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FMS6646
Six Channel, SD/HD 1080p Video Filter Driver

Features
- Three Selectable 8/75MHz (SD/HD 1080p) Filters
- Three Fixed 8MHz (SD) Filters
- Transparent Input Clamping
- Single Video Load Drive (2Vpp, 150Ω, AV = 6dB)
- AC- or DC-Coupled Inputs
- AC- or DC-Coupled Outputs
- DC-Coupled Outputs Eliminate AC-Coupling Capacitors
- Low-Power
- Robust Output ESD Protection: 9kV HBM

Applications
- Cable and Satellite Set-Top Boxes
- DVD Players
- HDTV
- Personal Video Recorders (PVR)
- Video On Demand (VOD)

Description
The FMS6646 Low Cost Video Filter (LCVF) is intended to replace passive LC filters and drivers with a low-cost integrated device. Six Butterworth filters provide improved image quality compared to typical passive solutions. The combination of low-power Standard-Definition (SD) and High-Definition (HD 1080p) filters greatly simplifies DVD video output circuitry. Three channels offer fixed SD filters, while the other three are selectable between SD and HD filters.

The FMS6646 offers a fixed gain of 6dB.

The FMS6646 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 AC-coupled inputs are required (see the Applications Information section for details).

The outputs can drive AC- or DC-coupled single (150Ω) video loads. DC-coupling the outputs removes the need for output coupling capacitors. The input DC levels are offset approximately +280mV at the output.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Operating Temperature Range</th>
<th>Gain Setting</th>
<th>Package</th>
<th>Packing Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMS6646MTC20X</td>
<td>-40°C to +85°C</td>
<td>6dB</td>
<td>TSSOP-20</td>
<td>2500 / Reel</td>
</tr>
</tbody>
</table>

Figure 1. Block Diagram
Pin Configuration

Figure 2. Pin Configuration

Pin Definitions

<table>
<thead>
<tr>
<th>Pin#</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SD IN1</td>
<td>Input</td>
<td>SD video input, channel 1</td>
</tr>
<tr>
<td>2</td>
<td>SD IN2</td>
<td>Input</td>
<td>SD video input, channel 2</td>
</tr>
<tr>
<td>3</td>
<td>SD IN3</td>
<td>Input</td>
<td>SD video input, channel 3</td>
</tr>
<tr>
<td>4</td>
<td>N/C</td>
<td>Input</td>
<td>No Connection</td>
</tr>
<tr>
<td>5</td>
<td>V CC</td>
<td>Input</td>
<td>+3.3V supply</td>
</tr>
<tr>
<td>6</td>
<td>FcSEL</td>
<td>Input</td>
<td>Selects filter corner frequency for pins 7, 8, and 9: “0” = SD, “1” = HD (1080p)</td>
</tr>
<tr>
<td>7</td>
<td>SD/HD (1080p) IN1</td>
<td>Input</td>
<td>Selectable SD or HD (1080p) video input, channel 1</td>
</tr>
<tr>
<td>8</td>
<td>SD/HD (1080p) IN2</td>
<td>Input</td>
<td>Selectable SD or HD (1080p) video input, channel 2</td>
</tr>
<tr>
<td>9</td>
<td>SD/HD (1080p) IN3</td>
<td>Input</td>
<td>Selectable SD or HD (1080p) video input, channel 3</td>
</tr>
<tr>
<td>10</td>
<td>N/C</td>
<td>Input</td>
<td>No Connection</td>
</tr>
<tr>
<td>11</td>
<td>N/C</td>
<td>Input</td>
<td>No Connection</td>
</tr>
<tr>
<td>12</td>
<td>SD/HD (1080p) OUT3</td>
<td>Output</td>
<td>Filtered SD or HD (1080p) video output, channel 3</td>
</tr>
<tr>
<td>13</td>
<td>SD/HD (1080p) OUT2</td>
<td>Output</td>
<td>Filtered SD or HD (1080p) video output, channel 2</td>
</tr>
<tr>
<td>14</td>
<td>SD/HD (1080p) OUT1</td>
<td>Output</td>
<td>Filtered SD or HD (1080p) video output, channel 1</td>
</tr>
<tr>
<td>15</td>
<td>N/C</td>
<td>Input</td>
<td>No Connection</td>
</tr>
<tr>
<td>16</td>
<td>GND</td>
<td>Input</td>
<td>Must be tied to ground</td>
</tr>
<tr>
<td>17</td>
<td>GND</td>
<td>Input</td>
<td>Must be tied to ground</td>
</tr>
<tr>
<td>18</td>
<td>SD OUT3</td>
<td>Output</td>
<td>Filtered SD video output, channel 3</td>
</tr>
<tr>
<td>19</td>
<td>SD OUT2</td>
<td>Output</td>
<td>Filtered SD video output, channel 2</td>
</tr>
<tr>
<td>20</td>
<td>SD OUT1</td>
<td>Output</td>
<td>Filtered SD video output, channel 1</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC</td>
<td>DC Supply Voltage</td>
<td>-0.3</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>VIO</td>
<td>Analog and Digital I/O</td>
<td>-0.3</td>
<td>VCC+0.3</td>
<td>V</td>
</tr>
<tr>
<td>IOUT</td>
<td>Output Current, Any One Channel, Do Not Exceed</td>
<td>50</td>
<td>mA</td>
<td></td>
</tr>
</tbody>
</table>

Reliability Information

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>TJ</td>
<td>Junction Temperature</td>
<td></td>
<td>+150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>TSTG</td>
<td>Storage Temperature Range</td>
<td>-65</td>
<td></td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>TL</td>
<td>Reflow Temperature</td>
<td></td>
<td>+260</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>θJA</td>
<td>Thermal Resistance, JEDEC Standard Multi-Layer Test Boards, Still Air</td>
<td>74</td>
<td></td>
<td>°C/W</td>
<td></td>
</tr>
</tbody>
</table>

Electrostatic Discharge Information

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD</td>
<td>Human Body Model, JESD22-A114</td>
<td>9</td>
<td>kV</td>
</tr>
<tr>
<td></td>
<td>Charged Device Model, JESD22-C101</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA</td>
<td>Operating Temperature Range</td>
<td>-40</td>
<td>+85</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>VCC</td>
<td>Supply Voltage Range</td>
<td>3.135</td>
<td>3.300</td>
<td>5.250</td>
<td>V</td>
</tr>
</tbody>
</table>

DC Electrical Characteristics

Unless otherwise noted, TA=25°C, VCC=3.3V, RSOURCE=37.5Ω, inputs AC coupled with 0.1µF, all outputs AC coupled with 220µF into 150Ω loads, referenced to 400kHz.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICC</td>
<td>Supply Current(1)</td>
<td>No Load</td>
<td>80</td>
<td>95</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>VIN</td>
<td>Video Input Voltage Range</td>
<td>Referenced to GND if DC Coupled</td>
<td>1.4</td>
<td></td>
<td>VPP</td>
<td></td>
</tr>
<tr>
<td>VIL</td>
<td>Digital Input Low(1)</td>
<td>FEBEL</td>
<td>0</td>
<td>0.8</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VIH</td>
<td>Digital Input High(1)</td>
<td>FEBEL</td>
<td>2.4</td>
<td></td>
<td>VCC</td>
<td>V</td>
</tr>
</tbody>
</table>

Note:

1. 100% tested at TA=25°C.
### Standard-Definition (480i) Electrical Characteristics

Unless otherwise noted, TA=25°C, VIN=1VPP, VCC=3.3V, RSOURCE=37.5Ω, all inputs AC coupled with 0.1µF, all outputs AC coupled with 220µF into 150Ω loads, referenced to 400kHz.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVSD</td>
<td>Channel Gain (2)</td>
<td>All SD Channels</td>
<td>5.8</td>
<td>6.0</td>
<td>6.2</td>
<td>dB</td>
</tr>
<tr>
<td>f1dBSD</td>
<td>-0.1dB Flatness</td>
<td>All SD Channels</td>
<td>5.5</td>
<td>5.5</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>f1dBSD</td>
<td>-1dB Flatness (2)</td>
<td>All SD Channels</td>
<td>5.50</td>
<td>7.15</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>fSD</td>
<td>-3dB Bandwidth (2)</td>
<td>All SD Channels</td>
<td>6.5</td>
<td>8.0</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>fSBSD</td>
<td>Attenuation (Stopband Reject) (2)</td>
<td>All SD Channels at f=27MHz</td>
<td>50</td>
<td>60</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>DG</td>
<td>Differential Gain</td>
<td>All SD Channels</td>
<td>0.5</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>DP</td>
<td>Differential Phase</td>
<td>All SD Channels</td>
<td>0.3</td>
<td></td>
<td></td>
<td>°</td>
</tr>
<tr>
<td>THD</td>
<td>Total Harmonic Distortion, Output</td>
<td>VOUT=1.4VPP, 3.58MHz</td>
<td>0.25</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>XTSKSD</td>
<td>Crosstalk (ch-to-ch)</td>
<td>1MHz</td>
<td>-70</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>SNR</td>
<td>Signal-to-Noise Ratio (3)</td>
<td>NTC-7 Weighting, 100kHz to 4.2MHz</td>
<td>72</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>tpsdSD</td>
<td>Propagation Delay</td>
<td>Delay from Input to Output, 4.5MHz</td>
<td>90</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>CLGSd</td>
<td>Chroma Luma Gain</td>
<td>f=3.58MHz (Refer to SDIN at 400kHz)</td>
<td>100</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>CLDSd</td>
<td>Chroma Luma Delay</td>
<td>f=3.58MHz (Refer to SDIN at 400kHz)</td>
<td>6</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

**Notes:**
2. 100% tested at TA=25°C.
3. SNR=20 • log (714mV / rms noise).

### High-Definition (1080p) Electrical Characteristics

Unless otherwise noted, TA=25°C, VIN=1VPP, VCC=3.3V, RSOURCE=37.5Ω, all inputs AC coupled with 0.1µF, all outputs AC coupled with 220µF into 150Ω loads, referenced to 400kHz.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVHD</td>
<td>Channel Gain (4)</td>
<td>All HD Channels</td>
<td>5.8</td>
<td>6.0</td>
<td>6.2</td>
<td>dB</td>
</tr>
<tr>
<td>f1dBHD</td>
<td>-1dB Bandwidth (4)</td>
<td>All HD Channels</td>
<td>55</td>
<td>65</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>fHD</td>
<td>-3dB Bandwidth (4)</td>
<td>All HD Channels</td>
<td>70</td>
<td>75</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>fSBHD</td>
<td>Attenuation Stopband Reject (4)</td>
<td>All HD Channels, f=148MHz</td>
<td>15</td>
<td>20</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>THD</td>
<td>Total Harmonic Distortion, Output</td>
<td>VOUT=1.4VPP, 22MHz</td>
<td>0.2</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>XTALKHD</td>
<td>Crosstalk (Channel-to-Channel)</td>
<td>1MHz</td>
<td>-72</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>SNR</td>
<td>Signal-to-Noise Ratio (5)</td>
<td>Unified Weighting; 100kHz to 60MHz</td>
<td>70</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>tpsdHD</td>
<td>Propagation Delay</td>
<td>Delay from Input to Output</td>
<td>6</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

**Notes:**
4. 100% tested at 25°C.
5. SNR=20 • log (714mV / rms noise).
Typical Performance Characteristics

Figure 3. SD Frequency Response

Figure 4. SD Frequency Response (Flatness)

Figure 5. HD Frequency Response
Typical Performance Characteristics (Continued)

Figure 6. HD Frequency Response (Flatness)

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Attenuation (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>-4.0</td>
</tr>
<tr>
<td>0.2</td>
<td>-3.5</td>
</tr>
<tr>
<td>0.3</td>
<td>-3.0</td>
</tr>
<tr>
<td>0.4</td>
<td>-2.5</td>
</tr>
<tr>
<td>0.5</td>
<td>-2.0</td>
</tr>
<tr>
<td>0.6</td>
<td>-1.5</td>
</tr>
<tr>
<td>0.7</td>
<td>-1.0</td>
</tr>
<tr>
<td>0.8</td>
<td>-0.5</td>
</tr>
<tr>
<td>0.9</td>
<td>0.0</td>
</tr>
<tr>
<td>1.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Figure 7. Differential Gain

<table>
<thead>
<tr>
<th>Differential Gain (%)</th>
<th>min = 0.00</th>
<th>max = 0.40</th>
<th>p-p/max = 0.39</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.09</td>
<td>0.23</td>
<td>0.31</td>
</tr>
<tr>
<td>0.40</td>
<td>0.28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 8. Differential Phase

<table>
<thead>
<tr>
<th>Differential Phase (deg)</th>
<th>min = -0.17</th>
<th>max = 0.00</th>
<th>pk-pk = 0.17</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>-0.05</td>
<td>-0.06</td>
<td>-0.07</td>
</tr>
<tr>
<td>-0.11</td>
<td>-0.17</td>
<td>-0.22</td>
<td>-0.30</td>
</tr>
</tbody>
</table>

1st. 2nd. 3rd. 4th. 5th. 6th.
Typical Application

Figure 9. Typical Application
Applications Information

Functional Description

The FMS6646 Low-Cost Video Filter (LCVF) provides 6dB gain from input to output. In addition, the input is slightly offset to optimize the output driver performance. The offset is held to the minimum required value to decrease the standing DC current into the load. Typical voltage levels are shown in Figure 10.

\[
\begin{align*}
1.0 & \rightarrow 1.02V \\
0.65 & \rightarrow 0.67V \\
0.3 & \rightarrow 0.32V \\
0.0 & \rightarrow 0.02V
\end{align*}
\]

\[
\begin{align*}
2.28V \\
1.58V \\
0.88V \\
0.28V \\
0.85V \\
0.5V \\
0.15V \\
1.98V \\
1.28V \\
0.58V
\end{align*}
\]

There is a 280mV offset from the DC input level to the DC output level. \( V_{OUT} = 2 \cdot V_{IN} + 280mV \).

I/O Configurations

For DC-coupled DAC drive with DC-coupled outputs, use the configuration shown in Figure 12.

\[
\begin{align*}
\text{DVD or STB} & \\
\text{SoC} & \\
\text{DAC Output}
\end{align*}
\]

\[
\begin{align*}
75 \Omega & \\
\text{LCVF Clamp Inactive}
\end{align*}
\]

\[
\begin{align*}
\text{DVD or STB} & \\
\text{SoC} & \\
\text{DAC Output}
\end{align*}
\]

\[
\begin{align*}
0.1 \mu F & \\
\text{LCVF Clamp Active}
\end{align*}
\]

If the DAC’s average DC output level causes the signal to exceed the range of 0V to 1.4V, it can be AC-coupled as shown in Figure 13.

For symmetric signals like C, U, V, Cb, Cr, Pb, and Pr; the average DC bias is fairly constant and the inputs can be AC-coupled with the addition of a pull-up resistor to set the DC input voltage. DAC outputs can also drive these same signals without the AC coupling capacitor. A conceptual illustration of the input clamp circuit is shown in Figure 11.

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The same method can be used for biased signals with the addition of a pull-up resistor to make sure the clamp never operates. The internal pull-down resistance is 800kΩ ± 20%, so the external resistance should be 7.5MΩ to set the DC level to 500mV. If a pull-up resistance less than 7.5MΩ is desired, an external pull-down can be added such that the DC input level is set to 500mV.

![Figure 15. Biased SCART with DC-Coupled Outputs](image)

The same circuits can be used with AC-coupled outputs if desired, as shown in Figure 16.

![Figure 16. DC-Coupled Inputs, AC-Coupled Outputs](image)

Figure 17. Coupled Inputs, AC-Coupled Outputs

External video source must be AC coupled.

![Figure 17. Coupled Inputs, AC-Coupled Outputs](image)

Figure 18. Biased SCART with AC-Coupled Outputs

Note:
6. The video tilt or line time distortion is dominated by the AC-coupling capacitor. The value may need to be increased beyond 220μF to obtain satisfactory operation in some applications.

Power Dissipation

The FMS6646 output drive configuration must be considered 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 FMS6646's power dissipation and internal temperature rise:

\[ T_J = T_A + P_d \cdot \theta_{JA} \]

where \( P_d = P_{CH1} + P_{CH2} + P_{CHx} \) and

\[ P_{CHx} = V_S \cdot I_{CH} - (V_O^2/R_L) \]

where \( V_O = 2V_IN + 0.280V \)

\[ I_{CH} = (I_{CC} / 6) + (V_O/R_L) \]

\( V_IN = \) RMS value of input signal

\( I_{CC} = 90mA, V_S = 3.3V \)

\( R_L = \) channel load resistance

Board layout can affect thermal characteristics. Refer to the Layout Considerations section for more information.

Output Considerations

The FMS6646 outputs will be DC offset from the input by 150mv therefore \( V_OUT = 2V_IN \pm 150mv. \) 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 FMS6646 has a 2x (6dB) gain, the output is typically connected via a 75Ω series back-matching resistor followed by the 75Ω video cable. Because of the inherent divide by two of this configuration, the blanking level at the load of the video signal is always less then 1V. When AC-coupling the output ensure that the coupling capacitor of choice will pass the lowest 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 FMS6646 output driver. Recommend distance from device pin to place series termination resistor should be no greater than 0.1 inches.

![Figure 19. Distance from Device Pin to Series Termination Resistor](image)
Layout Considerations

General layout and supply bypassing play major roles in high-frequency performance and thermal characteristics. Fairchild offers a demonstration board, FMS6646DEMO, to guide layout and aid device testing and characterization.

The FMS6646DEMO is a four-layer board with a full power and ground plane. Following this layout configuration provides the optimum performance and thermal characteristics. For best results, follow the steps below as a basis for high-frequency layout:

- Include 0.01μF and 0.1μF ceramic bypass capacitors.
- Place the 0.01μF capacitor within 0.75 inches of the power pin.
- Place the 0.1μF capacitor within 0.1 inches of the power pin.
- For multi-layer boards, use a large ground plane to help dissipate heat.
- For two-layer boards, use a ground plane that extends beyond the device by at least 0.5 inches.
- Minimize all trace lengths to reduce series inductances.
Physical Dimensions

Figure 20. 20-Lead Thin Shrink Small Outline Package (TSSOP)

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