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April 1998

Application Note 42035

Component Video Filtering Using the ML6420/ML6421

INTRODUCTION

This Application Note provides the video design engineer with practical circuit examples of Micro Linear's triple active video filters, the ML6420 and ML6421. Beginning with a brief review of basic video terminology and definitions, distinct features of each part are discussed followed by a selection table to guide the designer in choosing the appropriate filter for any given application. Practical examples are given along with graphical information displaying the performance of the filters. The information presented herein allows even the novice video or experienced digital design engineer to choose and apply Micro Linear's active video filters.

WHY FILTER VIDEO?

Video filtering became a necessity due to the manner in which video signals were originally defined in the U.S. by the National Television Standards Committee (NTSC). When television signals were first broadcast (in the 1940's) broadcast and reception was in black and white (monochrome) only. Later, when it became possible for cameras to process color, a method was devised to broadcast the color information in the same channel frequency band as the monochrome signal. This new signal, containing color, had to be received by black and white sets without degradation of picture quality and provide a quality image on the newer color sets. Unfortunately, because of the limited bandwidth allocated to each channel, the color (chrominance or chroma for short) and monochrome (commonly referred to as luminance or luma for short) signal frequencies overlapped, making it difficult for the color televisions to separate the signals into useful information. This is when video filtering was implemented to separate the luminance and the chrominance signals.

The NTSC method of combining and processing video signals is used in North America, Japan and a few other countries. As television was first evolving, a similar standard for video broadcast and reception was developed in Europe. Phase Alternating Line (PAL) broadcast and reception is not unlike NTSC in several regards, but differs in certain respects such as vertical scan rate, total number of horizontal scan lines per frame and video bandwidth. Micro Linear offers video filters for both systems.

Although filtering of the luma and chroma signals is still performed in television sets, video filters are seeing more widespread use in newer video systems where the signals are digitized for ease of processing and manipulation. Set-top converters used to permit an ordinary television to receive hundreds of channels over cable use digital video and must convert these digital signals into analog video in order for your television to process the picture and sound. Because the D to A conversion produces some unwanted imperfections into the original video signal, filtering is required at the output of the D to A converter. Digitized video signals are also present in satellite dish receivers, digital cable TV, digital cable TV and numerous computer related peripherals including the video signal output by the computer to the monitor.

NTSC & PAL VIDEO SIGNAL BANDWIDTH ALLOCATION

The complete video signal used by NTSC and PAL systems (chroma and luma) consists of three separate signal components. The luminance (black and white or brightness information) abbreviated as Y, and two color (chroma) components abbreviated as U and V. This YUV signal contains all the video information necessary for a television to correctly display the transmitted image. The reason for generating two chroma signals is to allow for the hue and saturation of the color to be separated, thereby making it easier for the receiver to faithfully reproduce the broadcast image. Hue is the attribute of color we perceive as being distinctly red, yellow, green, etc. Saturation is the measure of the purity of any distinct color. For example the color red at different saturations may be pink, orange, reddish brown, etc. Figures 1 and 2 display the YUV video bandwidths of the NTSC and PAL systems respectively.

The term YUV is referred to as a color space, indicating how the brightness, hue and saturation of color (including black and white) are arithmetically related. Other examples of popular color spaces are: YIQ, YC_BC_R, RGB, and Y/C, also known as S-video.

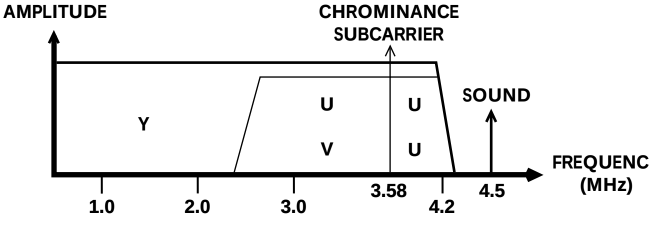

Figure 1. Bandwidths of (M) NTSC Systems Using 1.3MHz U and V Signals

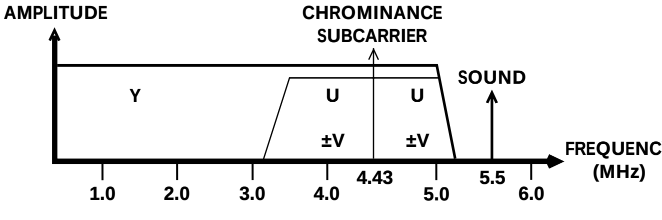

Figure 2. Bandwidths of a Common PAL System

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WHY FILTER VIDEO? (Continued)

THE ML6420 AND ML6421

The ML6420/ML6421 pair is a triple low pass 6th-order phase-equalizer precision video filter. It offers a ±10% frequency accuracy over the temperature and voltage range, a selectable input range of 0 to 2V or 0.5 to 2.5V, and an output drive of $1V_{P-P}$ into 75Ω or $2V_{P-P}$ into 150Ω. The ML6421 offers a (sin x)/x correction which is designed for restoration filtering at the output of a DAC.

The ML6420/ML6421 pair has unity gain when connected to a 150Ω load, and a -6dB output level when connected to a 75Ω load via a series output resistor. The output may be either AC coupled or DC coupled. For AC coupling the –3dB point should be at 5Hz or lower. There must be a DC path of <500Ω for input biasing. The input resistance is 4kΩ. For the ML6420 the input may be either AC coupled or DC coupled. For AC coupling the –3dB point should be at 5Hz or lower. The ML6421 is designed to be driven directly by the DAC. A termination resistor might be necessary at the output of the DAC (usually 75Ω or 150Ω). The following definitions are provided for better understanding of the specifications of the ML6420 and ML6421.

Passband

The Passband is the range of frequencies that is passed by a filter, from DC up to a specified maximum frequency. Inside this range the filter maintains a certain targeted attenuation of the signal.

Stopband

The stopband is the range of frequencies which are attenuated by the filter, from the cutoff frequency up.

Group Delay

Group Delay is defined as a signals change in phase with respect to frequency. This value indicates how signals of different frequencies are delayed by different amounts of time as they pass through the part. Group delay is a function of frequency and is specified in seconds. A high quality filter has a low group delay value.

AC Coupling (Figure 3)

AC coupling is a method of connecting a video signal to a circuit in a manner that removes the DC offset.

DC Restoration (Figure 3)

DC restoration is what is done to the video signal after it has been AC coupled and has to be digitized. If the video waveform has been AC coupled, the DC level is unknown. We don't know where the porch sits or what the bottom of the sync tip is, or if they're changing over time. Since the register ladder of the flash ADC is tied to a pair of voltage references (such as REF- to 0 volts and REF+ to 1.3V) the video waveform has to be referenced to some known DC level. Otherwise it could not be correctly digitized. DC restoration is essentially providing a DC component. It might or might not be the same as the original DC component which was removed to make an AC coupled signal. The zero reference for the ADC may need to correspond to either the bottom of the sync pulse (in systems where the digital processing needs the sync and burst pulses) or the blanking level at the beginning and end of the sync pulse (for systems where the digital processing is only concerned with picture content).

COMPONENT VIDEO

A type of video signal where the luma and chroma signals are separated as opposed to composite video. Examples are: RGB, YUV, Y/C.

Note: The timing (sync) signal is present on one of the separate video signals. For example, with RGB, the sync is present on the green channel.

COMPOSITE VIDEO (CV)

A type of video signal where the luma, chroma and timing signals are all combined into one signal. Examples are NTSC and PAL.

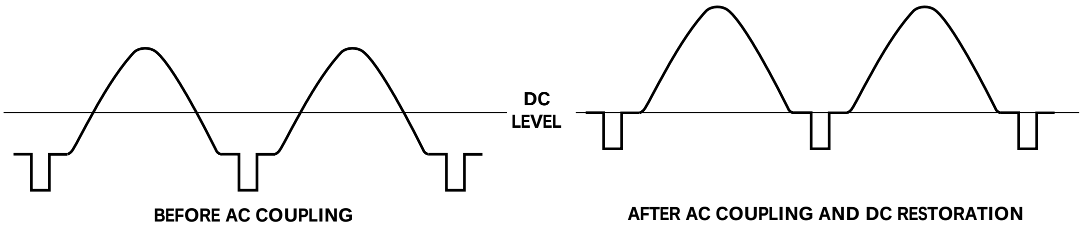

Figure 3. Effects of AC Coupling

CHOOSING A VIDEO FILTER

The ML6420/ML6421 pair provides several choices in filter cutoff frequencies depending on the application. See Table 1.

RGB: When the bandwidth of each signal is the same the 5.5MHz filter is most appropriate.

YUV: When the Luminance bandwidth is different from the color bandwidth the 5.5MHz filter with two 1.8MHz filters is most appropriate. The 1.8MHz filter provides a narrower Bandwidth for optimal data compression (with MPEG and other compression schemes), and has a time delay of 3.5 clock cycles at 13.5MHz for simple delay pre-compensation

S-Video: For Y/C and Y/C + CV (Composite Video) systems the 5.5MHz filter is appropriate. In NTSC the C signal occupies the bandwidth from about 2.6MHz to about 4.6MHz, while in PAL the C signal occupies the bandwidth from about 3.4MHz to about 5.4MHz. In both cases, a 5.5MHz low pass filter provides adequate rejection for both sampling and reconstruction. In addition, using the same filter for both Y/C and CV maintains good signal timing without adjustments.

Composite: When one or more composite signals need to be filtered the 5.5MHz filter permits filtering of one, two or three composite signals.

Over-sampling: While these filters can eliminate the need for over-sampling combined with digital filtering, there are times when over-sampling is used. For these situations, 8MHz is used in place of 5.5MHz, and 3MHz is used in place of 1.8MHz.

NTSC/PAL: A 5.5MHz cutoff frequency provides good filtering for 4.2MHz, 5MHz and 5.5MHz signals without the need to change filters on a production basis.

(sin x)/x: For the output of a digital video system with D/A converters there is a fall off in response with frequency due to discrete sampling. The fall off follows a (sin x)/x response. The ML6421 filters have a complementary boost to provide a flatter overall response. The boost is designed for 13.5MHz Y/C and CV sampling and 6.75MHz U/V sampling. The ML6421 has the same pin-out as the ML6420.

VERSION	FILTER A	FILTER B	FILTER C	APPLICATION	I/O FILTER
ML6420-1	5.5MHz	5.5MHz	5.5MHz	Y/C, RGB, CV	Input
ML6420-2	5.5MHz	1.8MHz	1.8MHz	YUV	Input
ML6420-3	8MHz	8MHz	8MHz	Oversampling	Input
ML6420-4	8MHz	3MHz	3MHz	Oversampling	Input
ML6420-5	5.5MHz	5.5MHz	5.5MHz	RGB, 2X gain	Input
ML6420-6	5.5MHz	2.5MHz	2.5MHz	YUV, 2X gain	Input
ML6420-7	9.3MHz	9.3MHz	9.3MHz	Oversampling	Input
ML6420—8	9.3MHz	3.3MHz	3.3MHz	Oversampling	Input
ML6420-12	12.0MHz	12.0MH	12.0MHz	RGB, 2X gain	Input
ML6421-1	5.5MHz	5.5MHz	5.5MHz	Y/C, RGB, CV	Output
ML6421-2	5.5MHz	1.8MHz	1.8MHz	YUV	Output
ML6421-3	8MHz	8MHz	8MHz	Oversampling	Output
ML6421-4	8MHz	3MHz	3MHz	Oversampling	Output
ML6421-5	5.5MHz	5.5MHz	5.5MHz	RGB, 2X gain	Output
ML6421-6	5.5MHz	2.5MHz	2.5MHz	YUV, 2X gain	Output
ML6421-7	9.3MHz	9.3MHz	9.3MHz	RGB, 2X gain	Output
ML6421-8	9.3MHz	3.3MHz	3.3MHz	Oversampling, YUV, 2x gain	Output
ML6422-1	5.5MHz		5.5MHz	Y/C, 2x gain	Output
ML6422-2	9.3MHz		9.3MHz	Y/C, 2x gain	Output

Table 1. Cutoff Frequencies

USING VIDEO FILTERS

There is a need for filtering. Different problems associated with video signals and filtering will be discussed in this section.

The ML6420 and ML6422 are monolithic, triple/dual lowpass filters intended for input anti-aliasing prior to analog to digital conversion in video systems.

ALIASING: THE PROBLEM (Figures 4-6)

Aliasing is a signal distorting process that occurs when an analog signal is sampled. If the analog signal contains frequencies greater than half of the sampling rate then those frequencies will be altered and "folded back" in the frequency domain. These frequencies represent a distortion of the original signal as represented in the sampled domain, and cannot be corrected after sampling.

THE RESULT OF ALIASING IN A TV PICTURE

Aliasing causes several disturbing distortions to a picture. Since the folded spectrum adds to the original spectrum it will sometimes be in phase and sometimes out of phase, causing ripples that depend on the position of the picture element relative to the clock. The net effect is that picture elements, edges, highlights, and details will "wink" in amplitude as they move across a picture if they have high frequency content above the Nyquist frequency of the sampler.

ANTI-ALIASING

Anti-aliasing reduces the bandwidth of the signal to a value appropriate for the sample processing system. Some detail information is lost, but only the information that cannot be unambiguously displayed is removed.

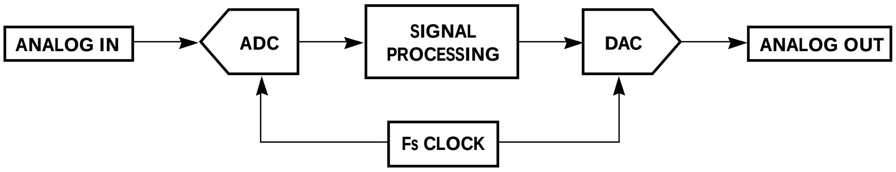

Figure 4. Simplified Digital Video Processing System

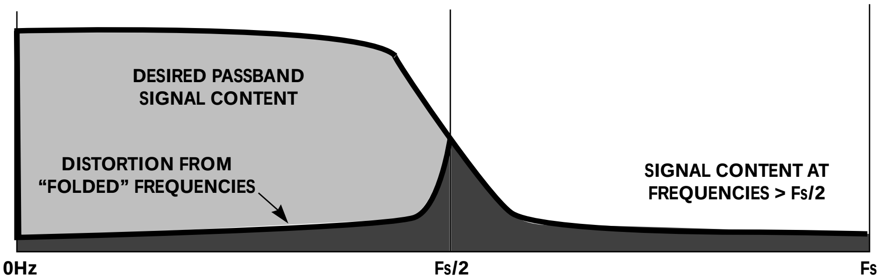

Figure 5. Aliasing in the Frequency Domain

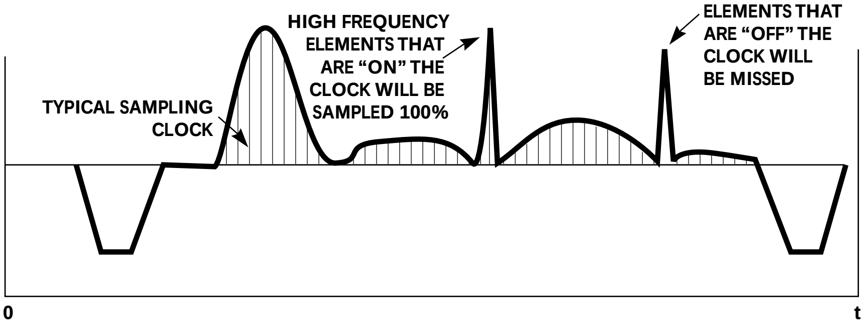

Figure 6. Aliasing in the Time Domain

USING VIDEO FILTERS (Continued)

Assuming that the passband contains the "real" picture information, the only distortion that occurs is due to amplitude and phase variations of the anti-aliasing filter in the passband. The following section shows approaches using digital and analog filters in an oversampled system, and a monolithic analog filter as a lower cost alternative.

OVERSAMPLING (Figure 7)

Aliasing cannot be removed once it occurs — it must be prevented at the signal sampler. Many current systems are choosing to prevent aliasing by increasing the clock rate of the sampler. This is known as "oversampling". Doubling the clock rate greatly reduces the burden on the analog anti-alias filter, but the increased data rate greatly increases the size, complexity, and cost of the Digital Signal Processing (DSP) circuitry. Since the higher clock rate generates more samples than are necessary to represent the desired passband content a digital filter may be used to reduce the signal back to a lower sample rate, saving size, complexity and power in the downstream circuitry. This method cannot be considered the lowest cost approach to solving the anti-alias problem since this digital filter itself is a complex digital block (Figures 8 and 9).

NYQUIST SAMPLING

In traditional systems, before the advent of higher speed ADCs, anti-aliasing filters were designed in the analog domain. The movement toward higher sampling rates was an attempt to circumvent the difficult challenge of designing a sharp roll-off, linear phase, non-distorting analog filter. The ML6420 series of filters solves this problem where it is best solved, in the analog domain (Figure 10). Since they are monolithic their application is

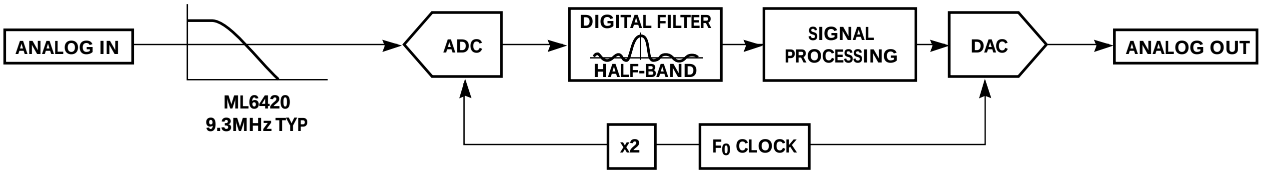

Figure 7. Oversampled Video Processing System with Analog LPF & Half-Band Digital Filter

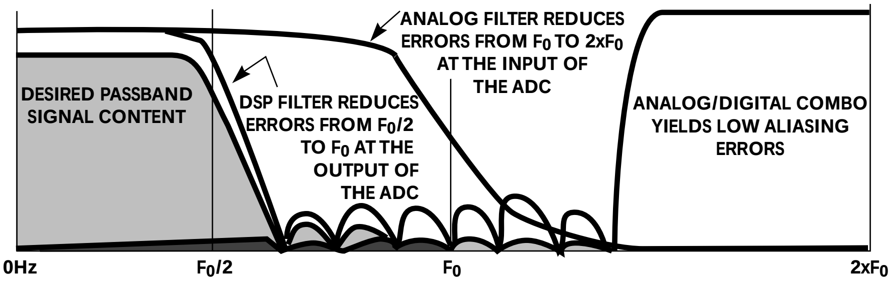

Figure 8. Digital Filtering in the Frequency Domain

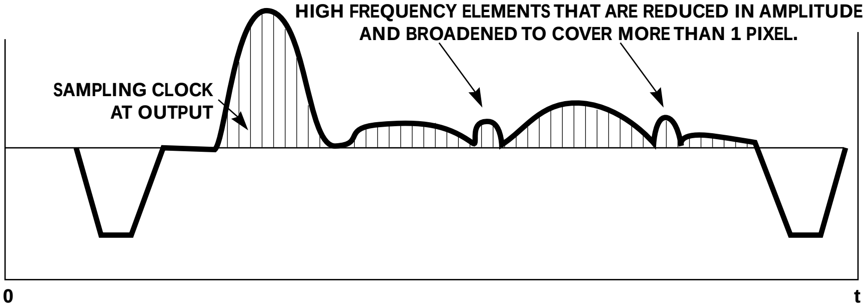

Figure 9. Digital Filtering in the Time Domain

USING VIDEO FILTERS (Continued)

simple. Since they have flat amplitude and linear phase they have low distortion. And since the aliasing is removed at the analog input to the ADC the clock rates are minimized, the DSP half band filter (a very expensive chip at current market prices) is eliminated, and significant power is conserved (Figure 11).

Oversampling vs Nyquist sampling

Clearly the purely analog monolithic solution and the analog/digital solution using DSP filtering are different ways of solving the same problem. Other than costs (purely analog is many times less expensive) there are no real differences in performance for applications that require flatness specs of +0.5dB to 4.5MHz for consumer and professional video applications. The ML6420 is also phase corrected for flat group delay, a feature not found in typical low cost analog filters, and a characteristic often associated with digital filters alone. The following section highlights the importance of linear phase response in video applications.

TIME DOMAIN RESPONSE: TRANSIENTS AND RINGING

The phase response of filters is often ignored in applications where time domain waveforms are not relevant. But in video applications the time domain waveform is the signal that is finally presented on the screen to the viewer, and so time domain characteristics such as pulse response symmetry, pre-shoot, overshoot and ringing are very important. Video applications are very demanding in that they require both sharp cutoff characteristics and linear phase. The application of DSP to the problem is based on the linear phase characteristic of a particular class of digital filters known as

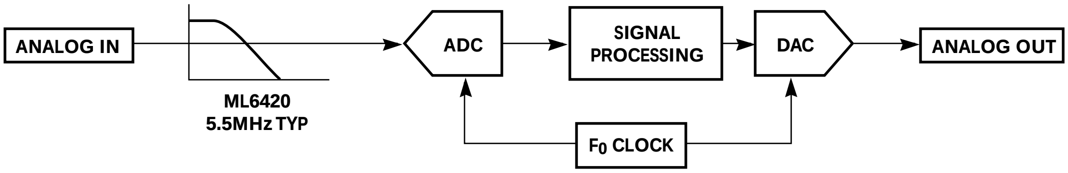

Figure 10. Video Processing System with Monolithic Analog Anti-Alias Filter

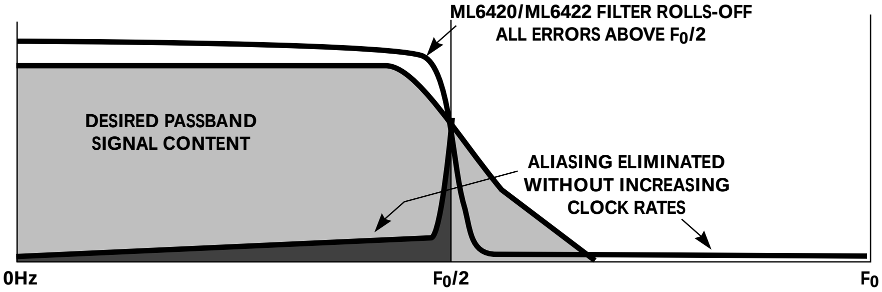

Figure 11. Analog Filtering in the Frequency Domain

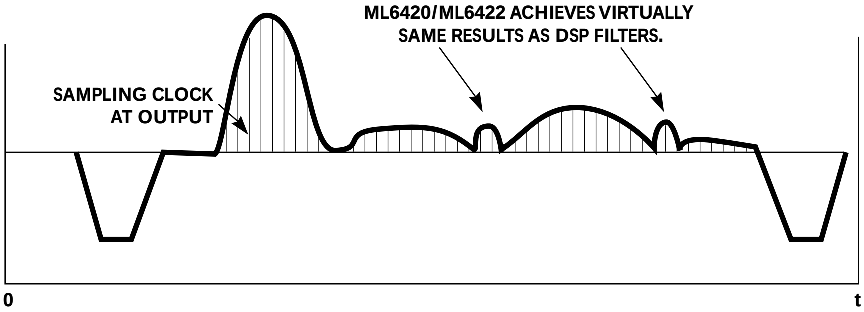

Figure 12. Analog Filtering in the Time Domain

USING VIDEO FILTERS (Continued)

symmetrical FIR filters. Use of these filters guarantees the best possible time domain characteristics for a given amplitude characteristic. In the analog domain phase linearity is not automatic (except for special phase linear filters such as Bessel or Thomson filters, both of which have inadequate amplitude characteristics for most video anti-alias applications) and it is often assumed that linear phase is unachievable. This is not true. Similarly, in the digital domain it is often assumed that sharp cutoff amplitude characteristics can be achieved without overshoot and ringing. This is also not true. Phase linear filters whether digital or analog have symmetrical response to symmetrical inputs. High roll-off rate uncompensated filters (whether analog or digital) have ringing and overshoot. In the example below, the traditional 2T test pulse is applied to a traditional, non-phase linear analog filter, the ML6420/ML6422 pure analog anti-alias filter (5.5MHz) and the combined analog/digital filters (9.3MHz analog filter and half-band digital filter.)

As seen in Figure 15, the ML6420/ML6422 filters provide a time domain response that is comparable to more complex and expensive filters.

TYPICAL PASSIVE FILTER (Figure 13)

The output waveform is not symmetric. All ringing occurs after the main pulse. The result is visual smearing and fine ghosting to the right of every edge in the picture.

PHASE CORRECTED ANALOG FILTER (Figure 14)

The output waveform is substantially symmetric and ringing is greatly reduced. The result is an increase in apparent resolution. There is no smearing or ghosting.

ANALOG FILTERING IN THE TIME DOMAIN (Figure 15)

The output waveform is symmetric. Ringing is about the same as in the ML6420 or ML6422 alone. The difference between a purely analog and an analog/digital approach is subtle and will only have a material effect on multi-pass video processing.

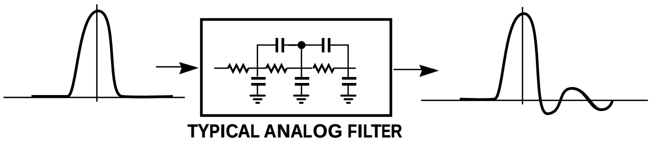

Figure 13. Typical Passive Filter

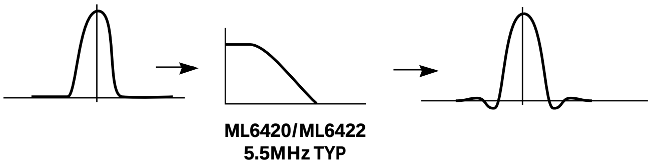

Figure 14. Phase Corrected Analog Filter

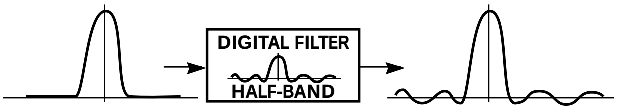

Figure 15. Analog Filtering in the Time Domain

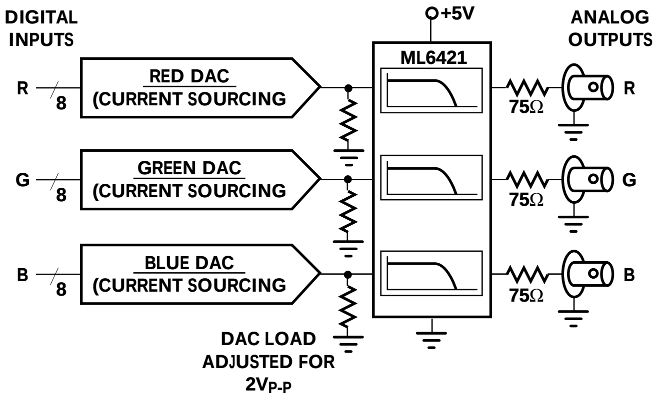

Figure 16. Typical ML6421 Reconstruction Application

FILTER PERFORMANCE

The reconstruction performance of a filter is based on its ability to remove the high band spectral artifacts (that result from the sampling process) without distorting the valid signal spectral contents within the passband. For video signals, the effect of these artifacts is a variation of the amplitude of small detail elements in the picture (such as highlights or fine pattern details) as the elements move relative to the sampling clock. The result is similar to the aliasing problem and causes a "winking" of details as they move in the picture.

Figure 17 shows the problem in the frequency domain. Curve A shows the amplitude response of the ML6421 filter, while Curve B shows the signal spectrum as it is distorted by the sampling process. Curve C shows the composite of the two curves which is the result of passing the sampled waveform through the ML6421 filter. It is clear that the distortion artifacts are reduced significantly.

Ultimately it is the time domain signal that is viewed on a TV monitor, so the effect of the reconstruction filter on the time domain signal is important. Figure 19 shows the sampling artifacts in the time domain. Curve A is the original signal, Curve B is the result of CCIR601 sampling, and Curve C is the same signal filtered through the ML6421. Again, the distortions in the signal are essentially removed by the filter.

In an effort to measure the time domain effectiveness of a reconstruction filter Figure 20 was generated from a swept frequency waveform. Curves A, B, and C are generated as in Figure 19, but additional curves D and E help quantify the effect of filtering in the time domain.

Curves D and E represent the envelopes (instantaneous amplitudes) of Curves B and C. Again it is evident in Curve D that the envelope varies significantly due to the sampling process. In Curve E filtering with the ML6421 removes these artifacts and generates an analog output signal that rivals the oversampled (and more ideal) signal waveforms. The ML6421 reduces the amplitude variation from over 6% to less than 1%.

DESIGNING A TEST BOARD

Typical I/O connections for the ML6420/ML6421 pair are:

1. AC coupled test circuit
2. DC coupled input and biasing connections
3. Video clamping prior to the filter input
4. Connections to A/D and DC loading considerations (<500Ω)

The same test circuits for both the ML6420 and the ML6421 are used for evaluation. The board includes the AC coupled DC bias circuit on filters B and C and the video clamp and gain circuit on filter A (see Figure 18).

AC COUPLED DC BIAS CIRCUIT

Figure 18 shows an optional AC coupled DC bias circuit on filters B and C. Generally, the ML6420/ML6421 pair can take a $1V_{P-P}$ or a $2V_{P-P}$ input, going as low as 0V (RANGE set high) or 0.5V (RANGE set low). This circuit is designed to take $2V_{P-P}$ input with RANGE set low. The DC bias is 1.5V so the input AC level is from 0.5V to 2.5V.

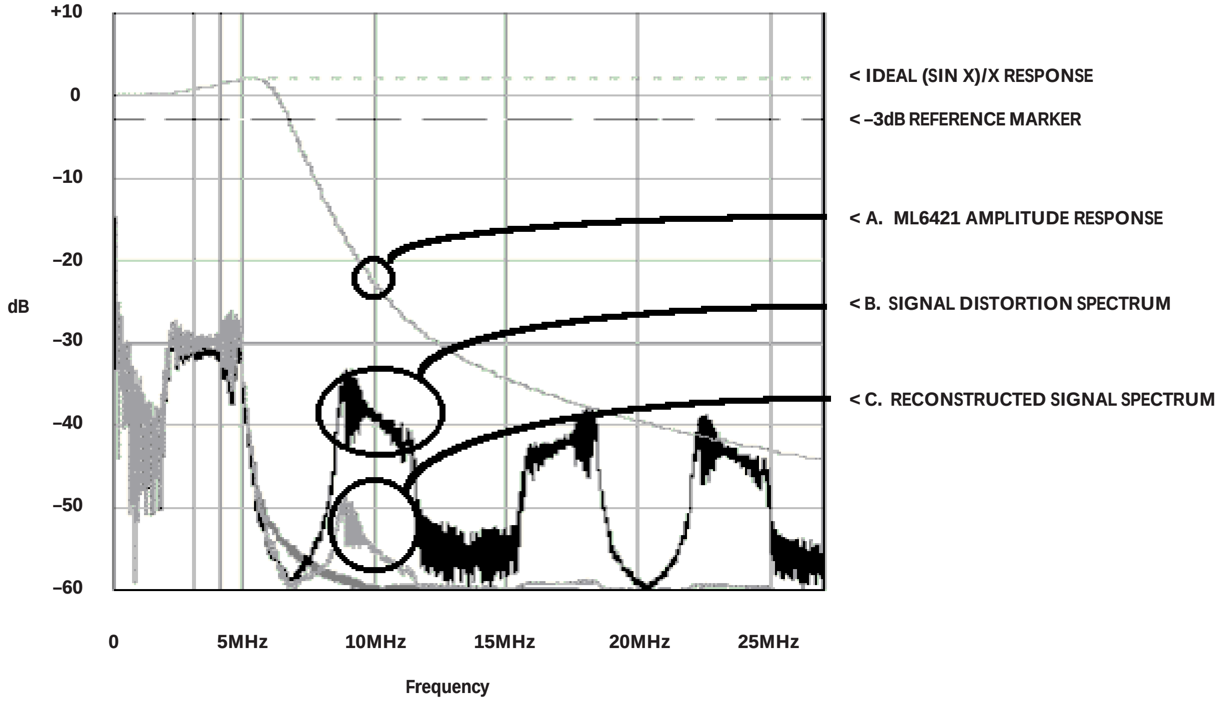

Figure 17. ML6421 Reconstruction Performance in the Frequency Domain

DESIGNING A TEST BOARD (Continued)

Filters B and C use the 0.01µF and the 100µF capacitors for AC coupling. This is required if the input signal DC level is unknown and needs to be removed. The 47Ω resistor with the 1µF capacitor are optional and help to clamp down on supply noise. The 1.86kΩ and 1kΩ resistors are used for DC biasing. The 1kΩ resistor is in parallel with the 4kΩ chip input resistance. This equals about 800Ω parallel resistance. The DC level is set to 1.5V ready to accept a $2V_{P-P}$ input signal with the RANGE pin set low. The input termination resistance will be the 85Ω resistor in parallel with the 1kΩ, 1.86kΩ and 4kΩ chip input resistance. This equals about 75Ω parallel resistance. The decoupling capacitors on the V_{CC} pins need to be as close as possible to the chip. The capacitors and ferrite beads are not all necessary if a clean V_{CC} signal is available.

CLAMP AND GAIN CIRCUIT

Figure 18 shows an optional clamp and gain circuit on filter A. The NPN transistor differential pair, with the network around them, serve as a gain stage for the input video signal. You can tune the circuit for different gains (currently, it is tuned for a gain of 2). The gain is (1+ (4 kΩ in parallel with 4kΩ) in parallel with 2kΩ) = 1 + 1 = 2. The input termination resistor is 75Ω and the input AC coupling capacitor is 47µF.

The two transistors on top perform the clamping function. They do not allow the input signal to go below 0.5V. The 82W resistor sets up the DC level for the transistors. This circuit detects the lowest level of the AC signal and sets that to 0.5V. This way, the whole AC signal will go from 0.5V to 1.5V (if the input was $0.5V_{P-P}$) or 0.5V to 2.5V (if the input was $1.0V_{P-P}$). It will do this by charging the 0.1µF and 200µF capacitors to the target DC level. The capacitors will sustain the DC level throughout the cycle with minimal loss.

Different characterization graphs were generated using this board. Some are included at the end of this document.

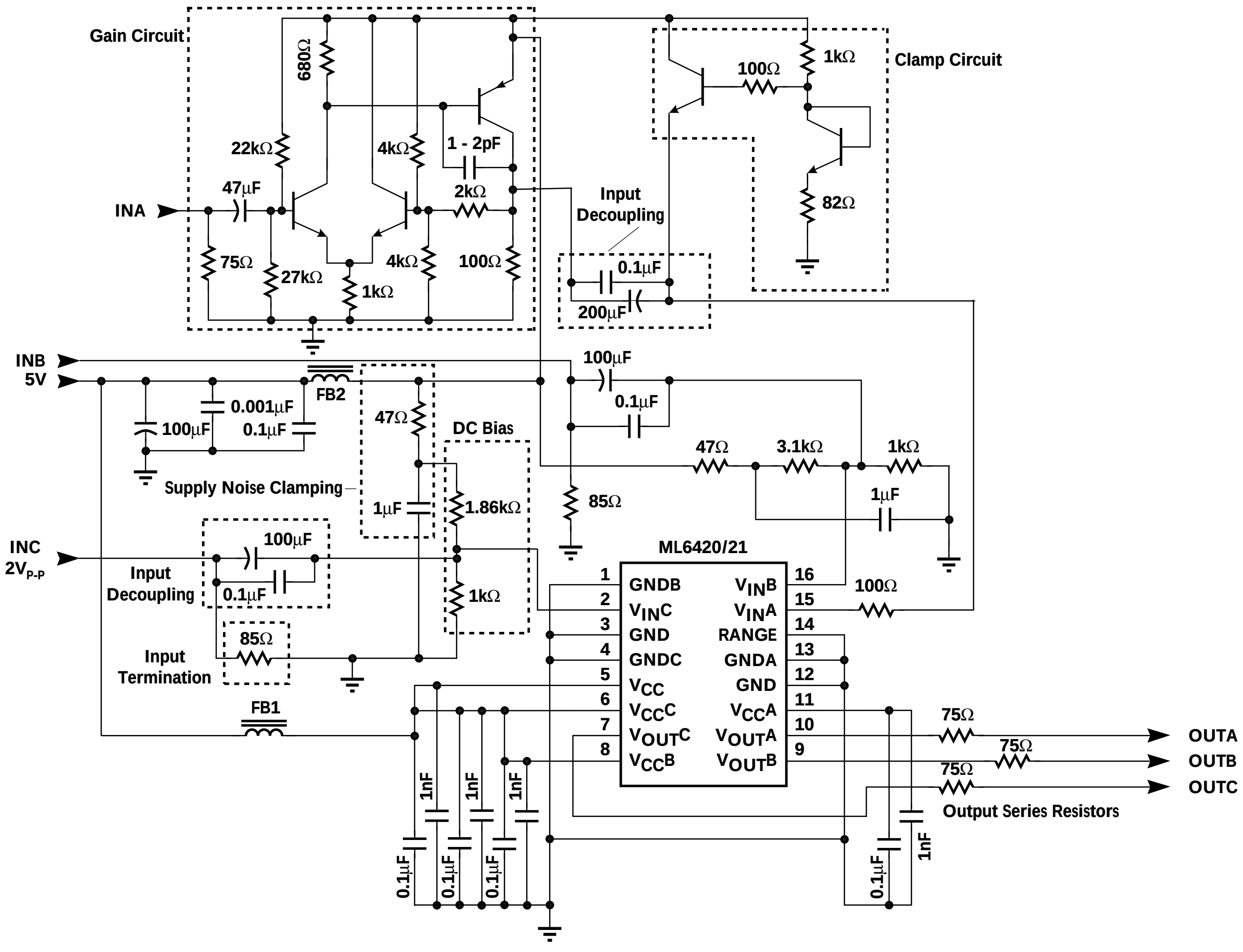

Figure 18. Video Clamp and Gain Circuit on Filter A; Optional AC Couple DC Bias Circuit on Filters B and C.

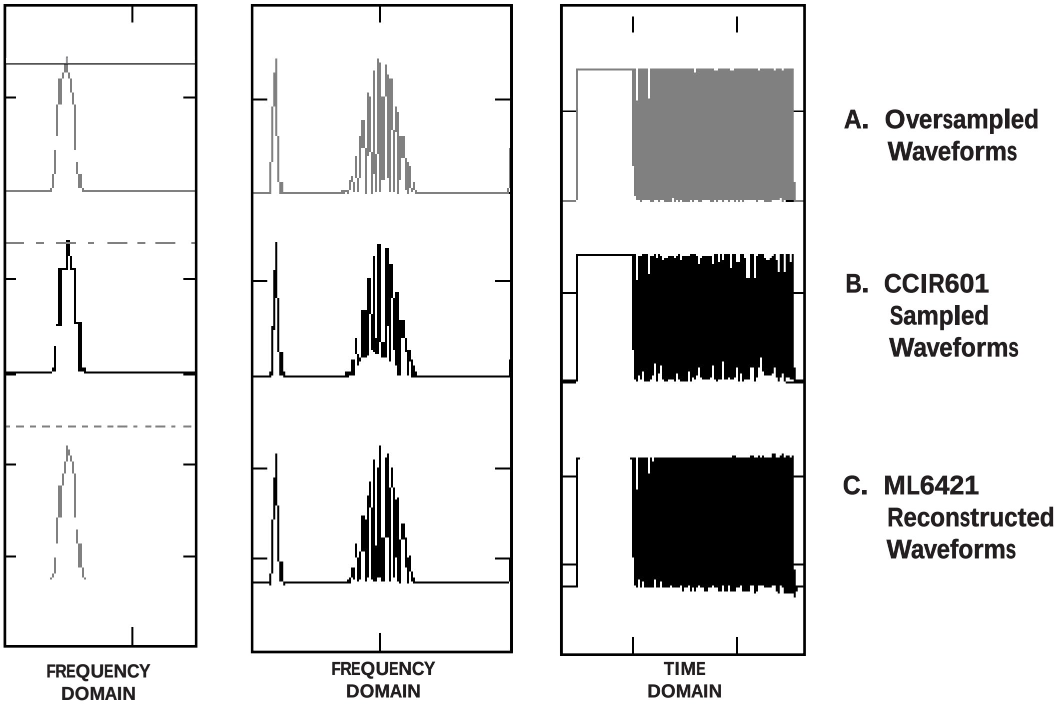

Figure 19. ML6421 Reconstruction Performance in the Time Domain

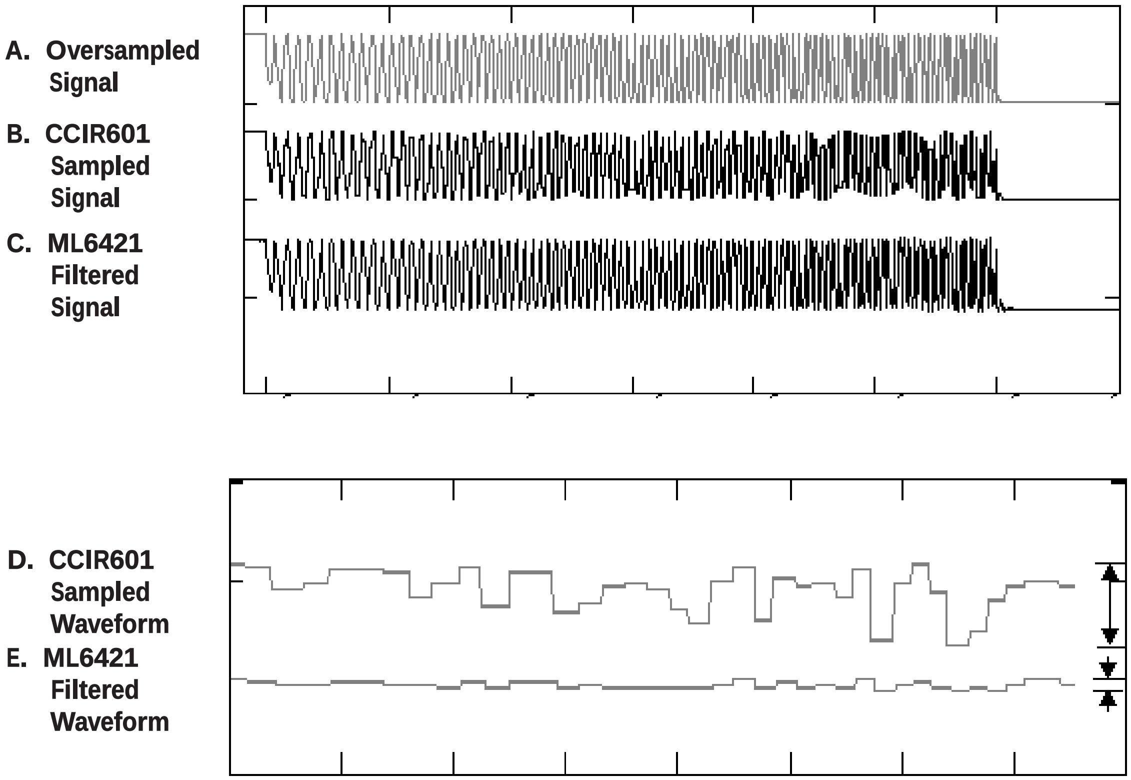

Figure 20. Amplitude Ripple of Reconstructed Swept Pulses

DESIGN CONSIDERATIONS

LAYOUT CONSIDERATIONS

You need to be very careful when laying out boards for the ML6420/ML6421 pair. This is an analog filter with many precise components that run at high frequencies and are susceptible to noise. The design guidelines discussed here have been used to minimize noise. Space the signal leads as far away from each other as possible.

OUTPUT CONSIDERATIONS

The ML6420/ML6421 pair has unity gain (0dB) when connected to a 150Ω load, and a –6dB gain when driving a 75Ω load via a 75Ω output resistor. The output may be either AC or DC coupled. The –3dB point should be 5Hz or less for AC coupling (Figure 18). There must also be a DC path of <500Ω to ground for biasing to improve step response.

INPUT CONSIDERATIONS

The input resistance is 4kΩ. The input may be either DC or AC coupled. Note that each input sources 80µA to 125µA of bias current

GROUND AND POWER CONSIDERATIONS

A ground plane is recommended for multilayer boards. Connections to the ground plane should be wide, and as short as possible, to minimize trace inductance. All ground pins and decoupling capacitors should be directly connected to the ground plane. The ground plane can be split between filters to minimize crosstalk.

Each filter has its own supply and ground pins. In the test circuit, a 0.1µF capacitor is connected in parallel with a 1nF capacitor on V_{CC} pins for maximum noise rejection (Figure 18). These capacitors should be as close as possible to the device pins, and preferably be surface mount.

Two separate power distribution networks are recommended for multilayer boards. One network would connect V_{CC}, V_{CCA}, V_{CCB}, and V_{CCC} to the chip through a ferrite bead from the main supply source. The other would be used for chip bias, which should also be connected through a ferrite bead from the main supply source. A typical supplier for beads is FairRite products (phone 914-895-2055, part # 2743021446). They should have a maximum resistance of 0.02Ω. Low resistance surface mount resistors (<10Ω) could be used instead of beads to provide low pass noise filtering.

There should be decoupling capacitors on the main supply source. Customers are advised to use this information as a guideline, and utilize the best design for their system.

ML6420 APPLICATION DESIGN

Figures 21 and 22 show two typical applications for the ML6420 for anti-aliasing prior to A/D conversion. In Figure 21 a single precision digital feedback clamp circuit includes both the ADC and the ML6420. This establishes the proper DC operating point for the ML6420 (with RANGE input = 0, $0.5V \leq V_{IN} \leq 2.5V$; with RANGE input = 5V, $0.0V \leq V_{IN} \leq 2.0V$) and the ADC. Figure 18 is typically used with ADCs requiring external clamp circuitry.

Figure 22 shows AC coupled application for ADC's with built-in clamps. In this case the clamp is internal to the ADC and the ML6420 uses a simple coarse clamp at its input to establish the proper operating point.

TYPICAL I/O CONNECTIONS FOR THE ML6421

The ML6421 offers a (sin x)/x correction which is designed for restoration filtering at the output of a DAC. It is designed to be driven directly by the DAC. A termination resistor might be necessary at the output of the DAC (usually 75Ω or 150Ω).

In a typical application the ML6421 is used as the final output device in a video processing chain. In this case inputs to the ML6421 are supplied by DAC outputs with their associated load resistors. Resistance values should be adjusted to provide $2V_{P-P}$ at the input of the ML6421. The ML6421 will drive 75Ω loads via 75Ω source termination resistors (making the total load 150Ω) so that no external drivers or amplifiers are required.

CHARACTERIZATION GRAPHS

Figure23 represents the ML6420/21 characteristics. These include stop band, pass band, and group delay, all discussed earlier.

Figure 24 represents the different pulse responses for the ML6420. These were taken using a Magni video scope.

Figure 25 represents comparisons between the ML6420 and ML6421.

All of these graphs were developed using the test circuit discussed previously.

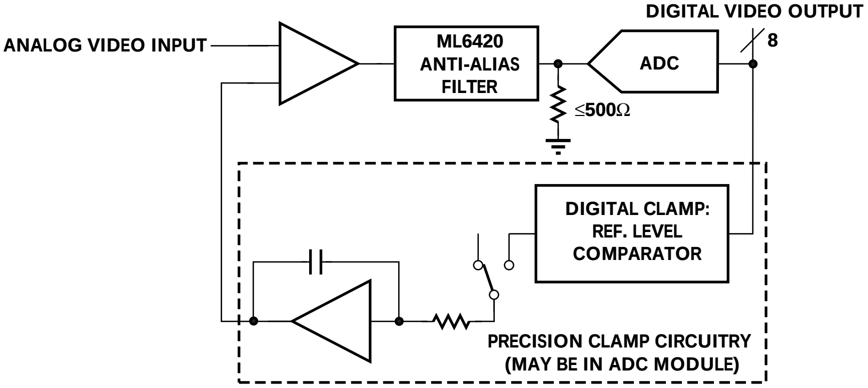

Figure 21. ML6420 in DC Couple Video Digitizer for $2V_{P-P}$ Video Signals

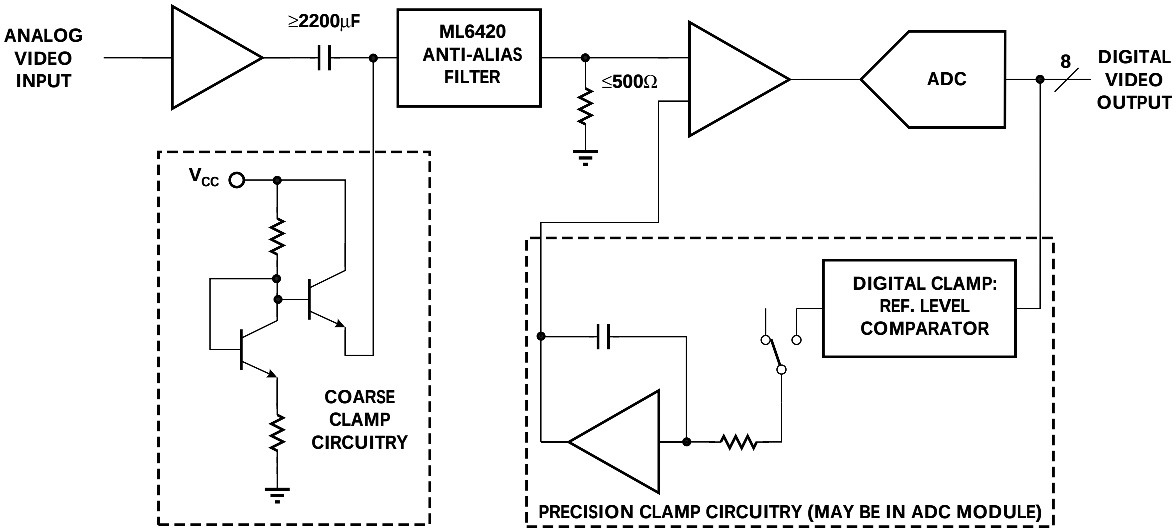

Figure 22. ML6420 in AC Coupled Video Digitizer for $2V_{P-P}$ Video Signals

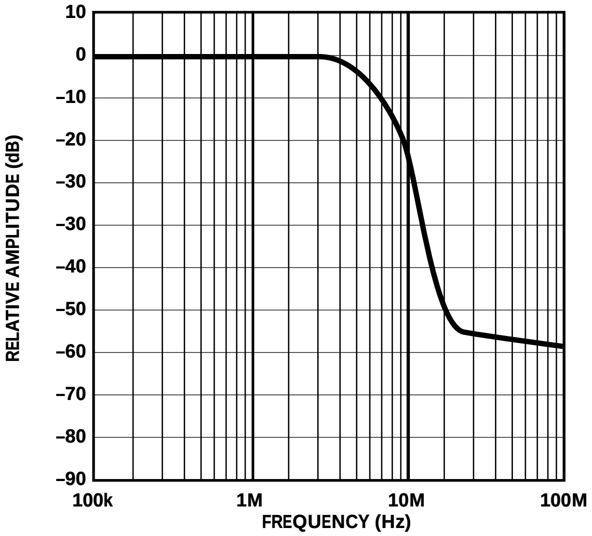

Figure 23a. Stopband Amplitude vs Frequency (f_C = 5.5MHz)

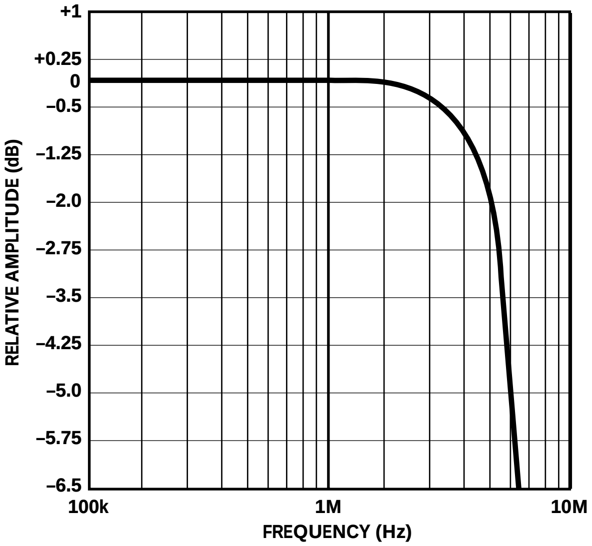

Figure 23b. Passband Amplitude vs Frequency (f_C = 5.5MHz)

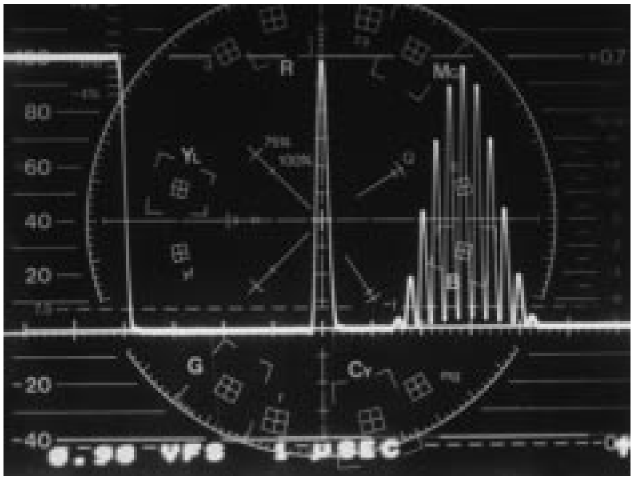

Figure 24a. Burst with 100ns Pulse and Fast Transition at ML6420 Output Showing Symmetrical Pulse Response

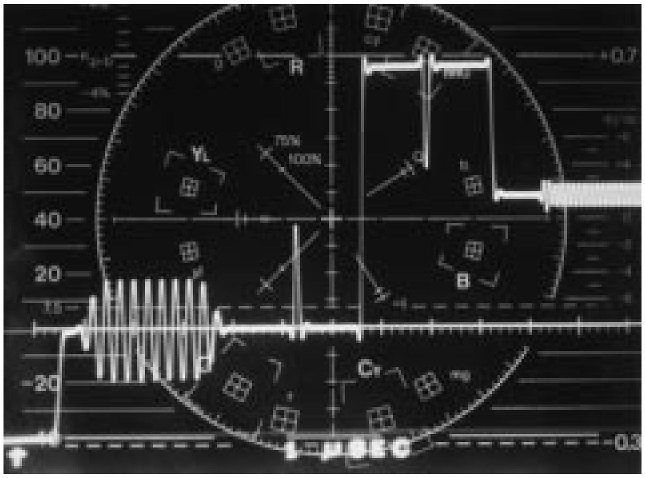

Figure 24b. Step with 2T and 12T Response at ML6420 Output Showing Pulse Without Overshoot or Ringing

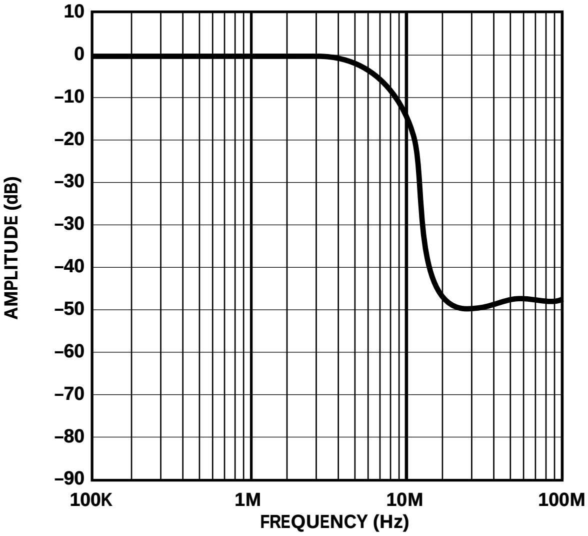

Figure 25a. Stopband Amplitude vs Frequency (f_C = 5.5MHz)

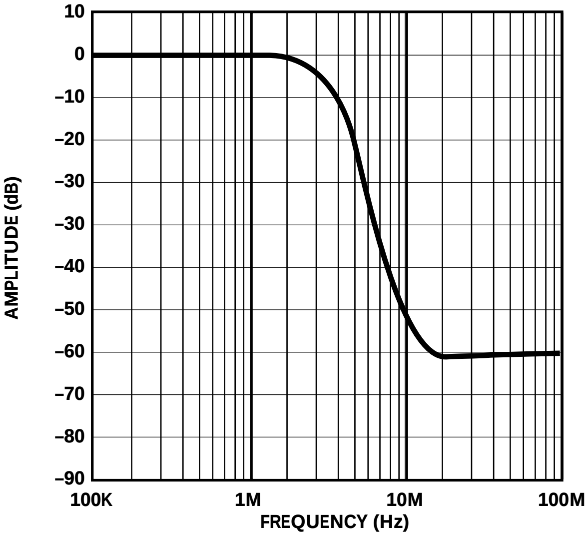

Figure 25b. Stopband Amplitude vs Frequency (f_C = 1.84MHz)

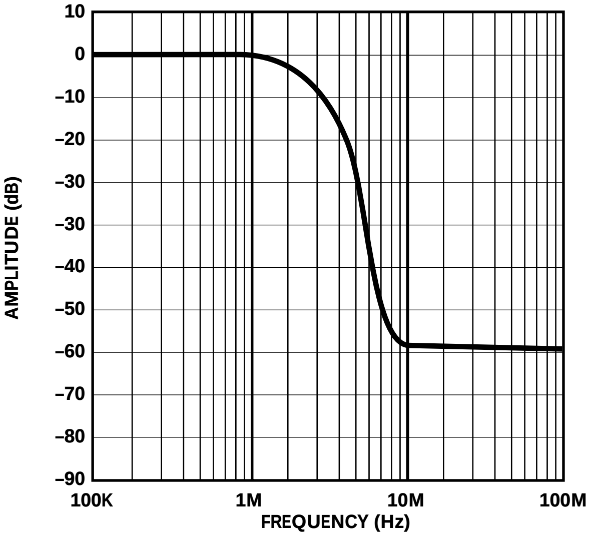

Figure 25c. Stopband Amplitude vs Frequency (f_C = 8.0MHz)

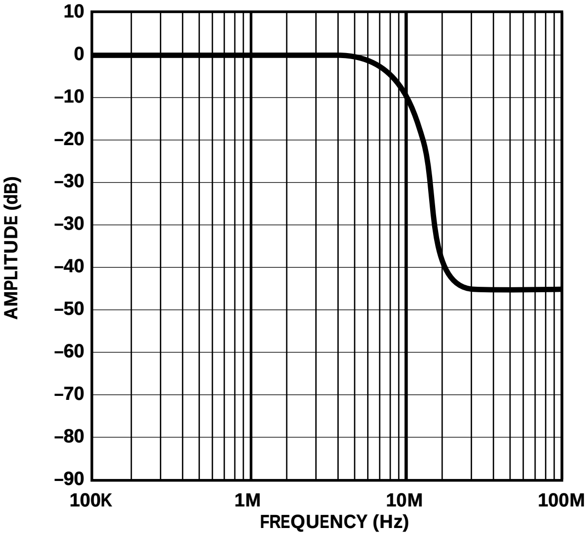

Figure 25d. Stopband Amplitude vs Frequency (f_C = 3.0MHz)

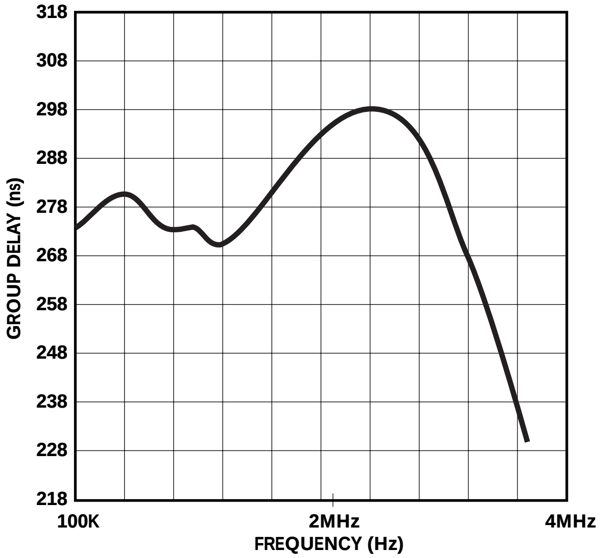

Figure 25e. Group Delay vs Frequency (f_C = 1.84MHz)

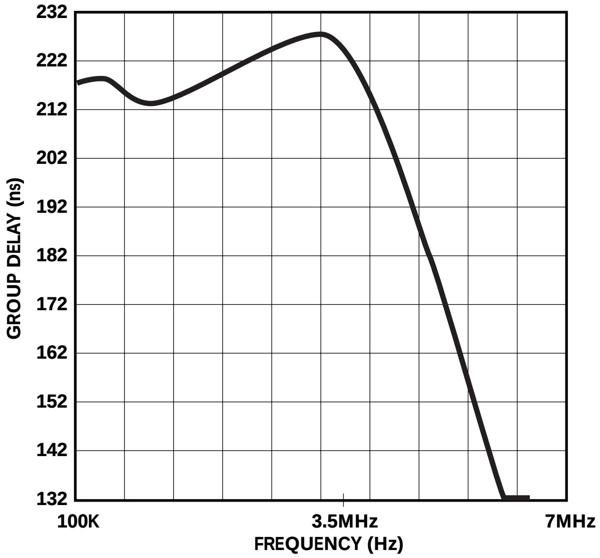

Figure 25f. Group Delay vs Frequency (f_C = 3.0MHz)

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