A 0.13μm CMOS 4-Channel UWB Timed Array Transmitter Chipset with sub-200ps Switches and All-Digital Timing Circuity

Zahra Safarian, Ta-Shun Chu, Hossein Hashemi

**Motivation**

- UWB signals allow higher data rate for communication systems and higher depth resolution for imaging systems;
- UWB multi-antenna transmitters allow focusing signal energy at the desired directions;
- Pulsed-sinusoid waveforms allow for:
  - independent control of center frequency and pulse-width (bandwidth);
  - simple generation for antenna arrays.

**Measurement Results**

**UWB Pulse-Forming Switch**

- Pulse-forming switch is absorptive;
- There are trade-offs in sizing of series and shunt transistors:
  - Larger M, reduces low-frequency loss, but, increases high-frequency loss;
  - Larger shunt transistors improve isolation, but, increase loss;
  - Rise and fall times are limited by poles of ladder LC network and the resistance at the transistor gate;
  - ESD protection circuits are used at the input and output.

**Timing Control and Impulse Generation Circuitry**

- It creates the delayed version of the input pulse sequence for all 4 channels by using a path-sharing time delay architecture;
- Path-sharing architecture reduces gate count, and therefore, reduces chip area.

**Transmitter Architecture**

- Chipset includes timing circuitry and UWB pulse-forming switches;
- Fabricated in 0.13μm CMOS;
- VCO and phase shifters are off-chip.

**Transmitter Architecture Advantages and Disadvantages**

<table>
<thead>
<tr>
<th>Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF True Time Delay</td>
<td>General for all waveforms</td>
<td>On-chip TTD blocks capable of generating nanosecond delay are lossy, have limited bandwidth, and consume large footprint</td>
</tr>
<tr>
<td>Path-Sharing</td>
<td>The relative delays of the UWB waveforms can be controlled during pulse generation without using TTD blocks</td>
<td>Needs phase shifters to align the initial phase of the pulse sinusoid for coherent signal addition at the target</td>
</tr>
<tr>
<td>Pulse Time-Delaying</td>
<td>Digital control of relative delays allows for small delay resolution and large maximum delay in a small area</td>
<td></td>
</tr>
</tbody>
</table>

**Switch measured small-signal s-parameters (probed)**

<table>
<thead>
<tr>
<th>Performance (0-6GHz)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion Loss</td>
<td>&lt; 4dB</td>
</tr>
<tr>
<td>Isolation</td>
<td>&gt; 40dB</td>
</tr>
</tbody>
</table>

**Measured 4-channel outputs at 1.3GHz**

**Syntesized array patterns for 22.8-cm antenna spacing, assuming energy detector at the receiver (in dB scale)**

**Measured 4-channel outputs at 5GHz**

**Syntesized array patterns for 26.4-cm antenna spacing, assuming energy detector at the receiver (in dB scale)**