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Low-power Modem SoCs for Future Cellular IoT Networks

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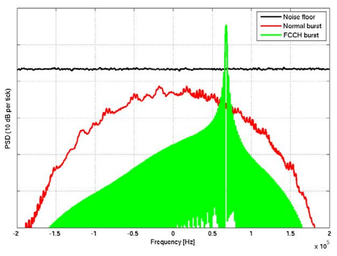
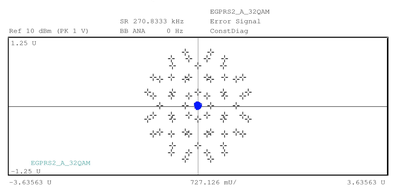
1. GSM/EDGE Networks - It's all about coverage!

- GSM/EDGE-only subscriptions represent the **largest share of mobile subscriptions** today worldwide
  - Due to its ubiquitous coverage, almost all 3G and 4G networks use GSM/EDGE as a fallback technology
  - In Middle East and Africa, GSM/EDGE dominates the cellular market with 85%
  - By the year 2019, 25% of all mobile subscriptions will still be GSM/EDGE only
- **Evolved EDGE:** Extension to enable 1.2 Mbit/s with dual carrier and 32-QAM
  - Receive diversity to **improve radio link quality**
  - up to 32-QAM to **enable higher throughput**
    → complex baseband signal processing
- **EC-GSM**: IoT extension 20 dB extended coverage
  - +20 dB coverage for **deep building penetration**
  - **10 years** of battery life
    → ultra low power baseband processing

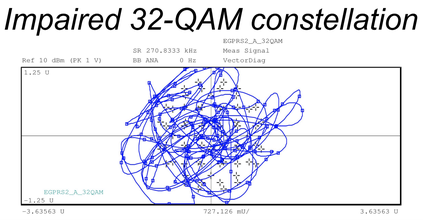
Signal below noise level



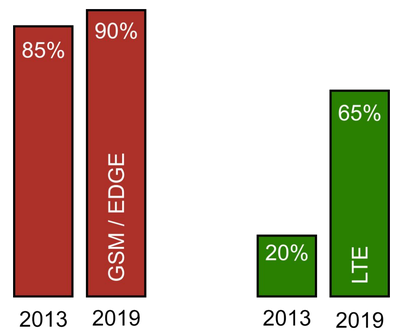
Ideal 32-QAM constellation



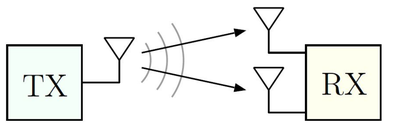
Impaired 32-QAM constellation



World population coverage by technology
[Ericsson Mobility Report 06/2014]



Mobile station receive diversity scheme

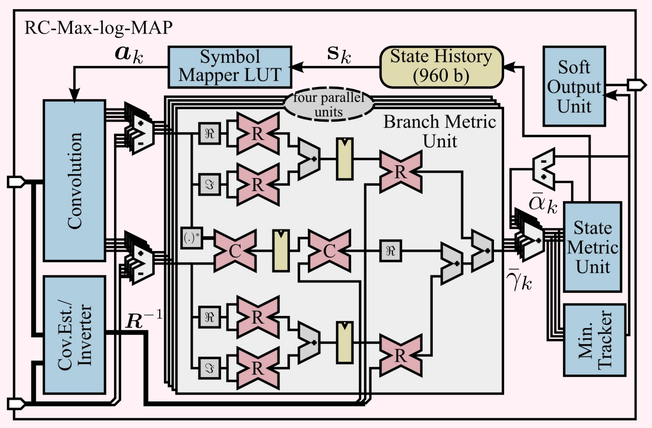


2. EC-GSM 2G Cellular IoT Networks

- Up to 50 billion mobile wireless devices by end of the decade
- Cellular devices connect **directly** to Internet over existing infrastructure
  → No access point (WLAN) or host computer (Bluetooth) required
- Ubiquity of GSM/EDGE enables remote sensor node placement
- **Software upgrade** to existing 2G networks
- Broad range of IoT applications
  - **Health monitoring**
  - Smart grid
  - Telemetry and Logistics
  - Car automation

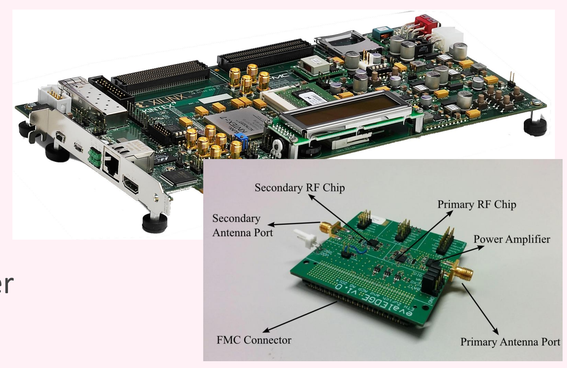
3. Algorithm-driven Hardware Design for Low-power cellular IoT SoCs

- Algorithm driven hardware design
- Dedicated architectures for baseband algorithms instead of instruction set architectures
- Allows flexible distribution of computational power within different parts of the SoC [1]
- Example: Max-log-Map Equalizer [2,3]

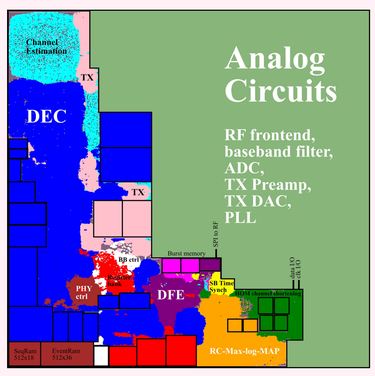


4. EvalEDGE - A Versatile Prototyping Platform

- **Low turn-around** time vs. silicon
- 2 component modem
  - Kintex 7 FPGA
    - digital baseband
    - PULPino CPU
  - evalEDGE: 2x ACP RF transceiver
- **HW/SW co-development**



5. StoneEDGE - A Single Chip PHY Solution

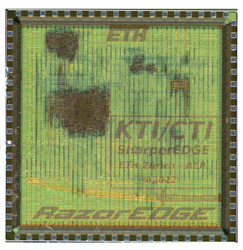


- First Evolved EDGE **single chip PHY** solution
  - Digital baseband: based on RazorEDGE
  - RF transceiver: based on product from project partner ACP
- 130 nm CMOS, BGA package, 14 mm^2
- Golden **candidate for ultra-low power** cellular IoT data modem

6. Cellular IoT Modem SoC Timeline

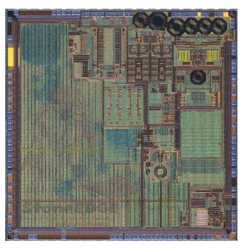
2012 — **RazorEDGE**: First single chip Evolved EDGE baseband

- Soft-Output Equalization
- **Rx diversity** support
- Built-in HARQ
- 130 nm CMOS
- QFN package 6mm^2
- **5 mW** power Consumption In single slot operation

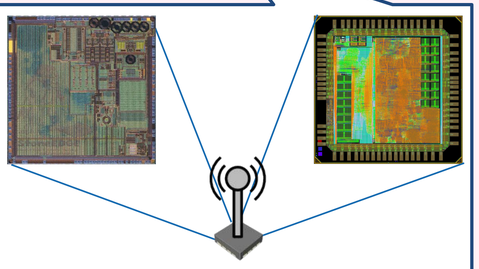


2014 — **StoneEDGE**: First single chip Evolved EDGE PHY

- **< 50 mW** power consumption in single slot operation
- 6x6 mm BGA package
- No EC-GSM support yet



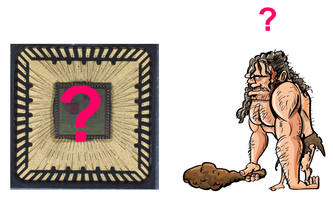
2016 — **CoverEDGE:** Single chip ultra-low power data modem for **cellular IoT**



- StoneEDGE + PULPino CPU
- EC-GSM support
- Single die 2G modem SoC
- 7x7 mm BGA package

2018 — EC-GSM cellular IoT network **deployment**

- Cellular IoT networks and base stations available
- Demonstrator set-up to communicate in extended coverage mode



References

[1] H. Kröll, S. Zwicky, B. Weber, C. Roth, C. Benkeser, A. Burg, Q. Huang. An Evolved EDGE PHY ASIC Supporting Soft-Output Equalization and Rx Diversity, presented at the European Solid-State Circuits Conference (ESSCIRC) Sept. 2014.
[2] H. Kröll, S. Zwicky, B. Weber, C. Roth, D. Tschopp, C. Benkeser, A. Burg, Q. Huang. An Evolved GSM/EDGE Baseband ASIC Supporting Rx Diversity, published in the IEEE JSSC, July 2015.
[3] H. Kröll, S. Zwicky, T. Willi, A. Burg, Q. Huang, Channel Shortening and Equalization based on Information Rate Maximization for Enhanced 2G Networks, presented at IEEE SiPS Workshop, Hangzhou, China, October 2015.