

DESIGN NOTES

Low Distortion, Low Noise Differential Amplifier Drives High Speed ADCs in Demanding Communications Transceivers

Design Note 366

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Introduction

Today's communications transceivers operate at much higher frequencies and wider bandwidths than those of the past. Combining this with higher resolution requirements, transceiver design can become daunting. For engineers designing these systems, small noise and distortion budgets leave little flexibility when choosing system components.

The LT[®]1993-x is designed to meet the demanding requirements of communications transceiver applications. It can be used as a differential ADC driver or as a general-purpose differential gain block. For single-ended systems, the LT1993-x can replace a transformer in performing single-ended to differential conversion without sacrificing noise or distortion performance.

LT1993-x Features

The LT1993-x is a fully differential input and output amplifier with up to 7GHz of gain-bandwidth product and an impressive feature set. There are three fixed-gain options with internal matched resistors: gain of 2 (6dB), gain of 4 (12dB) and gain of 10 (20dB). The LT1993-x is DC-coupled, precluding the need for DC blocking capacitors on the inputs and outputs. The output common mode voltage is independently controlled with an external pin, allowing optimal bias conditions for the ADC inputs. The LT1993-x features two sets of differential outputs: a normal output and a filtered output. The output filter eliminates additional filtering in many applications, but if necessary, additional filtering can be achieved with a few external components. Figure 1 shows a block diagram of the LT1993-x.

High Speed ADC Driving

One of the more challenging tasks in a modern communications transceiver is driving the analog-to-digital converter (ADC). Today's converters sample data at tens to hundreds of Megahertz with up to 16 bits of resolution. With each sample cycle, the switching of the internal ADC sample and hold injects charge into the output of the driver which must absorb the charge and settle its output before the next sample is taken. This charge injection is inherent in nearly all high speed, high resolution ADC topologies and must be considered when choosing a suitable driver.

The LT1993-x was designed specifically to drive high speed ADCs to their full potential. With a $3.8nV/\sqrt{Hz}$ voltage noise specification and $-70dBc$ of harmonic distortion at 70MHz ($2V_{p-p}$ differential output), the LT1993-x meets and exceeds the requirements for driving high resolution high speed ADCs. Figure 2 shows an FFT of sampled data taken on a 70MHz input signal with the LT1993-2 driving an LTC[®]2249 sampling at 80MSPs.

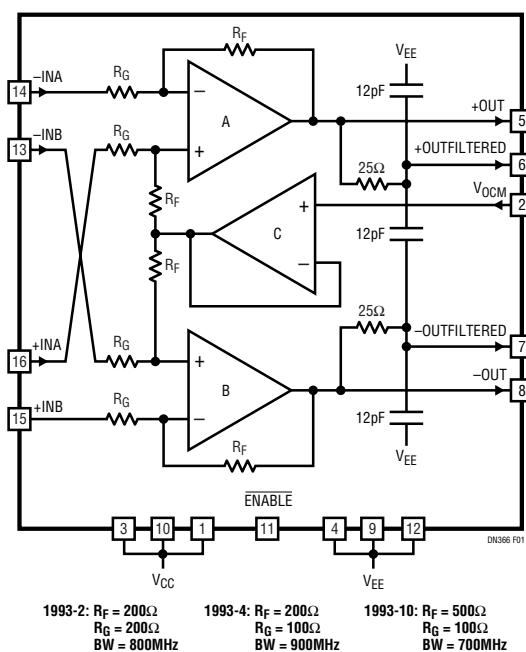


Figure 1. Block Diagram of the LT1993-x and the Differences Between the Gain Options. Input Impedance Is 200Ω for the 6dB Version and 100Ω for the Other Two Versions

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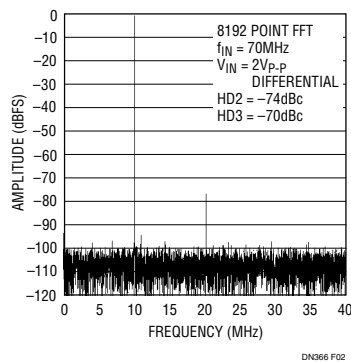


Figure 2. FFT Data Taken Using the LT1993-2 and the LTC2249 ADC Sampling at 80MSPs. The Second Harmonic Is at -74dBc and the Third Harmonic Is at -70dBc

WCDMA Amplifier and ADC Driver

Wideband CDMA transceivers often use direct IF sampling, meaning that the ADC samples signals with a 70MHz center frequency and 5MHz of bandwidth per channel. Up to 4 WCDMA channels are transmitted simultaneously, spaced closely in frequency. This places difficult intermodulation distortion (IMD) and noise requirements on the components in the transceiver, since both raise the noise floor in the closely spaced adjacent channels. The LT1993-2 boasts an exceptional -70dBc IMD and low noise, allowing 63dBc of adjacent channel leakage ratio (ACLR) for WCDMA signals. This figure exceeds most WCDMA manufacturers' ACLR specifications.

Figure 3 shows the LT1993-2 driving a LTC2255 14-bit ADC with a 70MHz, 4-channel WCDMA signal. On the output of the LT1993-2 is a simple LC bandpass filter that adds additional out-of-band filtering. Figure 4 shows the FFT data from the LTC2255, demonstrating the good ACLR possible

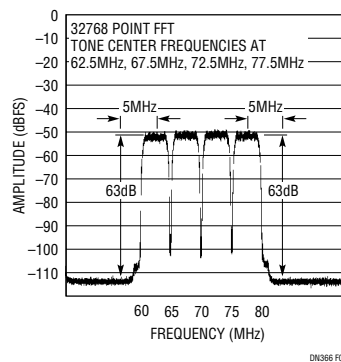


Figure 4. FFT Data Taken from the Output of the LTC2255 ADC. The Low IMD of the LT1993-2 Preserves the Signal-to-Noise Ratio of the WCDMA Channels

with the LT1993-2. The small aberrations on the sides of the WCDMA signals are artifacts of a noisy signal generator, whose output was bandpass filtered prior to reaching the LT1993-2.

Conclusion

The LT1993-x is a flexible, cost saving, and easy-to-use differential amplifier and ADC driver that ensures the best performance in high speed communications transceiver applications. Besides the low noise, low distortion and high speed, the LT1993-x also saves space with its 0.8mm tall 3mm x 3mm QFN package. Minimal support circuitry is required to operate the LT1993-x under most conditions and output lowpass filtering is included. Three different gain options increase the flexibility of system design and help reduce the gain requirements of noisier system components. The LT1993-x can simplify transceiver designs, reduce component count and reduce product time-to-market.

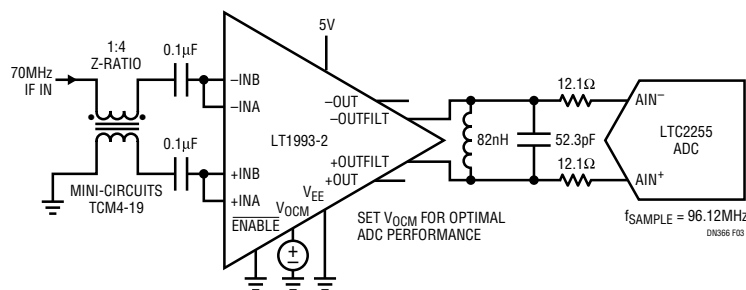


Figure 3. The LT1993-2 Driving an LTC2255 ADC Sampling at 96.12MSPs with a 70MHz, 4-Channel WCDMA Signal. The Simple LC Output Network Provides Out-of-Band Filtering

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