AC Coupling Capacitor Selection for Wolfson AFE devices

INTRODUCTION

For many imaging designs it is necessary to add ac coupling capacitors to the analogue inputs of the AFE to remove the dc offset generated by the sensor. In the majority of cases this will be required for CCD style sensors but may also be applicable to some CIS sensors. The selection of the capacitor can have a large bearing on the quality of conversion and therefore requires careful selection. This document explains the purpose of the decoupling capacitor and aids with selection of the correct value.

AC COUPLING CAPACITOR SETUP

Figure 1 demonstrates how the three channels of a sensor, Red-Green-Blue, are ac coupled to a Wolfson AFE. **Note:** For monochrome or sequenced RGB output sensors only a single channel is required.

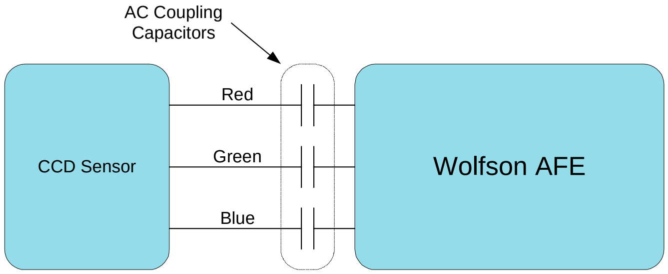

Figure 1 Power Supply Arrangement with Noisy Supplies

Many imaging sensors will have dc offset associated with the analogue output, which will be specified in the manufacturer's datasheet and in some cases can be up to $10V_{dc}$. The analogue signal applied to any Wolfson AFE must be in the range from 0V to AVDD. Figure 2 indicates the potential problem.

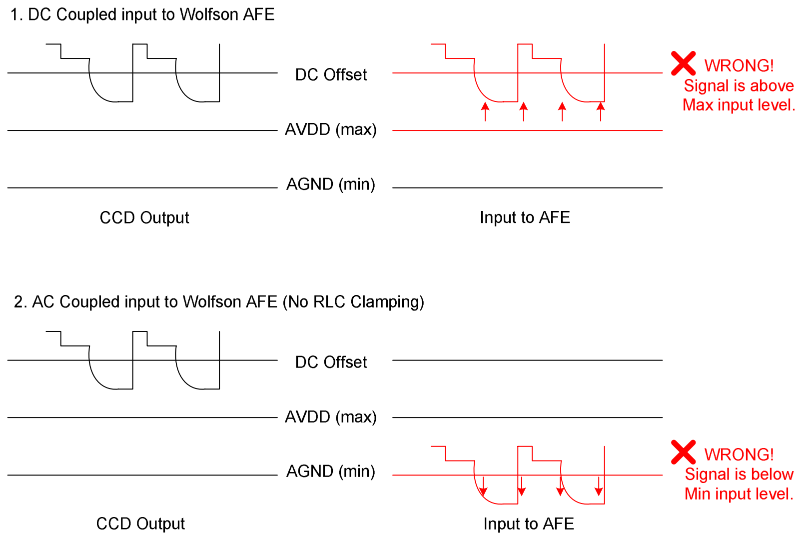

Figure 2 DC Offset Connection to AFE

As can be seen from Figure 2, adding a capacitor alone does not resolve the problem. With the capacitor in place the dc from the sensor is blocked, however, the connection into the AFE then drifts around zero volts causing a portion of the signal to go below 0V and out of the permissible range of input to the AFE.

To resolve this problem Reset Level Clamping (RLC) must be applied to clamp the ac coupled signal to a known dc level, this allows the input to fall within the range 0V to AVDD. This clamping is normally completed during the RESET portion of the sensor output. Figure 3 is an example of RLC clamping and timing associated.

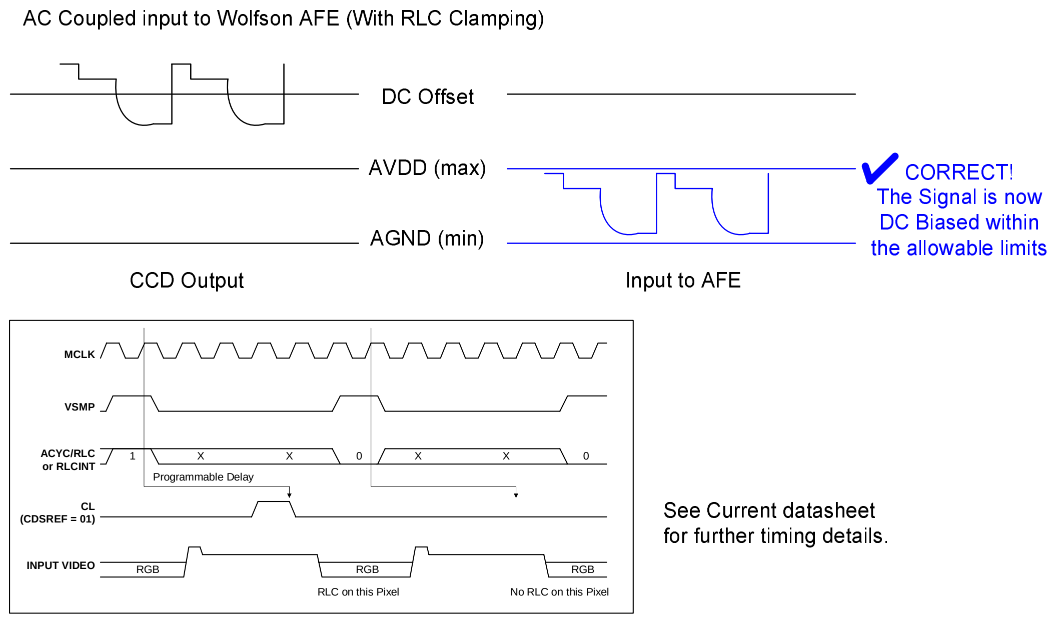

Figure 3 RLC Clamping

RLC CLAMPING EFFECT

The clamping needs to be considered with respect to the frequency. When RLC clamping is selected the length of clamp is determined by MCLK. This internal clamp is named CL and is displayed in Figure 4.

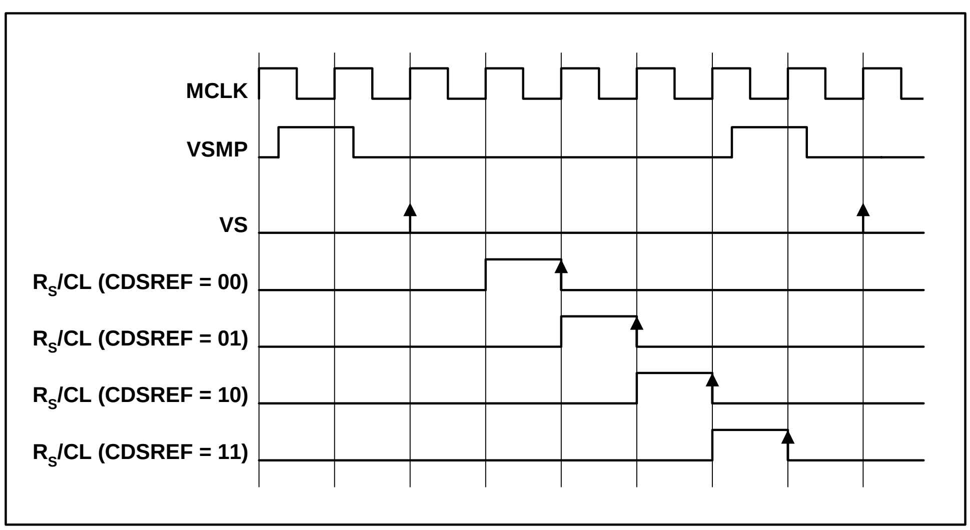

Figure 4 Reset Sample and clamp timing

The CL clamp lasts for one MCLK cycle and the Reset sample is taken on the rising edge of MCLK at the end of the CL pulse.

Therefore the length of time per clamp is:

Clamp time = 1 / MCLK frequency

For every RLC clamp command the ac coupling capacitor will be charged for the clamp time duration.

SENSOR INPUT SIGNAL AMPLITUDE

The dc level on the ac coupling capacitor depends on the length of time of the capacitor charging, the value of capacitance, the voltage applied and the resistance in the circuit. Figure 5 shows the equivalent circuit that represents the common R/G/BINP input to Wolfson AFE's.

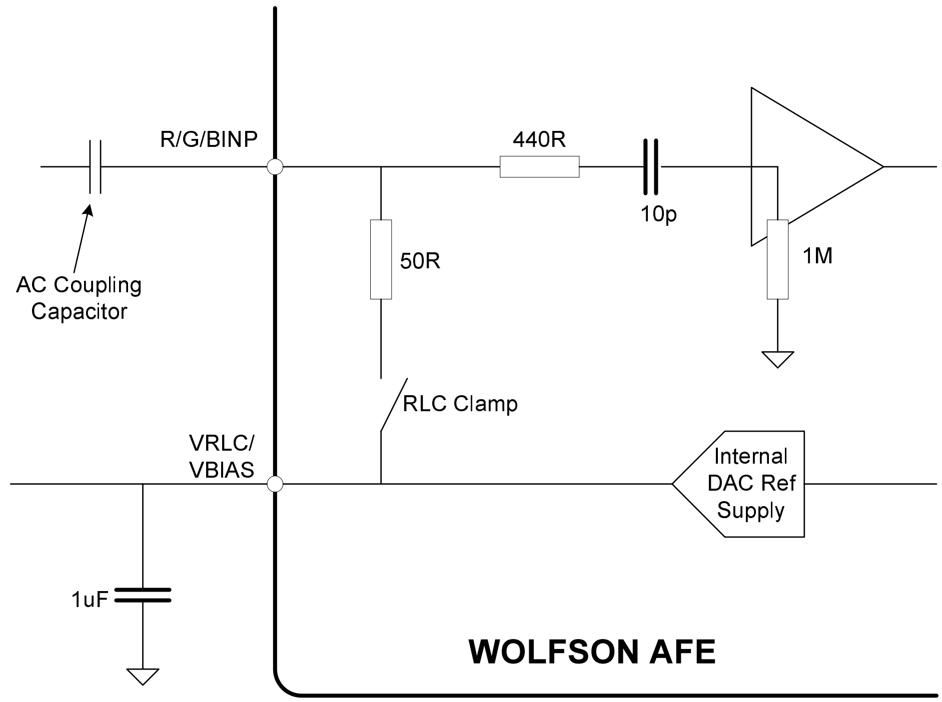

Figure 5 AFE Equivalent Input Circuit

In some situations, where the AFE is used at higher frequencies, the generally recommended 220pF ac coupling capacitor value maybe too small. In these circumstances the capacitor should be changed in order to achieve correct operation and minimize the drop across the capacitor. The internal capacitance for the Wolfson AFE is approximately 10pF. Using this value in a theoretical potential divider calculation will provide an accurate guide to the minimum external capacitor required. The input waveform from the sensor is potentially divided across the two capacitors, Figure 5. The amplitude of the signal sampled internally to the Wolfson AFE is at a level described by the equation:

$$V_{SAMPLE} = V_{SENSOR} * [XC_{AFE} / (XC_C + XC_{AFE})]$$

Where: $XC_{AFE} = 1 / [2\pi fC_{AFE}]$ and $XC_C = 1 / [2\pi fC_C]$

EXAMPLE

An example of the effect of poor selection of input capacitor on the amplitude of the signal is as follows:

A system requires ac coupling for a 6MSPS CCD sensor. Initially a 100pF capacitor is selected to ac couple the 0.5Vp-p Signal. The actual input signal amplitude sampled within the AFE is calculated using the following values:

$$V_{SENSOR} = 0.5V_{p\text{-}p},\ C_C = 100pF,\ C_{AFE} = 10pF$$

The reactance is calculated thus:

$$XC_{AFE} = 1 / [2\pi fC_{AFE}] \quad = 1 / [2\pi * 6e10^{6} * 10e10^{-12}] = 2652.6\Omega$$

$$XC_C = 1 / [2\pi FC_C] \quad = 1 / [2\pi * 6e10^{6} * 100e10^{-12}] = 265.26\Omega$$

And the actual sample voltage is:

$$V_{SAMPLE} = V_{SENSOR} * [XC_{AFE} / (XC_C + XC_{AFE})]$$

$$V_{SAMPLE} = 0.5 * [2652.6 / (265.26 + 2652.6)]$$

$$V_{SAMPLE} = 0.5 * 0.909 = 0.454V_{p\text{-}p}$$

The minimum input signal (i.e. sampled amplitude) may potentially be 0.4V therefore the drop across the ac coupling capacitor is very significant in terms of maximising the dc input range. Increasing C_C, for example, to 330pF would increase $V_{SAMPLE} = 0.485V_{p\text{-}p}$ and so increase the input range.

SUMMARY

This application note explains the importance of careful choice of ac coupling capacitors between imaging sensors and Wolfson AFE devices. The choice of capacitor is related to the maximum sampling frequency expected to be encountered in the application where the device is used.

APPLICATION SUPPORT

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