Interfacing HS ADCs with AMPs

HS Converter Applications Group

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TEXAS INSTRUMENTS

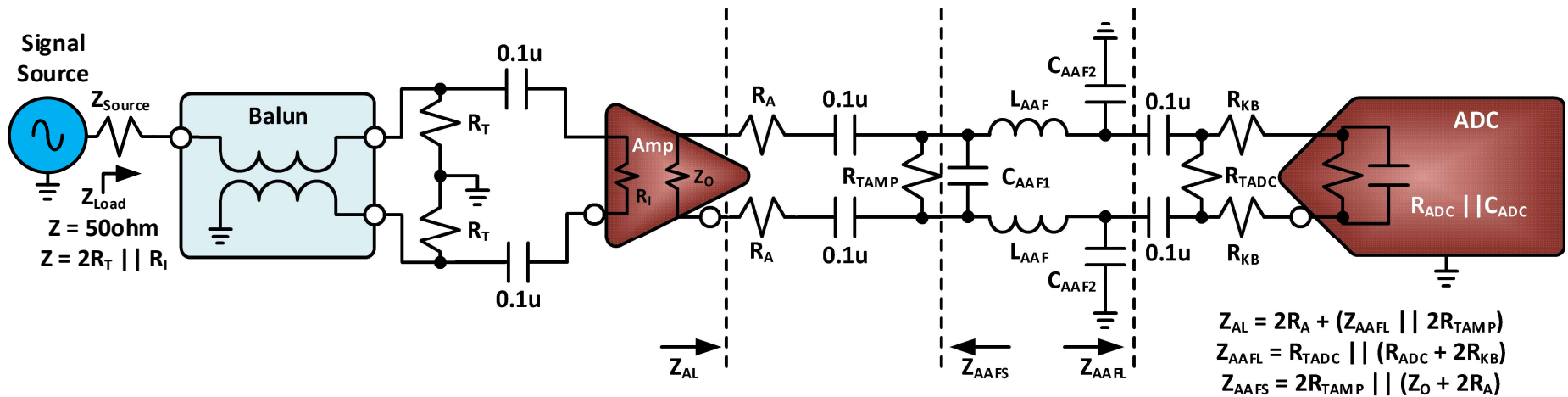# Anti-aliasing filters (AAF) – things to watch out for…
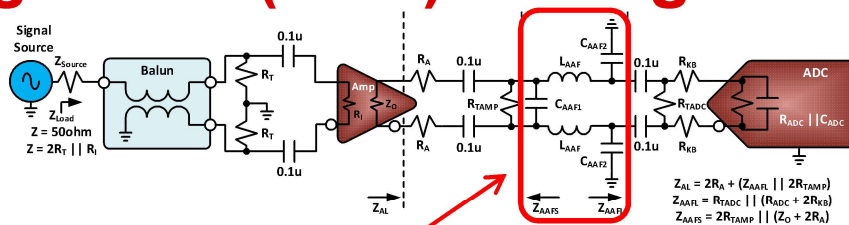
- Too many components in the AAF design can cause mismatches (component tolerance) in differential filters, therefore giving rise to even order distortions (HD2) due to imbalance
- Not all inductors are created equal, so model or simulate those inductors, so that, sim = pcb design
  - Download Sparameters, Modelithics models or measure them on VNA
- Inductors can sometimes have assembly issues giving rise to poor connections due to hidden end tabs.
  - This can lead to distortion effects because of lop-sided filtering
- When designing an AAF or even using a filter to test an ADC, make sure the stopband region is specified to be flat, broadband noise can still fold back in-band

Anti-aliasing filters (AAF) – design procedure

$$Z_{AL} = 2R_A + (Z_{AAFL} \mathbin{||} 2R_{TAMP})$$
$$Z_{AAFL} = R_{TADC} \mathbin{||} (R_{ADC} + 2R_{KB})$$
$$Z_{AAFS} = 2R_{TAMP} \mathbin{||} (Z_O + 2R_A)$$

The amplifier should see the correct dc load recommended by the data sheet for optimum performance. 50ohm? 100ohm? 200ohm?, etc.

The correct amount of series resistance must be used between the amplifier and the load presented by the filter. This is to prevent undesired peaking in the pass band.

The input to the ADC should be reduced by an external parallel resistor, and the correct series resistance should be used to isolate the ADC from the filter. This series resistor also reduces peaking.

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Anti-aliasing filters (AAF) – design procedure, cont.

The basic design process is as follows:

1) Select the external ADC termination resistor RTADC so that the parallel combination of RTADC and RADC is between 200 Ω and 400 Ω. This can help stabilize the filter design.

2) Select RKB based on experience and/or the ADC data sheet recommendations, typically between 5 Ω and 36 Ω.

3) Calculate the filter load impedance using: $ZAAFL = RTADC \parallel (RADC + 2RKB)$

4) Select the amplifier external series resistor RA.

  Make RA less than 10 Ω if the amplifier differential output impedance is 100 Ω to 200 Ω.

  Make RA between 5 Ω and 36 Ω if the output impedance of the amplifier is 12 Ω or less.

5) Select RTAMP so that the total load seen by the amplifier, ZAL, is optimum for the particular differential amplifier chosen using the equation: $ZAL = 2RA + (ZAAFL \parallel 2RTAMP)$.

6) Calculate the filter source resistance: $ZAAFS = 2RTAMP \parallel (ZO + 2RA)$.

7) Using a filter design program select the filter's source and load impedances, ZAAFS and ZAAFL, type of filter, bandwidth, and order. Use a bandwidth that is slightly higher than one-half the sampling rate to ensure flatness in the frequency span between dc and fs/2.

8) The internal ADC capacitance, CADC, should be subtracted from the final shunt capacitor value generated by the program. The program will give the value CSHUNT2 for the differential shunt capacitor. The final common-mode shunt capacitance is $CAAF2 = 2(CSHUNT2 − CADC)$.

Anti-aliasing filters (AAF) – design procedure, cont.

After running these preliminary calculations, the circuit should be given a quick review for the following items.

1) The value of CAAF2 should be at least 10 pF so that it is several times larger than CADC. This minimizes the sensitivity of the filter to variations in CADC.
2) The ratio of ZAAFL to ZAAFS should not be more than about 7 so that the filter is within the limits of most filter tables and design programs.
3) The value of CAAF1 should be at least 5 pF to minimize sensitivity to parasitic capacitance and component variations.
4) The inductor, LAAF, should be a reasonable value of at least several nH.

In some cases, the filter design program may provide more than one unique solution, especially with higher order filters. The solution that uses the most reasonable set of component values should always be chosen. Also, choose a configuration that ends in a shunt capacitor so that it can be combined with the ADC input capacitance.

See #1 & 2 in the reference section for more detail

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References

1. CN-0227: High Performance, 16-Bit, 250 MSPS Wideband Receiver with Antialiasing Filter, Rob Reeder, Analog Devices, Inc.

2. CN-0238: High Performance, 12-Bit, 500 MSPS Wideband Receiver with Antialiasing Filter, Rob Reeder, Analog Devices, Inc.

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