Challenges in Mixed Signal Designs

By Rajaram Shastri, Senior Architect (Hardware), Mistral Solutions Pvt. Ltd.

Introduction

Designers who are working on next generation designs need to intermix and deal with a variety of RF elements, data converters and complex digital designs. As the clock speeds increase, voltage levels reduce and circuit sizes shrink, the engineers are forced to understand and address the analog behavior of digital components.

The current market trend forces IC manufacturers to high level of integration, by putting RF, analog and digital circuits in a single package.

This forces designers to address the mixed signal behavior like never before. This is one such attempt to address this issue

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The ground reality is there is no ready-made solution or answer to this question.

What is mixed signal Design?

Answer to this question is multifold and there is no single and/or straightforward answer to this.

A digital design engineer may say he doesn't have to worry about the analog nature of the signal, but the fact is that as frequency increases and voltage level decreases, he has to worry about signal rise time, slew rate, offsets, coupling issues, impedance matching and measuring instrument parameters such as bandwidth, termination, coupling etc.

For an analog engineer the situation is different. The high-level of integration of PLLs, mixers, attenuators, detectors, which have digital control and digital output, have complicated the issues of power supply and GND isolation, return-path issues, logic level compatibility, drive strength etc.

The design of data converters such as ADCs and DACs add to the above mentioned complexity and the designer has to address all these parameters for a single device to successfully integrate these devices.

The high degree of integration has also demanded designers to address thermal issues of various ICs such as ADC, DAC, PLL/VCO, clock buffers and mixers. Removing hot-spots from these components is critical else the performance can be severely degraded.

PCB design considerations are another aspect which designers have to address. Due to the high level of integration, the differentiation between RF design and analog design is very fine. Modern ICs support zero IF or low IF receivers and transmitters at various frequencies band, starting from S-band and going up to C-band and even higher frequency band. Usage of these ICs allows design of direct conversion transmitters and receivers. The Zero-IF or low IF base-band signals can be directly digitized using high-speed ADCs. The processed base-band signal, up to 1GHz frequency can be re-generated using High-speed DACs and DDS techniques. This results in usage of complex, inter-mix of RF and data converter ICs in a single design. Here the designer has to understand and address the PCB parameters such as dielectric loss, dissipation factor, skin-depth etc. The FR4 PCB material may not be sufficient when the frequencies increase beyond 1GHz range and other Teflon based material may have to be looked into.

The other side of the frequency spectrum has its own challenges. The low frequency analog design has its own challenges. Precision measurement of analog signals, used in instrumentation and sensor design is the key application here. The ICs available in the market for such a solution are highly integrated with digital circuitry. The challenge for the designer here is to keep the power supply noise very low, guarding the analog signals from digital interferences and offset issues.

Testing and Debug

Testing and Debugging is another aspect for designers to address. Digital designers have to understand the clock and data characteristics, or differential behavior of the signals. Usages of CROs with active probes and differential probes have been common practice. The designer needs to understand rise-time, band-width and coupling methods of CROs and probes. Advanced triggering methods such as triggering of a glitch, droop and analog and digital cross triggering help designers to debug the issues.

Analog Engineers have to use spectrum analyzers and power meters to measure phase-noise of the clock or the base-band signal power. The instrument resolution, frequency response, gain flatness and cable loss are some of the things to take care of while testing mixed signal designs.

Mistral's Capability in Mixed Signal Designs

Mistral's team of hardware engineers have over the years mastered the challenges in the arena of mixed signal designs, having worked on several high-speed DAC and ADC designs and multiple RF designs for defense, aerospace, consymer electronics, industrial and medical applications.

The first mixed design board designed in mistral had a 16-bit ADC with sample clock of 80MHz, an FPGA and a DSP processor. This design was successfully designed and tested, way-back in-the year, 2000-2001. From then on, Mistral's journey in the field of mixed signal designs has been impressive.

Mistral's contributions in the field of mixed signal design include:

- Video capture and processing board with video-codec, FPGA and processor
- Direct conversion modulator and demodulator with DAC and ADC operating up to 1.2GHz sampling and RF input up to 3.5GHz.
- Low precision designs consisting of sensors and signal conditioning circuitry for detecting temperature as low as 30mili Kelvin
- Usage of 24-bit to 31-bit ADCs

Mistral's hardware team has extensive expertise in the design of, LNA amplifiers, high-speed fully differential amplifiers, low noise amplifiers, clock synthesizers, low noise power supply design, de-coupling design which are essential for the mixed signal designs.

Along with the circuit design and simulation, the PCB designs have also used mixed dielectric materials, combination of RO-4350B and FR-4, for the designs which have a mix of RF and ADC/DAC. Such PCBs provide best performance where both RF and IF designs are realized on a single PCB.

Mistral has wide range of test equipments which consists of High-end CROs, Spectrum Analyzers, RF Signal generators, Logic analyzers and precision signal sources. These help in generating appropriate test signal and characterize the design. The test method for Data converters, PLLs and other mixed designs has been standardized across the organization. This will help in continuous improvement and getting better performance out of each design.