High Performance Reconfigurable Software Defined Radio Platform

IMECAS
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1. Introduction
2. SDR01 platform
3. SDR02 platform
4. SDR platform with OpenAirInterface (OAI)
5. Conclusion
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IMECAS main R&D directions: IC design/IC manufacturing process/Electronic system engineering.

Communications & Information Engineering Center is mainly focused on theory research and project application about complex signal processing, innovative communications, computer vision, radio-frequency technologies, integrated information platform, etc., the center has solid technical strength, abundant engineering experience and high-qualified professional technicians, the main R&D directions include:

- Software Defined Radio & Software Communications architecture
- High performance Power Amplifier
- Radio-Frequency SoC
- Cognitive Radio & Dynamic Spectrum Access
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2.1 SDR01 platform: introduction

High technical threshold:
- Dedicated equipment on assigned RF bands
- Customized software

Common platform:
- Common reconfigurable radio equipment
- Common software

<table>
<thead>
<tr>
<th>频段</th>
<th>上行频率</th>
<th>下行频率</th>
<th>制式</th>
</tr>
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<tbody>
<tr>
<td>band3</td>
<td>1710-1785</td>
<td>1805-1880</td>
<td>FDD</td>
</tr>
<tr>
<td>band4</td>
<td>1710-1755</td>
<td>2110-2155</td>
<td>FDD</td>
</tr>
<tr>
<td>band7</td>
<td>2500-2570</td>
<td>2620-2690</td>
<td>FDD</td>
</tr>
<tr>
<td>band38</td>
<td>2570-2620</td>
<td>2570-2620</td>
<td>TDD</td>
</tr>
<tr>
<td>band39</td>
<td>1880-1920</td>
<td>1880-1920</td>
<td>TDD</td>
</tr>
<tr>
<td>band40</td>
<td>2300-2400</td>
<td>2300-2400</td>
<td>TDD</td>
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</table>
2.2 SDR01 platform: specification

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>30MHz~3000MHz</td>
</tr>
<tr>
<td>Noise figure</td>
<td>&lt;7dB</td>
</tr>
<tr>
<td>Max. output level</td>
<td>&gt;10W ± 1.5dB</td>
</tr>
<tr>
<td>GPS accuracy</td>
<td>≤2.5m (GPS)</td>
</tr>
<tr>
<td>Frequency stability</td>
<td>≤± 0.2ppm (GPS timing)</td>
</tr>
<tr>
<td>services</td>
<td>voice, data, video, PTP</td>
</tr>
<tr>
<td>interfaces</td>
<td>LAN, USB3.0</td>
</tr>
<tr>
<td>power</td>
<td>220V AC</td>
</tr>
<tr>
<td>dimension(W×H×D)</td>
<td>205×83×264mm</td>
</tr>
<tr>
<td>others</td>
<td>Support software &amp; waveform upgrade</td>
</tr>
</tbody>
</table>

SDR01——

- **“True” SDR module:**
  - Multiple LO & flexible clock tree
  - High performance FPGA
  - High speed AD/DA supporting direct RF sampling

- **RF front-end:**
  - Efficient & high quality linear PA
  - Wide band LNA & tuning filter

- **PC:**
  - Fully function EPC/BBU

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**Diagram:**

- CPU
- GPS
- Power supply
- FPGA
- DPD+ DDC DUC
- V7 FPGA
- DAC
- ADC
- 1.8G-3G
- DC-3G
- 1PPS
- Sync clock filter
- FPGA Block Diagram
- Peripheral unit interface
- “True” SDR PLATFORM
- RFE
“True” SDR module

Features:
- **FPGA**:
  - DDC/DUC
  - Clock timing functions maintenance
  - DPD + Nonlinear harmonic elimination
  - Control logic/interfaces IP
- **AD/DA**:
  - RF sampling
  - Tuning filter
- **Interfaces**:
  - GPS module
  - Voice processing module

RF Front End

Features:
- **Tx & Rx**:
  - High quality linear PA
  - Wide band LNA
  - Tuning filter
- **Control**:
  - Frequency-selecting
  - Tx & Rx switching
  - Temperature measurement & monitoring
  - Current protection & alarm
2.4 SDR01 platform: SDR module

- Power supply
- Interface logic
- Clocking
- Main control
- RF control
- DDC/DUC
- DPD+

- Z7 FPGA
- V7 FPGA
- RF sampling
- DAC
- max 9G sampling rate
- max IBW 200MHz
- 2X DAC
- DC-6GHz
- 30MHz~3G Hz
- Tuning filter

- Ethernet interface
- GPS
- USB3.0
- Low jitter clock
- High performance GPS module

- Clock & s.
- RF sampling
- ADC
- max 3G sampling rate
- max IBW 200MHz
- 2X ADC
- DC-4GHz

- Tuning filter
2.5 SDR01 platform: RF FE

- PA control
- Link control
- monitors

- 30-3000MHz tuning filter

- Tuning Filter

- 30MHz~3GHz

- FPGA

- LHA

- GaN PA
# 2.6 SDR01 platform: 5G NR

<table>
<thead>
<tr>
<th>Item</th>
<th>R15 NR</th>
<th>LTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>&lt;52.6GHz</td>
<td>&lt;6GHz</td>
</tr>
<tr>
<td>Services</td>
<td>voice, eMMB, URLLC</td>
<td>voice, eMMB</td>
</tr>
<tr>
<td>Max. channel bandwidth</td>
<td>&lt;6GHz: 100MHz</td>
<td>20MHz</td>
</tr>
<tr>
<td></td>
<td>&gt;6GHz: 400MHz</td>
<td></td>
</tr>
<tr>
<td>Frame length</td>
<td>10ms</td>
<td>10ms</td>
</tr>
<tr>
<td>Slot length</td>
<td>1~14 OFDM symbol</td>
<td>2/7/14 OFDM symbol</td>
</tr>
<tr>
<td>Uplink/Downlink switch mode</td>
<td>0.5/0.625/1.25/2.5/5/10ms (periodical semi-static switching)</td>
<td>5/10ms (periodical semi-static switching)</td>
</tr>
<tr>
<td></td>
<td>1/2/5/10/20ms (dynamic switching)</td>
<td>10ms (dynamic switching)</td>
</tr>
<tr>
<td>CA &amp; Dual connectivity</td>
<td>max. CA: 32; Dual connectivity: 32</td>
<td>max. CA: 32; Dual connectivity: 64</td>
</tr>
</tbody>
</table>

### FlexRAN 系统架构

**Intel**

- IT Domain: Asynchronous, Variable workload, User level firmware
- Comm. Domain: Synchronous, Fixed workload, Cell level processing

**GigE to PCIe**

**USB3.0**

**Clock Dis.**

**GPS**

**RF SAMPLING ADC**

** Filtering**

**Universal High Performance reconfigurable SDR**

- CA & Dual connectivity max.: 32
- Dual connectivity: 64
- Dual channel AD: DC~4GHz, 200MHz BW
- Dual channel DA: DC~6GHz, 200MHz BW

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**FlexRAN**

**Intel**

- Acceleration
- Intel Xeon CPUs
- Ethernet
- CPRI
- Front End
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## 3. SDR02 platform

- Compatible with GNURadio
- Compatible with MATLAB/Simulink
- Based on ADI AD9361

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>70MHz~6000MHz</td>
</tr>
<tr>
<td>Max. output level</td>
<td>&gt;10dBm</td>
</tr>
<tr>
<td>Position &amp; 1PPS</td>
<td>GPS</td>
</tr>
<tr>
<td>interfaces</td>
<td>USB3.0</td>
</tr>
<tr>
<td>power</td>
<td>5V DC</td>
</tr>
<tr>
<td>others</td>
<td>Support software &amp; waveform upgrade</td>
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OAI ENB & EPC ALL in ONE with USRP B210

Mobile phones can communicate without Internet (Linphone App, OpenSips). Also can with Internet by LAN or WLAN.

We have verified that the communication distance can be up to 500 meters with 1W PA & 2 plane direction antennas.

All in ONE box
The latest version of the kernel for PCIe interface is 4.2.x, which is different from the version of openair-cn kernel (latest develop branch with tag v0.4.0 is 4.7.x)——EPC/ENB on different PC.

The communication is very unstable, why?
OAI ENB+EPC (all in one with B210) + 1 OAI UE (laptop with B210) + 2 COTS UE

PC + B210 (OAI UE using S1)

3 UEs connected
OAI UE can access Internet or video call
Ping to baidu
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Open Lab

(IME inside)

Software User Variables (PWM/ADC)

Configuration OS/DD

Hardware platform

“turn-key” Solution:

- GPP/CPU/FPGA/ADC/DAC all in one series
  - FPGA+ADC/DAC
  - GPP/CPU+FPGA
- RF module series
  - Tx & Rx
  - T/R component
  - PA & front-end
  - Frequency synthesizer
- Complete integration solution
  - BSP & drivers & IP
  - Reference design
  - Hardware + software all in one

5. Conclusion