CHALLENGES OF AUTOMOTIVE RADAR SENSOR NETWORKS

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Market trends

- Trend for RADAR modules with 4-16 RX antennas each
- Multiple RADAR modules for 360 degree vehicle coverage
- Slow chirp modulation → fast chirp modulation → OFDM
- Higher ADC sample rates; 40-100 Msps becoming the norm
- Higher sweep bandwidths up to 4 GHz
- RFCMOS 65nm → 40nm → 28nm for 77-81 GHz
- 2D → 3D → RADAR imaging
- MISO → MIMO
- Higher carrier frequencies 77 GHz → 120 GHz
- Antennas integrated into package
360° Coverage by Sensor Units

- **Side Impact**
- **Object Detection**
- **Brake Assist**
- **Adaptive Cruise Control**

**MRR**
- Rear
  - SOP: 2014
  - Range: up to 100 m

**MRR**
- Front
  - SOP: 2013
  - Range: up to 160 m

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360° Coverage by Sensor Network

- Multi-mode RADAR and parking without ultrasonic sensors.
- Central ECU receives and processes RADAR sensor signals
- Central ECU performs RADAR and camera sensor fusion
Challenges of Sensor Network

- Ideally one sensor module family to cover parking, SRR, MRR and LRR
- RF modulation supporting a wide distance range, low interference
- Each sensor module has 4 to 16 receive and 4 to 16 transmit antennas
- Sensor fusion, classification and action in the ECU
- Functional Safety
- Low system power consumption

Data rates from each sensor module to ECU

- Option 1: 12-channels of 12-bit raw RF samples at 40 MHz = 5.76 Gbps (10 Gbe)
- Option 2: 12-channels of 32-bit FFT data at 40 Msps = 15.36 Gbps (Fiber)
- Option 3: 128 objects of 20 states of 32-bits in 20ms = 4.1 Mbps (CAN-FD)
Issues for current Tier 2 chipsets

- What the market wants is RADAR Imaging to challenge LIDAR
- DSP throughput is well below market needs, roadmap is not addressing L4/L5
- Software libraries are basic - Effort is delegated to Tier 1
- RF/DSP Integration is behind the curve
- 100 ms measurement cycle repetition is too long, not aligned to image sensors
- RF overheating at high duty cycles
- Large and expensive packaging - Renesas RH850V1R: 17 x 17 mm
### Minimum sensor processing every 20 ms

<table>
<thead>
<tr>
<th>Processing</th>
<th>fixed point MOp/s</th>
<th>floating point MOp/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1024 point Range FFT</td>
<td>6300</td>
<td></td>
</tr>
<tr>
<td>256 point Doppler FFT</td>
<td>630</td>
<td></td>
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<td>1024 point Az' th and Elevation FFT</td>
<td>525</td>
<td></td>
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<tr>
<td>Range CFAR Detection</td>
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<td>Doppler CFAR Detection</td>
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<td>Kinematics</td>
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<td>Measurement validation</td>
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<td>530</td>
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<tr>
<td>Track association</td>
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<td>625</td>
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<tr>
<td>Kalman Filter</td>
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<td>5</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>11,000</strong></td>
<td><strong>1,160</strong></td>
</tr>
</tbody>
</table>

- NXP MPC577xK: 2 cores x 2 floating point ops x 133 MHz = 533 MFLOPs max
- NXP MPC577xK: 2 cores x 4 integer ops x 266 MHz = 2,100 MOPs max

Software DSP Unsuitable
EnSilica ADAS RADAR Imaging Solution

- Support various MIMO RF modulations FMCW, CDMA, OFDM
- 16 antennas, up to 400 Msps with plot extraction and tracking 128 objects
- 3D and < 1° azimuth to enable real-time RADAR Imaging
- Low power: < 200 mW, small package: 8 mm x 8 mm
- Free up the ECU for FUSION
Conclusion

Dedicated RADAR Imaging engine enabling:

- RADAR close to LIDAR resolution
- Parking, short, long range & 3D RADAR
- RADAR sensor networks providing object lists to ECU
- Lowest latency and power solution
- ECU headroom for track-to-object recognition and make safety decisions
- Significant cost saving by edge processing