Embrace a Brand New Cooperation in 5G Era

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27 Sept, 2017
Why should we come here? 😊
When there are many loops in a chain ...
Direct Talks needed, a New Circle

Silicon Ingot & Wafer ➔ Processed Wafer ➔ Die ➔ IC Module

Operator ➔ Phone ➔ PCB

中国移动

China Mobile
RF-SOI in the phone

If more RF-SOI, ...

- Higher level of integration?
- Smaller chip size?
- Lower consumption?
- Faster speed?
- Any other components on SOI?
- Similar cost as Bulk CMOS?
Which process technologies fit 5G Device?

Which is the best fit for 5G Device?
Outline

- What is 5G?
- Wish list for 5G Device
- Looking forward to cooperation
5G = eMBB + uRLLC + mMTC

**eMBB - Seamless wide-area coverage**
- User Experiencing Rate: 100Mbps
- Mobility: 500Km/h

**uRLLC - Ultra Reliable & Low Latency Communication**
- One-way Latency: 1ms
- Reliability: 99.999%

**mMTC - Massive Machine Type Communication**
- Connection Density: 1 million/km²
- Low Power Consumption, Low Cost

**eMBB - Hotspot and high data rate**
- User Experiencing Data Rate: 1Gbps
- Peak Rate: 20Gbps
- Traffic Volume density: 10Tbps/km²
‘5G Flower’

**Higher rate**
4G X 100
(0.1~1Gbps)

**Larger connection density**
4G X 10
(1million connections/Km^2)

**Higher traffic**
Volume density
(10~100 Tbps/Km^2)

**Lower latency**
4G X 1/5
(1ms)

**Higher peak rate**
4G X 20
(10~20 Gbps)

**Faster mobility**
4G X 4
(500+ Km/h)
Outline

- What is 5G?
- Wish list for 5G Device
- Looking forward to cooperation
About 5G eMBB Device

—– enhance Mobile BroadBand
## Several Key Spec. for Sub-6GHz 5G eMBB Device

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Bands</td>
<td>20+ Bands</td>
</tr>
<tr>
<td>Multi-antenna scheme</td>
<td>UL &amp; DL: 2Tx &amp; 4Rx</td>
</tr>
<tr>
<td></td>
<td>UL &amp; DL: 4Tx &amp; 8Rx (recommended)</td>
</tr>
<tr>
<td>UE Output Power</td>
<td>$P_{out_max} = +26\text{dBm}$, Tolerance: $+2\text{dB/-2dB}$</td>
</tr>
<tr>
<td>System Bandwidth</td>
<td>$\geq 100 \text{ MHz per CC}$</td>
</tr>
<tr>
<td>Modulation Scheme</td>
<td>DL: QPSK, 16QAM, 64QAM, 256QAM</td>
</tr>
<tr>
<td></td>
<td>UL: QPSK, 16QAM, 64QAM, 256QAM (recommended)</td>
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Could RF-SOI help to improve 5G eMBB Device performance above?
Sub 6GHz Frequency Band

3.3 GHz~3.6 GHz, 4.4 GHz~4.5 GHz, 4.8 GHz~5 GHz

* According to the announcement of the Ministry of Industry and Information Technology of the People’s Republic of China (MIIT) on Jun. 5th and Sep. 1st.
mmWave Frequency Band

24.75 GHz~27.5 GHz, 37GHz~42.5GHz or other bands

* According to the announcement of the Ministry of Industry and Information Technology of the People’s Republic of China (MIIT) on June 8.
## Potential Frequency Band Requirements

### 6 Modes, 20+ Bands

<table>
<thead>
<tr>
<th>5G NR (TBD)</th>
<th>TD-LTE</th>
<th>LTE FDD</th>
<th>TD-SCDMA</th>
<th>WCDMA</th>
<th>GSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3GHz~3.8GHz</td>
<td>Band 41</td>
<td>Band 7</td>
<td>Band 34</td>
<td>Band 1</td>
<td>Band 3</td>
</tr>
<tr>
<td>3.3GHz~4.2GHz</td>
<td>Band 38</td>
<td>Band 3</td>
<td>Band 39</td>
<td>Band 2</td>
<td>Band 2</td>
</tr>
<tr>
<td>4.4GHz~4.5GHz</td>
<td>Band 40</td>
<td>Band 1</td>
<td></td>
<td>Band 5</td>
<td>Band 8</td>
</tr>
<tr>
<td>4.8GHz~5GHz</td>
<td>Band 34</td>
<td>Band 4</td>
<td></td>
<td></td>
<td>Band 5</td>
</tr>
<tr>
<td>......</td>
<td>Band 39</td>
<td>Band 8</td>
<td>Band 20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Band 12(17)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **<1GHz**
- **1.7GHz~2.2GHz**
- **2.3GHz~2.7GHz**
- **>3GHz**
Sub-6GHz 5G eMBB Device Diagram

4Rx+2Rx for smart phone, and 8Rx+4Tx for CPE

- Multi-Modes Multi-Bands
- Limited Antennas
- Sharing PAs
  - ……
- Switches
- Antenna Tuners

Tremendous Demand for RF components, especially switches and tuners
Even with +26dBm output power of UE, 5G coverage is still UL limited.
RF components need to handle higher power (+3dB)
High Power PA

Improving the Voltage Swing

Reducing the Equivalent Output Impedance

Which process technology suits the High Power PA best?
Sub-6GHz System Bandwidth

\[ \geq 100 \text{ MHz per CC} \]

- Power Consumption
- Resolution
- Gain-bandwidth product
- Power Consumption
- Efficiency
- Large-bandwidth
- Insertion Loss
- Attenuation OOB
- 200MHz+

ADC + BB filter + LNA + … + Rx

DAC + … + PA

100MHz
100MHz
100MHz
100MHz/CC
26dBm
UL 256QAM

- Computing power
- Noise: ≤1.5%
  - I/Q imbalance
  - Phase Locking Loop’s Phase Noise: higher frequency, bigger challenge (Temperature drift real-time correction? Raising UE’s reference clock?)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Modulation</th>
<th>EVM</th>
<th>Maximum Power Reduction (MPR)</th>
</tr>
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<tr>
<td>4G</td>
<td>256QAM</td>
<td>3.5%</td>
<td>≤5</td>
</tr>
<tr>
<td>5G</td>
<td>256QAM</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
CMCC’s Plan towards 5G

1. Key Technology Validation
   - 2014~2016
   - 7 sites/city
     - 5 cities

2. Proof-of-Concept (PoC) Systems
   - 2017
   - 100+ sites/city
     - N+X cities

3. Pre-commercial network Trial
   - 2018
   - 20 sites/city
     - N cities

Large-scale Pre-commercial Test
   - 2019
   - Large-scale Pre-commercial Test
     - 10,000+ sites

Large-scale Commercialization
   - 2020~
CMCC’s Plan of Sub-6GHz 5G Device

R&D Plan

2016

2017

2018

2019

2020

2021

System Verification

Layer1 frozen

R15 Release

R16 Release

Large-Scale Trial

5G commercialization

5G Prototype Testing

5G Chipset/Terminal Testing

5G Chipset/Terminal commercial product

Device Testing

5G IOT/FT Testing

5G friendly User Testing

Device Test Equipment

General test platform

Integrated platform

5G Commercial Test system

CMCC’s Plan of Sub-6GHz 5G Device

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2017

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2020

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About M-IoT

—– Mobile Internet of Things
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</tr>
<tr>
<td>Frequency Bands</td>
<td>Band 8 (900MHz, Mandatory)</td>
</tr>
<tr>
<td></td>
<td>Band 3 (1800MHz, Optional)</td>
</tr>
<tr>
<td></td>
<td>Band 20 (800MHz, Optional)</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>Stand-by Background Current $\leq 1\text{mA}$</td>
</tr>
<tr>
<td></td>
<td>PSM Sleeping Current $\leq 5\text{uA}$</td>
</tr>
<tr>
<td>Working Voltage</td>
<td>Normal Type: $3.4\text{V}\sim4.2\text{V}$</td>
</tr>
<tr>
<td></td>
<td>Low-voltage Type: $2.1\text{V}\sim3.6\text{V}$</td>
</tr>
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Could RF-SOI help to improve NB-IoT Device performance above?
Higher RF FEM Integration

Could RF-SOI help to improve RF FEM Integration?
Universal Module, Key to Volume

<table>
<thead>
<tr>
<th>Size</th>
<th>Max</th>
<th>Middle</th>
<th>MiniPro</th>
<th>Mini</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26mm*24mm</td>
<td>24mm*20mm</td>
<td>20mm*16mm</td>
<td>18mm*16mm</td>
</tr>
</tbody>
</table>

- Basic
  - No GNSS
- Enhanced
  - With GNSS
- Smart
  - With AP and GNSS

- Same Interface
- Same Size
- Same Package
- Pin2Pin Compatible
CMCC’s plan for M-IoT

- **Functionality, Interoperability, SDK test in lab**
- **Performance, Interoperability, Service test in field**
- **Device Conformance, Power consumption, OTA test on test platform**

**E2E Capability Evaluation for Commercialization, focus on:**

- **Lab test**
- **Small-scale field trial**
- **Large-scale field trial**
- **384 cities Commercial Launch**
Outline

- What is 5G?
- Wish list for 5G Device
- Looking forward to cooperation
About GTI

—–Global TD-LTE Initiative
GTI – Global TD-LTE Initiative

Kicked off GTI in 2011

We become

- Influential player across the mobile community
- Global presence with operators and key vendors

GTI 1.0
2011 ~ 2015

132 operators have joined GTI

146 vendors have joined GTI Partner Forum

01 Successfully built global end-to-end TD-LTE ecosystem

02 Successful global commercialization of TD-LTE

03 Successful convergence of TDD/FDD and initiation of joint operation

Source: GTI, TDIA and GSA As of Q1, 2017
GTI 2.0

Kicked off GTI 2.0 in 2016

Move forward

- 4G Development
- IoT/5G R&D and Commercial Preparation
- Cross-industry Opportunity

1. Continuing TD-LTE Global Development
   - Continuing to promote TD-LTE global deployment
   - Continuing to enlarge the scale of converged TDD/FDD terminal and network
   - Further promote the development of TD-LTE enhanced technologies

2. Propel IoT/5G Development
   - Promote advantage of TDD and the deeper convergence of TDD/FDD
   - Promote IoT/5G unified standard and end-to-end ecosystem
   - Explore IoT/5G cross-industry market and opportunities
<table>
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<tr>
<th>GTI 5G eMBB Program</th>
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<tr>
<td><strong>Project 1:</strong> Sub 6GHz</td>
</tr>
<tr>
<td><strong>Spectrum WG</strong></td>
</tr>
<tr>
<td><strong>Network WG</strong></td>
</tr>
<tr>
<td><strong>Terminal WG</strong></td>
</tr>
<tr>
<td><strong>Business WG</strong></td>
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Welcome to Join GTI

How to join as GTI Operator Member (with TDD spectrum)?
1. Submit the application form to Secretariat GTI_Secretariat_list@lte-tdd.org
2. Secretariat reviews the application form and send the Letter of Intent (LOI) to applicant.
3. The applicant signs the LOI for participation into the GTI.
4. The applicant receives an official confirmation from GTI Secretariat.

How to join as GTI Operator Member (without TDD spectrum)?
1. Submit the application form to Secretariat GTI_Secretariat_list@lte-tdd.org
2. Secretariat reviews the application form and send the declaration form to applicant.
3. The applicant signs the declaration form for GTI SC’s approval
4. The applicant receives an official confirmation from GTI Secretariat.

How to join as GTI Partner Forum Member?
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CLICK HERE http://gtigroup.org/joinUs.html

IOS
Android
About China Mobile 5G Innovation Center
China Mobile 5G Innovation Center

**PROMOTE**
Maturity of Communication Capabilities

**INCUBATE**
Integrated Innovative Applications

**DEVELOP**
Win-win Cross-industry Ecosystem

Open Labs established: Beijing, Qingdao, Hangzhou

Open Labs in progress: Shanghai, Chengdu, Shenzhen, Nanjing, Chongqing……

* As of June 2017.
Driven by promoting the maturity of 5G communication system and creating connection value, 5G Innovation Center targets for 5 types of substantive joint innovation results.

- **End-to-end technologies, solutions and prototypes**
  - White papers, technical reports, test specifications, prototypes, etc.

- **Demonstrations**
  - Innovative application demonstration & exhibition, practice of new services and business models

- **Innovative applications and business**
  - Integrated joint innovative applications and products

- **Business models**
  - Cross-industry cooperation and new business models

- **Innovation incubation**
  - Enhanced value chain by incubating more innovations

**Expected Joint Innovation Outputs**
Cooperation with international organizations to create a wonderful 5G era

Currently 94 partners have joined 5G Innovation Center

**Member-Network Equipment**
- Huawei
- Ericsson
- Nokia
- ZTE
- Datang
- No.14 Institute of CETC
- Tongyu Communication

**Member-Terminal/Chips**
- Qualcomm
- Intel
- Leadcore
- Spreadtrum
- Samsung Electronics
- MediaTek
- Xilinx
- TE Connectivity
- Qorvo
- Apple
- Hisilicon
- No.13 Research Institute of CETC
- NXP
- MACOM
- No. 55 Institute of CETC
- Alps
- Skyworks
- Thunder Software
- ADI
- Vivo

**Member-Vertical Industry**
- Haier
- Hisense
- Shougang Automation Information Technology
- Wireless Car
- BYD
- GAC ENGINEERING
- DJI
- Changhong
- Neusoft
- Goer Tek
- SAFT SA
- EVE Energy
- Maxell
- Jinan Towngas
- Qingdao IESlab
- Philips Lighting
- Audi China
- LeAutoLink
- Xiaomi
- BAIC Motor
- Technical Center
- Lite-On
- Global Energy Interconnection Research Institute
- AsialInfo
- JD Smart
- Tendyron
- Ruijie Networks
- UISEE Technologies
- DPVR

**Joint Innovation Partner**
- OVIPHONE
- Polycis
- CloudMinds
- Tximist Batteries
- Wapwag
- Enice
- FeiTian
- Beijing Canny Robot Technology
- Istaging
- TalentLinked
- China AVIC
- Aviconics Systems
- Beijing R&D Center

**Member-Instrument**
- Rohde & Schwarz
- Keysight
- Cobham Wireless
- StarPoint
- Transcom Instruments
- China Research Institute of Radio wave Propagation
- Prisma

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- China Research Institute of Radio wave Propagation
- Prisma
Welcome to Join us

Members
Lead the key joint innovation projects, and participate in the construction of Open Labs

- **Major Manufacturers in telecommunication industry**
- **Leading enterprises in vertical industries**
- **Important cooperation organizations and research institutions**

Joint Innovation Partner
Carry out research and test of innovation products in Open Labs

- **Small and medium-sized enterprises in vertical areas**
- **Third party developer organizations or individuals**

How to join us:

1. Submit the application form
2. Cooperation communication
3. Sign a MoU with 5G Innovation Center
4. Receive a confirmation e-mail
Let us HIGH 5G!