April 1998

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Application Brief 42016

The Low Noise Characteristics of the ML6428

INTRODUCTION

This Application Note discusses noise measurements taken on the Micro Linear video filter family. The reason for the measurements is that noise, like group delay or diff-gain/diff-phase, is a budgeted parameter; only so much noise can be added to a signal during processing. Unlike the other important video signal parameters noise is both difficult to define and difficult to measure. Each component in a system (*e.g.,* a resistor, a capacitor, an inductor, or an IC chip) will add some noise to the signal. In general, active components add more noise than passive ones. Measuring this added noise is very difficult since it is random and based on the laws of statistical thermodynamics.

Theoretically, random noise contains all frequencies. In practice, the noise spectrum is limited by the system bandwidth.

Random noise has a Gaussian amplitude distribution. Therefore, no single peak-to-peak (P-P) amplitude can be measured. A root mean squared (RMS) voltage or power in watts can be associated with the noise on a signal. In order to compare the RMS noise voltage to the signal, the signal must be converted to an RMS voltage. Active video can't be used; its RMS value changes with time. The one standard constant video signal is a white bar. Since it is a constant voltage, its peak value is its RMS value. A comparison can now be made between the RMS value of the white bar and the RMS value of the noise with no signal present (*e.g.,* a black burst). Further, the effects of the sync tip and the color burst should be excluded. Setting up this measurement could present problems.

Fortunately, the Tektronix VM700T/TG2000 does that as one of its standard tests. Figure 1 shows the noise floor of the black burst signal to be 82.3 dB. Figure 2 shows that the noise added by the Y channel or the C channel of the ML6428 is 1.5 dB (82.3 dB - 80.8 dB = 1.5 dB). The circuits are identical; and therefore, add the same amount of noise to the signal in each channel. Figure 3 shows the noise on the composite video output of the ML6428. It is 3.1 dB higher than the noise on either the Y or the C output. This requires some explanation.

Starting with S Video, a Y signal with its noise must be added to a C signal with its noise to obtain composite video (CV). The Y signal will have a maximum amplitude of 1 V P-P. The C signal may have an amplitude of 0.5 V P-P. The CV signal will have a maximum amplitude of 1 V P-P, not 1.5 V P-P. The noise voltages will also add, but not directly. If they are uncorrelated, they must be added vectorially.

If $\overline{V}_{NY}$ is the noise voltage in the Y channel and $\overline{V}_{NC}$ is the noise voltage in the C channel then:

$$\overline{V}_{TOTAL} = \sqrt{\left(\overline{V}_{NY}\right)^2 + \left(\overline{V}_{NC}\right)^2}$$

If the Y and C channels are identical, then $\overline{V}_{NY}$ will equal $\overline{V}_{NC}$. Call that voltage $\overline{V}_{N}$. Then:

$$\overline{V}_{TOTAL} = \sqrt{\left(\overline{V}_{N}\right)^2 + \left(\overline{V}_{N}\right)^2} = \sqrt{2\left(\overline{V}_{N}\right)^2} = \sqrt{2}\left(\overline{V}_{N}\right)$$

The VM700/TG2000 computes the signal-to-noise ratio (SNR) as

$$SNR = 20\log\frac{0.174\overline{V}^{\dagger}}{\overline{V}_N}$$

which becomes

$$SNR = 20\log\frac{0.714\overline{V}}{\sqrt{2}\left(\overline{V}_N\right)}$$

(†) White Bar Signal

Remembering that log AxB = log A+log B

$$SNR = 20\log\frac{0.714}{\overline{V}n} + 20\log\frac{1}{\sqrt{2}}$$

but

$$20\log\frac{1}{\sqrt{2}} = -3.0\text{dB}$$

This shows that the CV output will always be 3 dB worse, i.e. have 3 dB more noise than either the C or the Y outputs. Further, numerically correlation is a coefficient ranging from –1 through 0 to +1. The –1 value means that the noise voltages would add to zero. The 0 value is the above case, totally uncorrelated. The +1 value means that the noise voltages would add directly, not vectorially. A coefficient with a value between 0 and +1 (*e.g.,* 0.5) means that half the signal is uncorrelated and the other half is correlated. The reduction in signal to noise ratio (SNR) with a coefficient of +1 would then be 6 dB, not 3 dB as above. The measured decrease in SNR for the CV output was 3.1 dB. The 0.1 dB is the noise added by the

CV output driver. There is a small positive correlation between the Y and C channel noise—it is one piece of silicon—or it could be a combination of the two. Of much more concern are the actual numbers. A SNR of –60 dB means there is 714 microvolts of RMS noise on the video signal. A SNR of –80 dB means 71.4 microvolts of RMS noise. Adding 3.1 dB of noise means the signal has 66.4 microvolts RMS more noise. This helps to explain the noise seen in the ML6428.

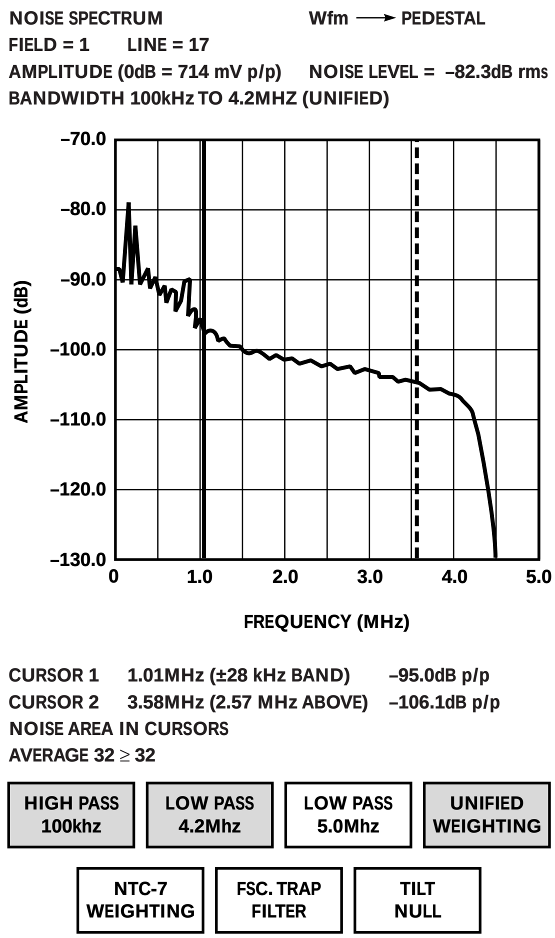

Figure 1.

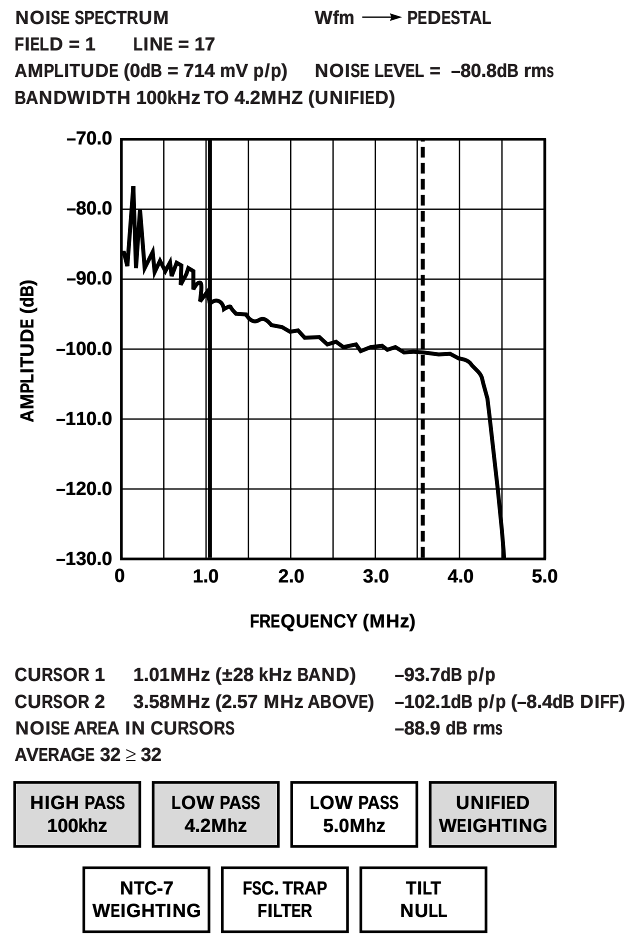

Figure 2.

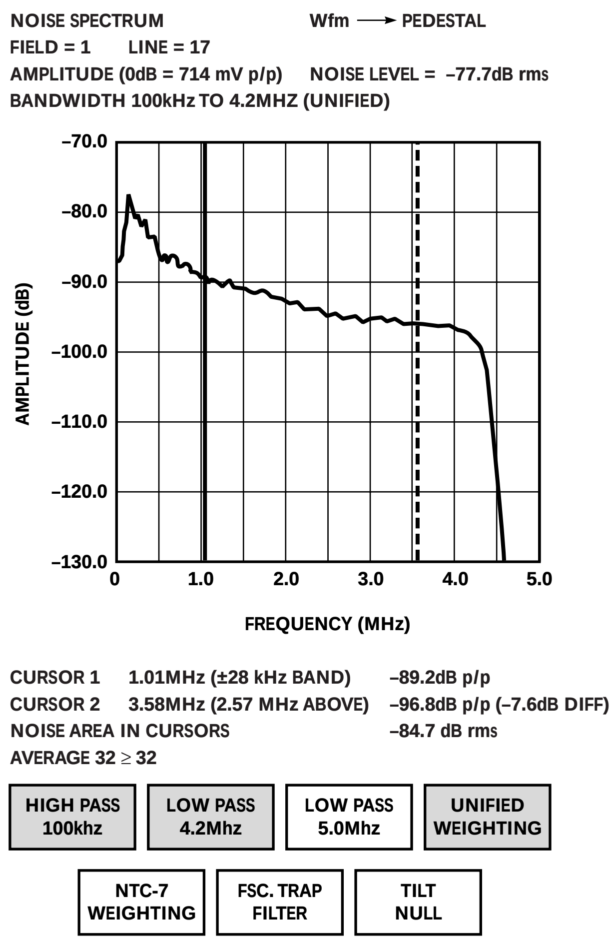
NOISE SPECTRUM
Wfm → PEDESTAL
FIELD = 1 LINE = 17
AMPLITUDE (0dB = 714 mV p/p)
NOISE LEVEL = –77.7dB rms
BANDWIDTH 100kHz TO 4.2MHZ (UNIFIED)
AMPLITUDE (dB)
–70.0
–80.0
–90.0
–100.0
–110.0
–120.0
–130.0
0
1.0
2.0
3.0
4.0
5.0
FREQUENCY (MHz)
CURSOR 1 1.01MHz (±28 kHz BAND) –89.2dB p/p
CURSOR 2 3.58MHz (2.57 MHz ABOVE) –96.8dB p/p (–7.6dB DIFF)
NOISE AREA IN CURSORS –84.7 dB rms
AVERAGE 32 ≥ 32
HIGH PASS 100khz
LOW PASS 4.2Mhz
LOW PASS 5.0Mhz
UNIFIED WEIGHTING
NTC-7 WEIGHTING
FSC. TRAP FILTER
TILT NULL

Figure 3.