Digital Predistortion for Wideband High Efficiency PA Suitable for High Throughput Satellites

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12th August 2013
Outline

- Background
- DPD in context
- Novelty
- Benefits for satellite communications
- Conclusions
Satellite Comms Links

- Increasing need to transmit more information
- Conflicting requirements:
  - Spectral efficiency
  - Power efficiency
- DPD could achieve both simultaneously
- First time to propose in satellite communications with:
  - Large fractional BW
  - High PAPR
PA power back-off

Output Power

Input Power

Max. average input power

2nd IBO to cope with PAPR

1st IBO to achieve linearity

Total OBO

Power Wasted as a heat
Problems attached to PA

- Spectral re-growth
- Error vector magnitude
Digital Predistortion DPD

DPD Nonlinear Gain + PA Nonlinear Gain → DPD+PA Linear Gain

Output Power vs Input Power graphs for DPD, PA, and DPD+PA.
DPD in a transmitter
## Aspects: Satellite vs Mobile

<table>
<thead>
<tr>
<th>Parameter variation</th>
<th>Satellite Communications</th>
<th>Mobile Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very slow/absent</td>
<td>Fast</td>
<td></td>
</tr>
</tbody>
</table>

| Adaptation                  | Not required             | Required              |

<table>
<thead>
<tr>
<th>System requirements</th>
<th>EVM</th>
<th>ACPR Efficiency</th>
</tr>
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<td>ACPR Efficiency</td>
<td>EVM</td>
<td></td>
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</table>

| Driver amplifier effect     | Included                 | Neglected             |
Envelope tracking

Baseband

- Modulator
- DPD1
- Band-limited envelope

- DPD2
- Frequency Upconversion

- EA
- PA
Load modulation
Proposed Architecture

- Driver PA efficiency included
- Improving efficiency at low output power
- Band-limited DPD (comparable to signal BW)
Novel Architecture Aspects

- Proposed architecture could achieve:
  - High channel throughput
  - Low EVM
  - High power efficiency (lowers thermal stresses)
- Non-adaptive DPD (may be reconfigurable)
- Benefits: less weight, volume, cost and power transmitters
Simulation Results

1024-QAM 1GHz BW 4GHz Carrier
Experimental Results

<table>
<thead>
<tr>
<th>Center 400 MHz</th>
<th>VBW 22 kHz</th>
<th>Span 50 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>#Res BW 220 kHz</td>
<td></td>
<td>Sweep 25.67 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACPR (dB)</th>
<th>NMSE (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 MHz LTE DL</td>
<td>-25</td>
</tr>
<tr>
<td>Center 400 MHz</td>
<td>Span 110 MHz</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Log 10 dB/div</td>
<td>Ref -10.00 dBm</td>
</tr>
</tbody>
</table>

**Table:**

<table>
<thead>
<tr>
<th>32MHz 1024 QAM</th>
<th>ACPR (dB)</th>
<th>NMSE (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-10</td>
<td>-33.54</td>
</tr>
<tr>
<td>ACPR (dB)</td>
<td>NMSE (dB)</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>-33.52</td>
<td></td>
</tr>
</tbody>
</table>

50 MHz 1024 QAM
Conclusions

- Proof-of-concept demonstrated
- Potential impact on satellite communication
- Achievable goals:
  - Improvement in the link budget & spectrum usage
  - Simple Tx
- Possible DPD uses:
  - Remote sensing (downlink)
  - COMMSAT Navigation
  - Radar applications
Questions?