG}
TL	Lead Temperature (Soldering 10 sec)	300	TL

*** Note:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	MIL-STD-883H Method 3015.8	8	kV
CDM	Charged Device Model ESD	JEDEC-EIA/JESD22-C101E	2	kV

Electrical Characteristics

All test condition is VDD = 3.3V, TA = +25°C, RL = 150Ω to GND, unless otherwise noted.

SYMBOL	PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
Input Electrical Specifications							
V_{DD}	Supply Voltage Range			3.0		5.5	V
I_{DD}	Quiescent current (I_Q) (1)		V_{DD} = 3.3V, V_{IN} = 500mV, no load		38.3	47.6	mA
			V_{DD} = 5.0V, V_{IN} = 500mV, no load		50.0	61.8	mA
$I_{CLAMP-DOWN}$	Clamp Discharge Current		V_{IN}=300mV, measure current	1.5	2.0	5.1	µA
$I_{CLAMP-UP}$	Clamp Charge Current		V_Y = -0.2V	-1.5	-1.7		mA
V_{CLAMP}	Input Voltage Clamp		I_Y = -100µA	-40	0	+40	mV
R_{IN}	Input Impedance		0.5V < V_Y < 1V	0.5	3		MΩ
AV	Voltage Gain		V_{IN}=0.5V,1V or 2V R_L=150Ω to GND	5.9	6.01	6.03	dB
ΔAV	Channel Mismatch			-2		+2	%
V_{OLS}	Output Level Shift Voltage		V_{IN} = 0V, no load, input referred	53	80	124	mV
V_{OL}	Output Voltage Low Swing		V_{IN} = -0.3V, R_L =75Ω		0.05		V
V_{OH}	Output Voltage High Swing		V_{IN} = 3V, R_L =75Ω to GND (dual load)		3.18		V
PSRR	Power Supply Rejection Ratio		ΔV_{DD} = 3.3V to 3.6V		61		dB
			ΔV_{DD} = 5.0V to 5.5V, 50Hz		67		dB
I_{SC}	Short-circuit current		V_{IN} = 2V, 10Ω, output to GND	65			mA
			V_{IN} =0.1V, output short to V_{DD}	65			mA
AC Electrical Specifications							
f_{-1dB}	-1dB Bandwidth	SD Channel	R_L=150Ω	7.6	8.2	9.1	MHz
		FHD Channel		53.1	63.2	72.9	
f_{-3dB}	-3dB Bandwidth	SD Channel	R_L=150Ω	7.8	9.0	10.5	MHz
		FHD Channel		63.7	71.5	80.1	
Att_{27MHz}	Stop Band Attenuation	SD Channel	f = 27MHz	38.2	57.2		dB
		FHD Channel	f =148MHz	34.0	39.0		dB
dG	Differential Gain		Video input range 1V	-0.1	0.4	0.8	%
dP	Differential Phase		Video input range 1V	-1.1	0.7	1.1	°
THD	Total Harmonic Distortion	SD Channel	f=1MHz, V_{OUT}=1.4V_{PP}	0.03	0.1	0.2	%
		FHD Channel	f=10MHz, V_{OUT}=1.4V_{PP}		0.15		
D/DT	Group Delay Variation	SD Channel	f = 100kHz to 5MHz		5.4		ns
		FHD Channel	f = 100kHz t0 60MHz		6.0		
X_{TALK}	Channel Crosstalk		f = 1MHz, V_{OUT}=1.4V_{PP}	-68	-74		dB
SNR	Signal-to-Noise Ration	SD Channel	f= 100kHz to 4.43MHz	65	69		dB
		FHD Channel	f= 100kHz to 60MHz		64		
R_{OUT_AC}	Output Impedance		f = 10MHz		0.5		Ω
CLG	Chroma-Luma-Gain (SD Channel)		400kHz to 3.58MHz and 4.43MHz		0.18	0.4	dB
CLD	Chroma-Luma-Delay (SD Channel)		400kHz to 3.58MHz and 4.43MHz		5		ns

Typical Performance Characteristics All test condition is VDD = 3.3V, TA = +25°C, RL = 150Ω to GND, unless otherwise noted.

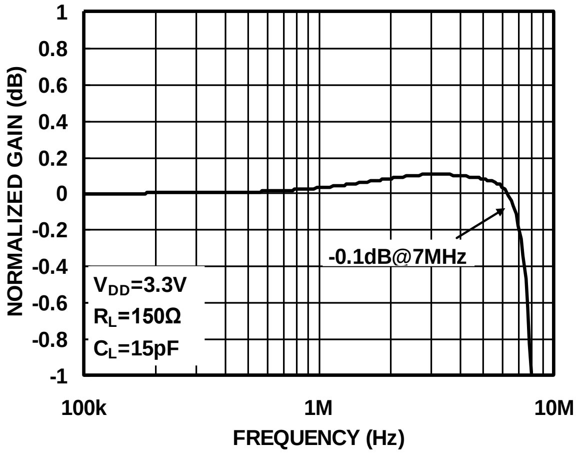


Figure1. Small-Scale Frequency Response

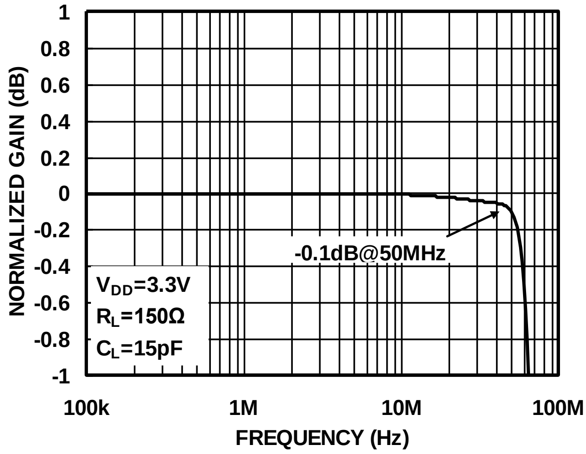


Figure2. Large-Scale Frequency Response

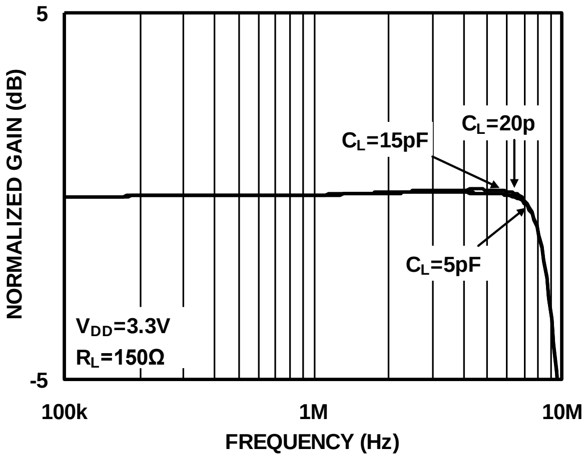


Figure3. Gain Vs. Frequency With CLOAD (SD Channel)

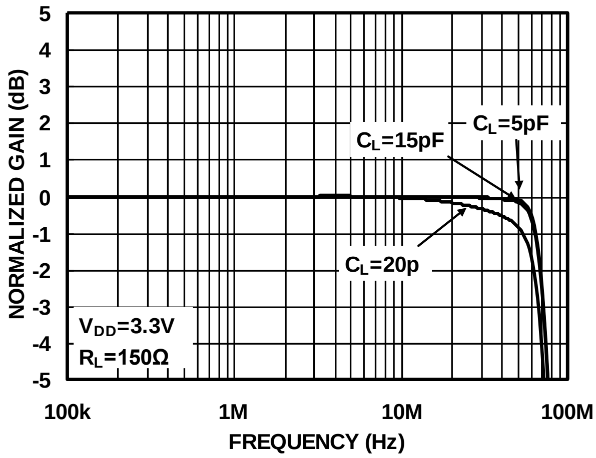


Figure4. Gain Vs. Frequency With CLOAD(FHD Channel)

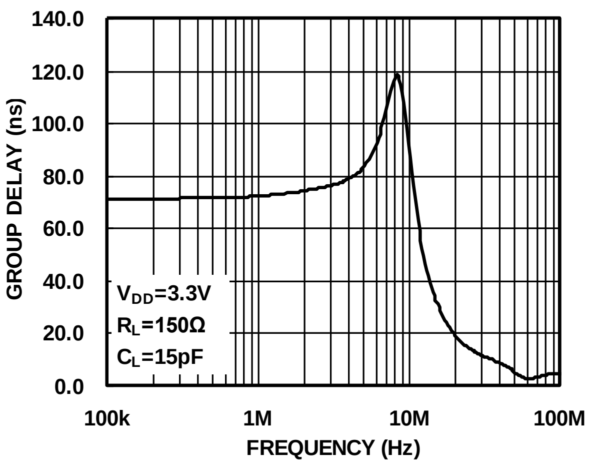


Figure5. Group Delay vs Frequency(SD Channel)

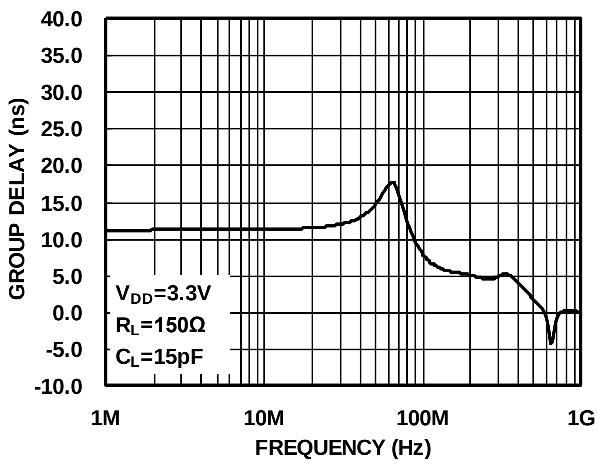


Figure6. Group Delay vs Frequency(FHD Channel)

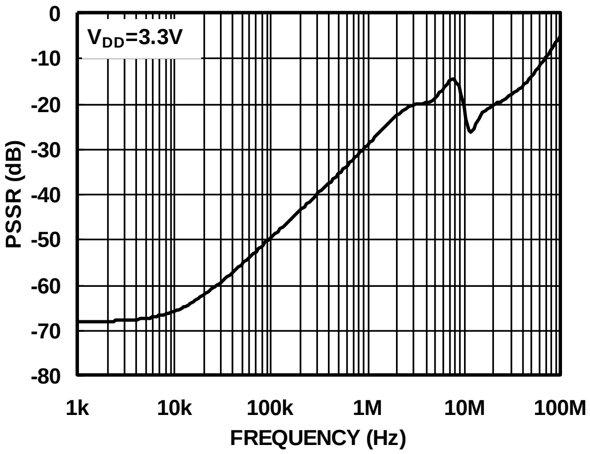


Figure7. PSRR Vs. Frequency(SD)

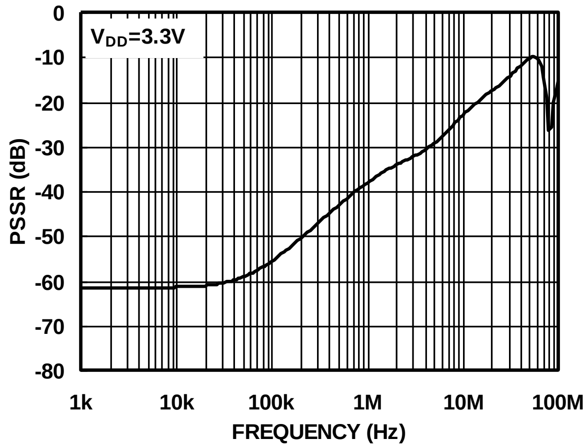


Figure8. PSRR Vs. Frequency(FHD)

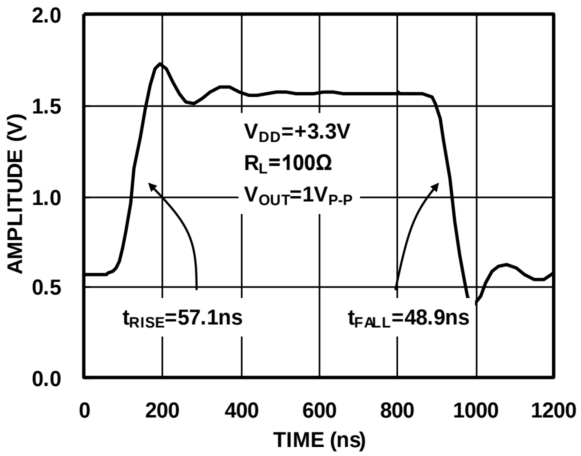


Figure9. Large-Signal Pulse Response Vs. Time(SD Channel)

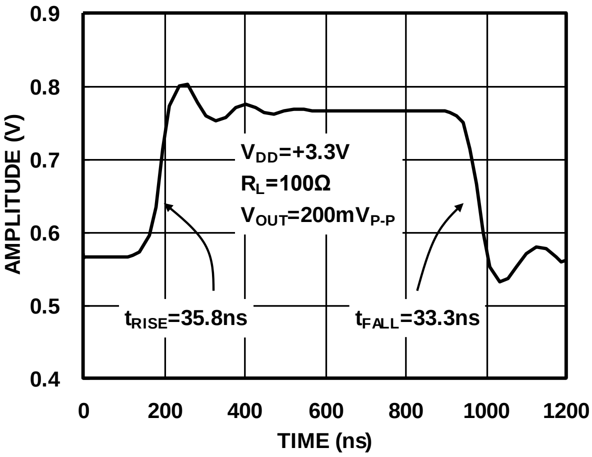


Figure10. Small-Signal Pulse Response Vs. Time(SD Channel)

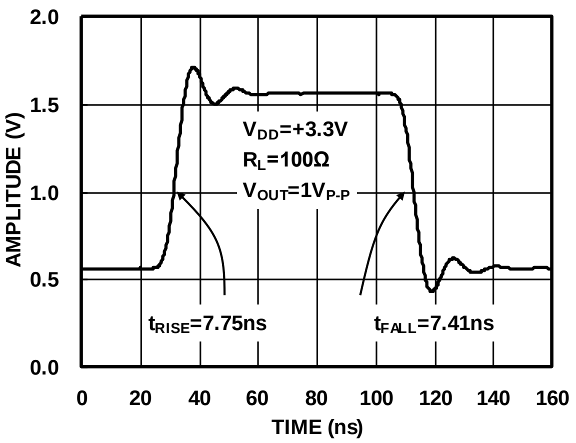


Figure11. Large-Signal Pulse Response Vs. Time(FHD Channel)

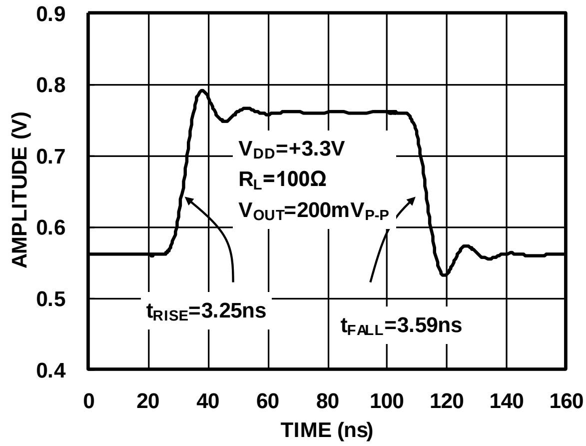
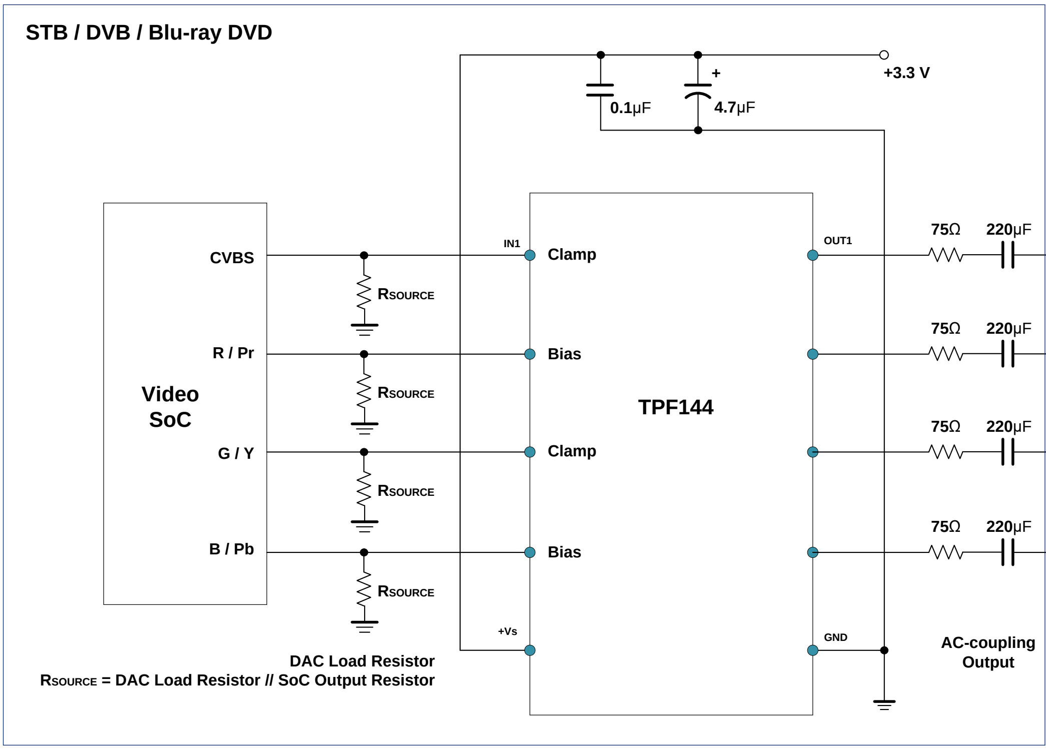


Figure12. Large-Signal Pulse Response Vs. Time(FHD Channel)

Typical Application



Reference Design

Application Information

The TPF144 is targeted for systems that require a single standard-definition (CVBS) video output for CVBS video support along with three high-definition (HD) video outputs. Although it can be used for numerous other applications, the needs and requirements of the video signal are the most important design parameters of the TPF144. The TPF144 incorporates many features not typically found in integrated video parts while consuming very low power.

Internal Sync Clamp

The typical embedded video DAC operates from a ground referenced single supply. This becomes an issue because the lower level of the sync pulse output may be at a 0V reference level to some positive level. The problem is presenting a 0V input to most single supply driven amplifiers will saturate the output stage of the amplifier resulting in a clipped sync tip and degrading the video image. A larger positive reference may offset the input above its positive range.

The TPF144 features an internal sync clamp and offset function to level shift the entire video signal to the best level before it reaches the input of the amplifier stage. These features are also helpful to avoid saturation of the output stage of the amplifier by setting the signal closer to the best voltage range.

The simplified block diagram of the TPF144 in Page-1. The AC coupled video sync signal is pulled negative by a current source at the input of the comparator amplifier. When the sync tip goes below the comparator threshold the output comparator is driven negative, The PMOS device turns on clamping sync tip to near ground level. The network triggers on the sync tip of video signal.

Droop Voltage and DC Restoration

Selection of the input AC-coupling capacitance is based on the system requirements. A typical sync tip width of a 64μs NTSC line is 4μs during which clamp circuit restores its DC level. In the remaining 60μs period, the voltage droops because of a small constant 2.0μA sinking current. If the AC-coupling capacitance is 0.1μF, the maximum droop voltage is about 1mV which is restored by the clamp circuit. The maximum pull-up current of the clamp circuit is 1.7mA. For a 4μs sync tip width and 0.1μF capacitor, the maximum restoration voltage is about 80mV.

The line droop voltage will increase if a smaller AC-coupling capacitance is used. For the same reason, if larger capacitance is used the line droop voltage will decrease. Table 1 is droop voltage and maximum restoration voltage of the clamp for typical capacitance.

Table 1. Maximum restoration voltage and droop voltage of Y and CVBS signals for different capacitance

CAP VALUE (nF)	DROOP IN 60μs (mV)	CHARGE IN 4μs (mV)
100	1.2	68
1,000	0.12	6.8

Low Pass Filter--Sallen Key

The Sallen Key is a classic low pass configuration. This provides a very stable low pass function, and in the case of the TPF144, two six-pole roll-off at around 9MHz and 72MHz. The six-pole function is accomplished with an RC low pass network placed in series with and before the Sallen Key.

Output Couple

TPF144 output could support both “AC Couple” and “DC Couple”, if use “AC Couple”, this capacitor is typically between 220-μF and 1000-μF, although 470-μF is common. This value of this capacitor must be this large to minimize the line tilt (droop) and/or field tilt associated with ac-coupling as described previously in this document.

The TPF144 internal sync clamp makes it possible to DC couple the output to a video load, eliminating the need for any AC coupling capacitors, thereby saving board space and additional expense for capacitors. This makes the TPF144 extremely attractive for portable video applications. Additionally, this solution completely eliminates the issue of field tilt in the lower frequency. The trade off is greater demand of supply current. Typical load current for AC coupled is around 1mA, compared to typical 6.6mA used when DC coupling.

Output Drive Capability and Power Dissipation

With the high output drive capability of the TPF144, it is possible to exceed the +125°C absolute maximum junction temperature under certain load current conditions. Therefore, it is important to calculate the maximum junction temperature for an application to determine if load conditions or package types need to be modified to assure operation of the amplifier in a safe operating area. The maximum power dissipation allowed in a package is determined according to Equation:

$$PD_{MAX} = \frac{T_{JMAX} - T_{AMAX}}{\theta_{JA}}$$

Where：
T_{JMAX} = Maximum junction temperature
T_{AMAX} = Maximum ambient temperature
Θ_{JA} = Thermal resistance of the package

The maximum power dissipation actually produced by an IC is the total quiescent supply current times the total power supply voltage, plus the power in the IC due to the load, or: for sourcing:

$$PD_{MAX} = V_s \times I_{SMAX} + (V_s - V_{OUT}) \times \frac{V_{OUT}}{R_L}$$

Where：
V_S = Supply voltage
I_{SMAX} = Maximum quiescent supply current
V_{OUT} = Maximum output voltage of the application
R_{LOAD} = Load resistance tied to ground

By setting the two PDMAX equations equal to each other, we can solve the output current and RLOAD to avoid the device overheat.

Power Supply Bypassing Printed Circuit Board Layout

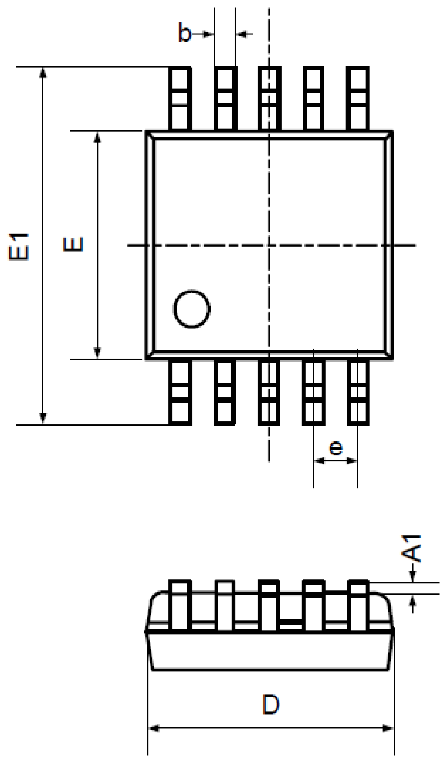
As with any modern operational amplifier, a good printed circuit board layout is necessary for optimum performance. Lead lengths should be as short as possible. The power supply pin must be well bypassed to reduce the risk of oscillation. For normal single supply operation, a single 4.7μF tantalum capacitor in parallel with a 0.1μF ceramic capacitor from VS+ to GND will suffice.

VIDEO FILTER DRIVER SELECTION GUIDE

P/N	Product Description	Channel	-3dB Bandwidth	Package
TPF110 /TPF110L	Low power, enable function and SAG correction, 1 channel 6th order 9MHz	1-SD	9MHz	SC70-5 SOT23-6
TPF113	Low power 3 channel, 6th-order 9MHz SD video filter	3-SD	9MHz	SO-8
TPF114	Low power 4 channel, 6th-order 9MHz SD video filter	4-SD	9MHz	MSOP-10 TSSOP-14
TPF116	Low power 4 channel, 6th-order 9MHz SD video filter for CVBS, SVIDEO	6-SD	9MHz	TSSOP-14
TPF123	3 channel 6th-order 13.5MHz, 960H/720H-CVBS video filter or Y'Pb'Pr 480P/576P video filter	3-ED	13.5MHz	SO-8
TPF133	Low power 3 channel, 6th-order 36MHz HD video filter	3-HD	36MHz	SO-8
TPF134	Low power 3 channel, 6th-order 36MHz HD video filter and 1 channel SD video filter	1-SD& 3-SD	9MHz 36MHz	MSOP-10 TSSOP-14
TPF136	Low power 3 channel, 6th-order 36MHz HD video filter and 3 channel SD video filter	3-SD& 3-HD	9MHz 36MHz	TSSOP-20
TPF143	Low power 3 channel, 6th-order 72MHz Full HD video filter	3-FHD	72MHz	SO-8
TPF144	Low power 3 channel, 6th-order 72MHz Full HD video filter and 1 channel SD video filter	1-SD& 3-FHD	9MHz 72MHz	MSOP-10 TSSOP-14
TPF146	Low power 3 channel, 6th-order 72MHz Full HD video filter and3 channel SD video filter	3-SD& 3-FHD	9MHz 72MHz	TSSOP-20
TPF153	Low power 3 channel, 6th-order 220MHz Full HD video filter	3-CH	220MHz	SO-8

Package Outline Dimensions

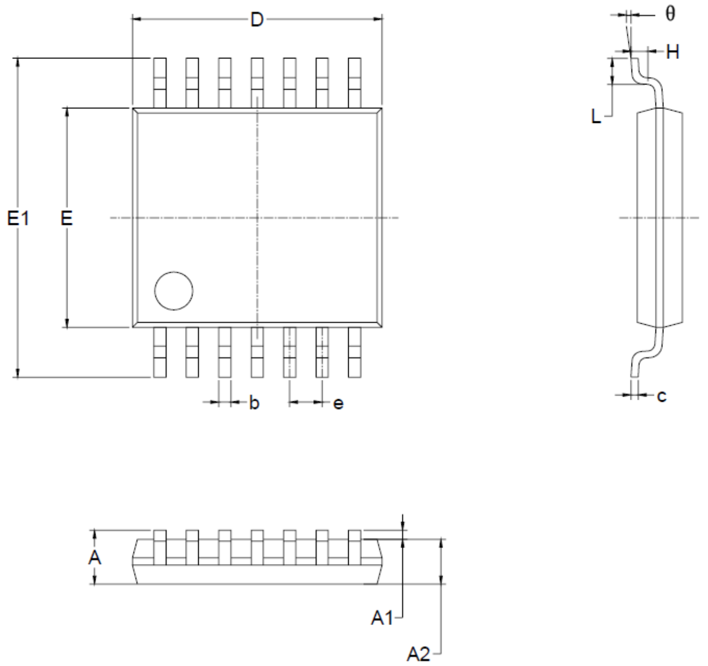
10 Lead MSOP Package——Main Body 3.00 mm [MSOP_N]



Units	Inches			Millimeters		
Dimensions	MIN	TYP	MAX	MIN	TYP	MAX
n		10			10	
e		.020			0.50	
A	.031		.047	0.80	1.00	1.20
A2	.030		.038	0.76		0.97
A1	.000		.008	0.00		0.20
E1	.185		.201	4.70		5.10
E	.114		.122	2.90	3.00	3.10
D	.114		.122	2.90	3.00	3.10
L	.016		.026	0.41		0.65
Φ	0°		6°	0°		6°
C		.006			0.152	
b		.012			0.30	

Package Outline Dimensions

14 Lead TSSOP Package——Main Body 4.40 mm [TSSOP_N]



Units	Inches			Millimeters		
Dimensions	MIN	TYP	MAX	MIN	TYP	MAX
n		14			14	
e		.026			0.65	
A		.043			1.10	
A2	.031		.039	0.80		1.00
A1	.002		.006	0.05		0.15
E1	.246		.258	6.25		6.55
E	.169		.177	4.30	4.40	4.50
D	.193		.201	4.90	5.00	5.10
L	.002		.028	0.50		0.70
Φ	1°		7°	1°		7°
c	.004	.006	.008	0.09		0.20
b	.007		.012	0.19		0.30

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