High Speed Transmission and Front-ends via Zone 3

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Class A1: Analog Signal Transmission via Z3

Properties of Class A1 Zone 3:

- 10 AC-coupled differential signals
- 10 DC-coupled differential signals
- 100 Ohm terminated (so far not specified on which side)
- 0…+1V voltage range, common mode voltage 0V

AMC ZONE 3 CONNECTOR ELECTRICAL SPECIFICATION RECOMMENDATION

<table>
<thead>
<tr>
<th>Class A1 / Zone</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
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<tbody>
<tr>
<td>MTCA 4 management</td>
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<td>FPGA / Standard Ctrl-Link</td>
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<td>FPGA / User-configuration</td>
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<td>Analog signals</td>
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</table>

Table 2: Electrical specification of Class A1 ("I"=input (μRTM to AMC), "O"=output (AMC to μRTM)), AMC side view
Termination of Zone 3 / 100 Ohm

Boundary conditions for high speed design from RTM to AMC in MTCA.4:

- The RTM / AMC transmission line lengths requires an RTM or AMC side broadband matching
  
  \[ Z_L = Z_W \]
  
  \[ Z_S = Z_W \]

  10cm – 30cm transmission line length is in the range of the frequency of interest of GHz

- Active or passive broadband impedance conversion from 50 Ohm to 100 Ohm Zone 3

- **Shielding**, crosstalk and EMC issues of the ERNI Zone 3 connector
AMC / RTM side located Front-end requires often a source termination:

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![Diagram of source termination](image-url)

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![Diagram of source termination](image-url)
Termination of Zone 3 / 100 Ohm

- Reflections over Zone 3 from poor ADC S11 for high frequencies:
  - AMC or RTM termination is needed for frequencies >300MHz to avoid reflections
**Termination of Zone 3 / 100 Ohm**

- **RTM** or **AMC termination ?:**

  **Up conversion 50Ohm to 100 Ohms:**
  
  (-) Core band limited AC support to 500MHz

  **Resistive matching**
  
  (-) Gain compensation cost bandwidth or high loss

  **Source matching**
  
  (-) Broadband baluns are rarely available for 1:2 impedance conversion
  (+) Lowest harmonic distortions

  **Passive attenuators on the AMC**
  
  (-) This is not an option since the full scale voltage level is defined at Zone 3 to maintain the modularity.

  **Active decoupling and matching on the AMC**
  
  (+) Dedicated OPVs for the ADCs are available and meanwhile below the noise floor of the ADC
  (+) Matching and transfer-function adjustments can be easily done which results into a high modularity
  (-) Anti-aliasing filter are required
  (-) Higher order distortions have to be corrected digitally

-> DC support with noise / distortion using OPVs can use AMC side matching

-> AC support without noise / distortion must use source termination and is bandwidth-limited.
RTM Termination

- Broadband return matching on the RTM -> loss on the RTM:

```
<table>
<thead>
<tr>
<th>Name</th>
<th>X</th>
<th>Y</th>
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<tbody>
<tr>
<td>m1</td>
<td>0.3041</td>
<td>-6.6270</td>
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<tr>
<td>m2</td>
<td>0.4966</td>
<td>-6.6815</td>
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<tr>
<td>m3</td>
<td>0.6918</td>
<td>-7.0888</td>
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</tbody>
</table>
```

Input transfer function

```
Curve Info
- dB(V(VOUT))+3.8
- LinearFrequency
```

- ADS42LB69EVM_Input_Sstage

- F [GHz]
- ADC amplitude [dB], normalized
- m1, m2, m3

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Dr. Frank Ludwig, DESY
High Speed Front-ends via Zone 3

AMC- or RTM distributed Front-ends scenarios

- Balun, Transformer or both
- High speed OPV, Buffer
- Point of termination
- Differential signal
- Single-ended signal
- Solution makes no sense

Problems via Zone 3 caused by:
- Radiation coupling into ERNI
- Ground distortion sensitivity
- Zone3 diff. length mismatch
- are not mentioned here.

No compromises except RTM space, Local front-end, No analog limitations, radiation and EMC

Diff. cables and connectors are not available.
Summary

- High speed ADCs produce reflections due to the capacitive inputs
- DC support needs a front-end OPV buffer
- Transmission over Zone 3 needs AMC or RTM matching
- AMC side matching can be done only with OPV buffers in front of the ADC
- RTM side matching is more band-limited for 100 Ohm transmission
- A complicated splitting of the front-end needs VCM-signals over Zone 3
- More detailed design example you can find under AP.1.2.2, Section 3.5.8

Thanks for your attention!
Backup Slides
50Ohm / 100 Ohm transmission

- Break the limitation of impedance conversion on the RTM by a 50Ohm system:

  - **100 Ohm differential transmission at Zone 3**
    (+) Distortion suppression, limited for high frequencies due to asymmetries
    (-) RTM 1:2 active impedance conversion, 1:2 RF baluns rarely on the market
    (-) RTM side matching limits the bandwidth
    (-) Differences between ERNI pairs leads to reflections
    ( ) ERNI crosstalk needs to be investigated for special pair distances

  - **50 Ohm single-ended transmission at Zone 3**
    (+) AC and DC support
    (+) Low crosstalk, <-80dB up to 6GHz
    (+) Low noise and low distortion AC support using source termination
    (+) RTM side matching using 1:1 baluns
    (-) No differential distortion suppression, ground effects might disturb – to be investigated
High Speed Front-ends via Zone 3

50Ohm / 100 Ohm transmission

ERNI vs. Coaxipack2 (without footprint):

3.4 Far End Crosstalk

![Graphs showing comparison between ERNI and Coaxipack2](image)

<table>
<thead>
<tr>
<th>Trc7</th>
<th>dB Mag</th>
<th>10 dB</th>
<th>Ref -70 dB</th>
<th>Cal Off</th>
<th>1 (Max)</th>
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</thead>
<tbody>
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<td>dB Mag</td>
<td>10 dB</td>
<td>0 dB</td>
<td>Cal Off</td>
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<tr>
<td>Trc9</td>
<td>dB Mag</td>
<td>10 dB</td>
<td>-1.8 dB</td>
<td>Cal Off</td>
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</table>

S21

| M1  | 1 GHz  | -90.3 dB |
| M2  | 1 GHz  | -21.6 dB  |
| M3  | 1 GHz  | -16.3 dB  |

Ch1 Base Freq Start 1 MHz Base Pwr 0 dBm Stop 8 GHz
DC support via Zone 3

- VCM via Zone 3

  - VCM via Zone 3 (not recommended)
  - (+) AC and DC support for lower frequencies
  - (-) A differential side RTM matching reduces the bandwidth.
  - (-) OPVs and ADCs are matched in high speed designs and belongs together.
    - This breaks the universal usage of AMCs and RTMs. The split front-end depends
    - On VCM range, OPV power supply, bandwidth, noise, slew-rate, output impedances …

If not VCM via Zone 3 -> For DC support AMC must have a high speed OPV