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**ON Semiconductor®** 

# FMS6141 Low-Cost, Single-Channel 4<sup>th</sup>-Order Standard Definition Video Filter Driver

Description

solutions.

The FMS6141 Low -Cost Video Filter is intended to replace

passive LC filters and drivers with a low-cost integrated

device. The 4th-order filter provides improved image

quality compared to typical 2nd or 3rd-order passive

The FMS6141 may be directly driven by a DC-coupled

DAC output or an AC-coupled signal internal diode clamps and bias circuitry may be used if an AC-coupled input is

The FMS6141's output can drive an AC- or DC-coupled

single (150  $\Omega$ ) or dual (75  $\Omega$ ) load. DC-coupling the output

removes the need for output coupling capacitors. The input DC level is offset approximately +280 mV at the

required (see Application Information for details).

output (see Application Information for details).

http://www.onsemi.com/pub/Collateral/AN-

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**Related Applications Notes** 

6041.pdf.pdf

6024.pdf.pdf

## Features

- Single 4th-Order 8 MHz (SD) Filter
- Drives Single, AC- or DC-coupled, Video Loads (2 V<sub>pp</sub>, 150 Ω)
- Drives Dual, AC- or DC-coupled, Video Loads (2V<sub>pp</sub>, 75Ω)
- Transparent Input Clamping
- AC- or DC-Coupled Input
- AC- or DC-Coupled Output
- DC-Coupled Output Eliminates AC-Coupling Capacitors
- Single Supply
- Robust 8 kV ESD Protection
- Lead-Free Packages: SOIC-8 or SC70-5

# Applications

- Cable Set-Top Boxes
- Satellite Set-Top Box es
- DVD Players
- HDTVs
- Personal Video Recorders (FVR)
- Video On Demand (VOD)

# **Functional Block Diagram**



FMS6141CSX   -40°C to +85°C   8-Lead, Small Outline Integrated Circuit (SOIC)   Tape and     FMS6141S5X   -40°C to +85°C   5-Lead SC70 Package   Tape and     Pin Configurations   8   VOUT   7   VCC   GND 1   5   VCC     N/C 2   FMS6141   8   VOUT   7   VCC   GND 1   5   VCC     N/C 2   FMS6141   SOIC-8   6   N/C   GND 2   FMS6141   SC 0-5   4   VOUT     N/C 4   5   N/C   VIN 3   4   VOUT   VIN 3   4   VOUT     Figure 2.   SOIC-8   5   N/C   VIN 3   4   VOUT     Figure 2.   SOIC-8   Figure 2.   SC70   4   VOUT     Figure 2.   SOIC-8   Figure 2.   SC70   4   VOUT     1   3   V <sub>AV</sub> Videb input   5   5   5     2   OL-8   NC   No Connect   5   5   N/C   5     3   1, 2   GND   Must Be Connected to Ground   5   N/C   No Connect <th>Part Number</th> <th>Operat Temperatur</th> <th>ing e Range</th> <th colspan="2">Package</th> <th>Packing Method</th>	Part Number	Operat Temperatur	ing e Range	Package		Packing Method			
FMS61411S5X   -40°C to +85°C   5-Lead SC70 Package   Tape and     Pin Configurations   VIN   1   8   VOUT   5   Vcc     N/C   2   FMS6141   7   Vcc   GND   1   5   Vcc     N/C   2   FMS6141   7   Vcc   GND   2   FMS6141   5   Vcc     N/C   4   5   N/C   VIN   3   4   Vour     Figure 2.   SOIC-8   5   N/C   VIN   3   4   Vour     Figure 2.   SOIC-8   5   N/C   VIN   3   4   Vour     Figure 2.   SOIC-8   Figure 2.   SC70     Pin Definitions     SOIC Pin #   SC70   Wideo Input     1   3   V/W   Video Input   Video Input     3   V2   GND   Must Be Connected to Ground   Video Input	FMS6141CSX	-40°C to +	85°C	8-Lead	, Small O	utline Integra	ted Circuit (SOIC)	Tape and Ree	
Pin Configurations $V_{IN}$ 8 $V_{OUT}$ 7 $N/C$ $GND$ $I$ 7 $V_{CC}$ $GND$ $GND$ 8 $N/C$ $GND$ $I$ $SOIC-8$ $GND$ $I$ $I$ $SOIC-8$ $I$	FMS6141S5X	-40°C to +	85°C	5- Lead	SC70 Pa	ackage		Tape and Ree	
VIN   1   8   VOUT     N/C   2   FMS6141   5   VCC     GND   3   6   N/C   GND   2   FMS6141     GND   3   6   N/C   GND   2   FMS6141   SC / O-5   4   VOUT     Figure 2. SOIC-8   6   N/C   VIN   3   Figure 2. SC / O   4   VOUT     Figure 2. SOIC-8   Figure 2. SC / O     Pin Definitions     SOIC Pin # SC / Pin# Name   Description     1   3   V <sub>IN</sub> Video input   Out     2   NC   No Connect   3   1, 2   GND   Must Be Connected to Ground   Out     3   1, 2   GND   Must Be Connect   0   0   N/C   No Connect   0   <	Pin Configura	ations							
N/C   2   FMS6141   7   V <sub>CC</sub> GND   1   5   V <sub>CC</sub> GND   3   N/C   4   6   N/C   GND   2   FMS6141   SC   0-5   4   V <sub>OUT</sub> Figure 2. SOIC-8   5   N/C   V <sub>IN</sub> 3   4   V <sub>OUT</sub> Figure 2. SOIC-8   Figure 3. SC70     Pin Definitions     SOIC Pin # SC70 Pint   Name   Description     1   3   V <sub>IN</sub> Video input   Output     3   1, 2   GND   Must Be Connected to Ground   Output     3   1, 2   GND   Must Be Connected to Ground   Output     5   N/C   No Connect   Output     5   N/C   No Connect   Output     5   V <sub>CC</sub> +5V Supply, Do Not Float   Output	VIN		8	VOUT					
GND 3   SOIC-8   6   N/C   GND 2   FMS 6141 SC 0-5     N/C 4   5   N/C   VIN 3   4   VOUT     Figure 2. SOIC-8     SOIC Pin #     Advance     Description     1     N/C     N/C     N/C     N/C     N/C     Soinect     Soinect     Soinect     Soinect     Soinect     N/C     N/C     N/C     Soinect     Soinect <td cols<="" td=""><td>N/C</td><td>FMS6141</td><td>7</td><td>V<sub>CC</sub></td><td></td><td>GND 1</td><td></td><td>5 VCC</td></td>	<td>N/C</td> <td>FMS6141</td> <td>7</td> <td>V<sub>CC</sub></td> <td></td> <td>GND 1</td> <td></td> <td>5 VCC</td>	N/C	FMS6141	7	V <sub>CC</sub>		GND 1		5 VCC
N/C   4   5   N/C   VIN   3   4   VOUT     Figure 2. SOIC-8   Figure 3. SC70     Figure 3. SC70     Pin Definitions     SOIC Pin #   SC70 Pint   Name   Description     1   3   V/IV   Video Input     2   N/C   N/C   No Connect     3   1,2   GND   Must Be Connected to Ground     4   N/C   No Connect     5   N/C   No Connect     6   N/C   No Connect     7   5   V <sub>CC</sub> +5V Supply, Do Not Float	GND	SOIC-8	6	N/C		GND 2	FMS6141 SC70-5	JE.	
Figure 2. SOIC-8     Figure 2. SC70     Pin Definitions     SOIC Pin #   SC7   Pin*   Name   Description     1   3   V <sub>IN</sub> Video Input   1     1   3   V <sub>IN</sub> Video Input   1     3   1,2   GND   Must Be Connected to Ground     3   1,2   GND   No Connect     5   N/C   No Connect     6   N/C   No Connect     7   5   V <sub>CC</sub> +5V Supply, Do Not Float	N/C	l	5			V <sub>IN</sub> 3	FO		
SOIC Pin #SC7Pin*NameDescription13V_INVideo Input2NCNo Connect31,2GNDMust Be Connected to Ground4N/CNo Connect5N/CNo Connect6N/CNo Connect75V <sub>cc</sub> +5V Supply, Do Not Float	Pin Definition	Figure 2. SOIC	-8		MM	END	Figure 3. SC7	0	
1   3   V <sub>IN</sub> Video input     2   NC   No Connect     3   1,2   GND   Must Be Connected to Ground     4   N/C   No Connect     5   N/C   No Connect     6   N/C   No Connect     7   5   V <sub>CC</sub> +5V Supply, Do Not Float	SOIC Pin #	SC70 Pin#	Nan	ie	<u>KÞ</u>	<u>, 60,</u>	Description		
2 NC No Connect   3 1, 2 GND Must Be Connected to Ground   4 N/C No Connect   5 N/C No Connect   6 N/C No Connect   7 5 V <sub>CC</sub>	1	3	V <sub>IIN</sub>	0	Video ir	nput			
3 1,2 GND Must Be Connected to Ground   4 N/C No Connect   5 N/C No Connect   6 N/C No Connect   7 5 V <sub>CC</sub> +5V Supply, Do Not Float	2	C M	NC	2 No Connect					
4     N/C     No Connect       5     N/C     No Connect       6     N/C     No Connect       7     5     V <sub>CC</sub> +5V Supply, Do Not Float	3	1,2	GNI	Must Be Connected to Ground					
5     N/C     No Connect       6     N/C     No Connect       7     5     V <sub>cc</sub> +5V Supply, Do Not Float	4		NVC	No Connect					
6 N/C No Connect   7 5 V <sub>cc</sub> +5V Supply, Do Not Float	5	<u> </u>	NC	C No Connect					
7 V <sub>cc</sub> +5V Supply, Do Not Float	6		N/C	No Connect					
	57	5	V <sub>CC</sub>	0	+5V Supply, Do Not Float				

FMS6141 — Low-Cost, Single Channel 4<sup>th</sup>-Order Standard Definition Video Filter Driver

# **Absolute Maximum Ratings**

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter	Min.	Max.	Unit
V <sub>cc</sub>	DC Supply Voltage	-0.3	6.0	V
V <sub>IO</sub>	Analog and Digital I/O	-0.3	V <sub>CC</sub> +0.3	V
I <sub>OUT</sub>	Output Current, Do Not Exceed		50	mA

# **Recommended Operating Conditions**

Symbol	Parameter	Min.	Typ.	Max.	Unit
T <sub>A</sub>	Operating Temperature Range	-40		85	°C
V <sub>cc</sub>	V <sub>cc</sub> Range	4.75	5.00	5.25	V
		END	EPon	2MAT	

# **ESD** Information

Symbol	Parameter	Value	Unit
ESD	Human Body Model, JESD22-A114	8.0	kV
ESD	Charged Device Model, JESD22-C101	1.5	kV
	SNOT COMME		

# Reliability Information

Symbol	C Parameter			Тур.	Max.	Unit
τJ	Junction Temperature				+150	°C
T <sub>STG</sub>	Storage Temperature Range		-65		+150	°C
TL	Lead Temperature (Soldering, 10 s)				300	°C
Θ	Θ <sub>JA</sub> Thermal Resistance SOIC-8   (JEDEC Standard Multi-Layer Test Boards, Still Air) SC70-5	SOIC-8		115		°C/W
OJA		SC70-5		332		°C/W

# **DC Specifications**

 $T_A = 25^{\circ}$ C,  $V_{CC} = 5.0$  V,  $R_S = 37.5 \Omega$ ; input is AC coupled with 0.1 µF; output is AC coupled with 220 µF into a 150  $\Omega$  load; unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
lcc	Supply Current <sup>(1)</sup>	No Load		7	12	mA
V <sub>IN</sub>	Video Input Voltage Range	Referenced to GND if DC-Coupled		1.4		$V_{pp}$
PSRR	Pow er Supply Rejection Ratio	DC		40		dB

Note:

1. 100% tested at 25°C

# **AC Electrical Specifications**

 $T_A = 25^{\circ}$ C,  $V_{CC} = 5.0$  V,  $R_S = 37.5 \Omega$ ; input is AC coupled with 0.1 µF; output is AC coupled with 220 µF into a 150  $\Omega$  load; unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
AV	Channel Gain <sup>(2)</sup>		5.6	6.0	6.4	dB
f <sub>1dB</sub>	-1dB Bandw idth <sup>(2)</sup>	03	4.0	ō.5	10.	MHz
f <sub>c</sub>	-3dB Bandw idth		0	77		MHz
f <sub>SB</sub>	Attenuation (Stopband Reject)	f. = 27 MHz		42		dB
dG	Differential Gain		50.	0.4		%
dφ	Differential Phase	-010 10 IP		0.4		0
THD	Output Distortion (all channels)	V <sub>OUT</sub> = 1.8 V <sub>pp</sub> , 1 MHz		0.4		%
SNR	Signal-to-Noise Ratio	NTC-7 Weighting; 100 kHz to 4.2 MHz		75		dB
t <sub>pd</sub>	P opagation Delay	Delay i rominput to output, 4.5 Miltz		55		ns
Note: 2. 100% te	sted at 25°C					

ISD

## **Application Information**

#### Input Considerations

The FMS6141 Low-Cost Video Filter provides 6 dB (2X) gain from input to output. The device provides an internal diode clamp to support AC-coupled input signals. In this configuration, a 0.1  $\mu$ F ceramic capacitor is used to AC couple the input signal. If the input signal does not go below ground, the clamp is inactive; but if the input signal goes below ground, the clamp circuitry sets the bottom of the sync tip (or low est voltage) to just below ground. The input level set by the clamp, combined with the internal DC offset, keeps the output signal within an acceptable range. This clamp feature also allows the FMS6141's input to be directly driven (DC-coupled) by a ground referenced DAC output. Figure 4 shows typical DC voltage levels for the input and output signals when driven by a DC-coupled DAC output or an AC-coupled and clamped Y, CV signal.



Figure 4. Typical DC Voltage Levels

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#### **Output Considerations**

The FMS6141 outputs will be DC offset from the input by 150 mv therefore  $V_{OUT} = 2^*V_{IN}$  DC+150 mv. This offset is required to obtain optimal performance from the output driver and is held at the minimum value in order to decrease the standing DC current into the load. Since the FMS6141 has a 2x (6 dB) gain, the output is typically connected via a 75  $\Omega$  series back-matching resistor follow ed by the 75  $\Omega$  video cable. Because of the inherent divide by two of this configuration, the blanking level at the load of the video signal is alw ays less then 1 V. When AC-coupling the output ensure that the coupling capacitor of choice will pass the low est frequency content in the video signal and that line time distortion (video tilt) is kept as low as possible.

The selection of the coupling capacitor is a function of the subsequent circuit input impedance and the leakage current of the input being driven. In order to obtain the highest quality output video signal the series termination resistor must be placed as close to the device output pin as possible. This greatly reduces the parasitic capacitance and inductance effect on the FMS6141 output oriver. Recommend distance from device pin to place series termination resistor should be no greater than 0.1 inches.



Figure 5. Distance from Device Pin to Series Termination Resistor





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#### Layout Considerations

General layout and supply bypassing play a major role in high-frequency performance and thermal characteristics. ON Semiconductor offers a demonstration board for the FMS6141 to guide layout and aid device evaluation. The demo board is a four-layer board with full power and ground planes. Following this layout configuration provides optimum performance and thermal characteristics for the device. For the best results, follow the steps and recommended routing rules listed below.

#### **Recommended Routing/Layout Rules**

- Do not run analog and digital signals in parallel.
- Use separate analog and digital pow er planes to supply pow er.
- Traces should run on top of the ground plane at all times.
- No trace should run over ground/pow er splits.
- Avoid routing at 90-degree angles.
- Minimize clock and video data trace length differences.
- Include 10 µF and 0.1 µF ceramic pow er supply bypass capacitors.
- Place the 0.1 µF capacitor within 0.1 inches of the device pow er pin.
- Place the 10 µF capacitor within 0.75 inches of the device pow er pin.
- For multilayer boards, use a large ground plane to help dissipate heat.
- For two-layer boards, use a ground plane that extends beyond the device body by at least 0.5 inches on all sides. Include a metal paddle under the device on the top layer.
- Minimize all trace lengths to require series inductance.

## Thermal Considerations

Since the interior of most systems, such as set-top boxes, TVs, and DVD players are at +70°C; consideration must be given to providing an adequate heat sink for the device package for maximum heat dissipation. When designing a system board, determine how much power each device dissipates. Ensure that devices of high power are not placed in the same location, such as directly above (top plane) and below (bottom plane) each other on the PCB.

#### PCB Thermal Layout Considerations

- Understand the system power requirements and environmental conditions.
- Maximize thermal performance of the PCB.
- Consider using 70 µm of copper for high-pow er designs.
- Make the PCB as thin as possible by reducing FR4 thickness.
- Use vias in pow er pad to tie adjacent lavers together.
- Remember that baseline temperature is a function of board area, not copper thickness.
- Modeling techniques can provide a first-order approximation.

# **Power Dissipation**

Consider the FMS6141's output drive configuration when calculating overall power dissipation. Care must be taken not to exceed the maximum die junction temperature. The following example can be used to calculate the FMS6141's power dissipation and internal temperature rise.

$$\begin{split} T_{J} &= T_{A} + P_{CHANNEL} \Theta_{JA} \\ w \text{ here } P_{CHANNEL} = V_{CC} \bullet I_{CH} + (V_{O}^{2}/R_{L}) \\ V_{O} &= 2V_{IN} + 0.280V \\ I_{CH} &= I_{CC} + (V_{O}/R_{L}) \\ V_{IN} &= RMS \text{ value of input signal} \\ I_{CC} &= 7mA \\ V_{S} &= 5V \\ R_{I} &= \text{channel load resistance} \end{split}$$

The FMS6141 is specified to operate with output currents typically less than 50 mA, which is more than sufficient for a dual (75  $\Omega$ ) video load. The internal amplifiers of the FMS6141 are current limited to a maximum of 100 mA and can withstand a brief-duration short-circuit condition, but this capability is not guaranteed.



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FMS6141 — Low-Cost, Single Channel 4<sup>th</sup>-Order Standard Definition Video Filter Driver

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