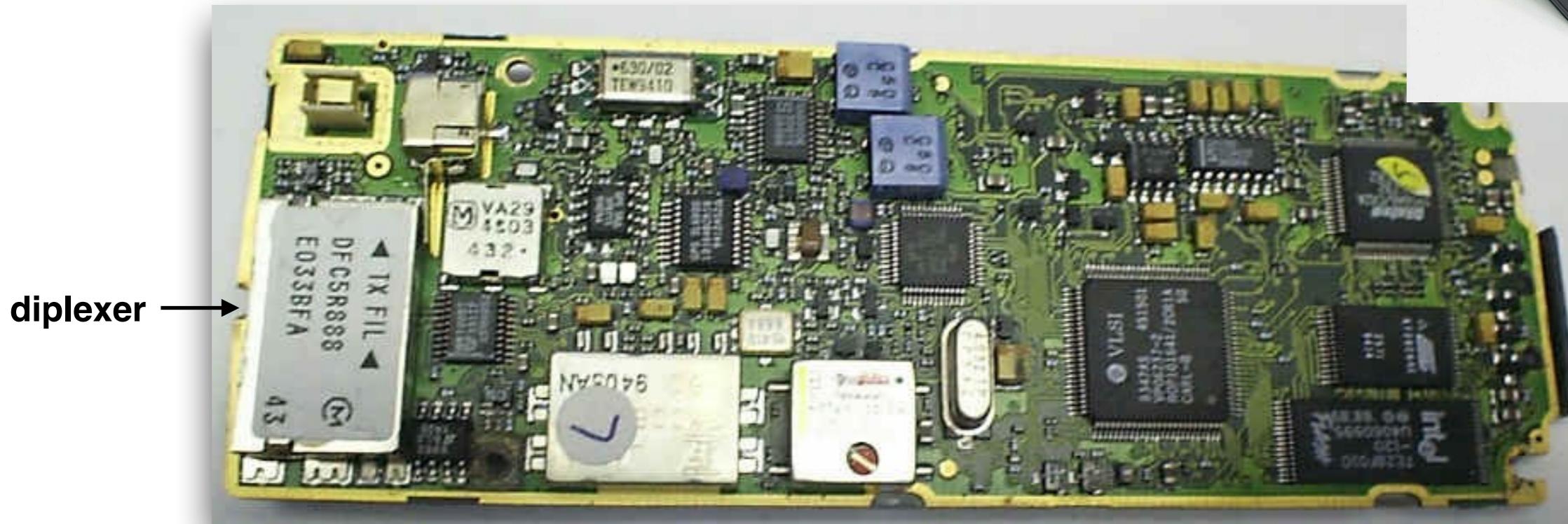


RF Circuit Design

Prof. Salvatore Levantino

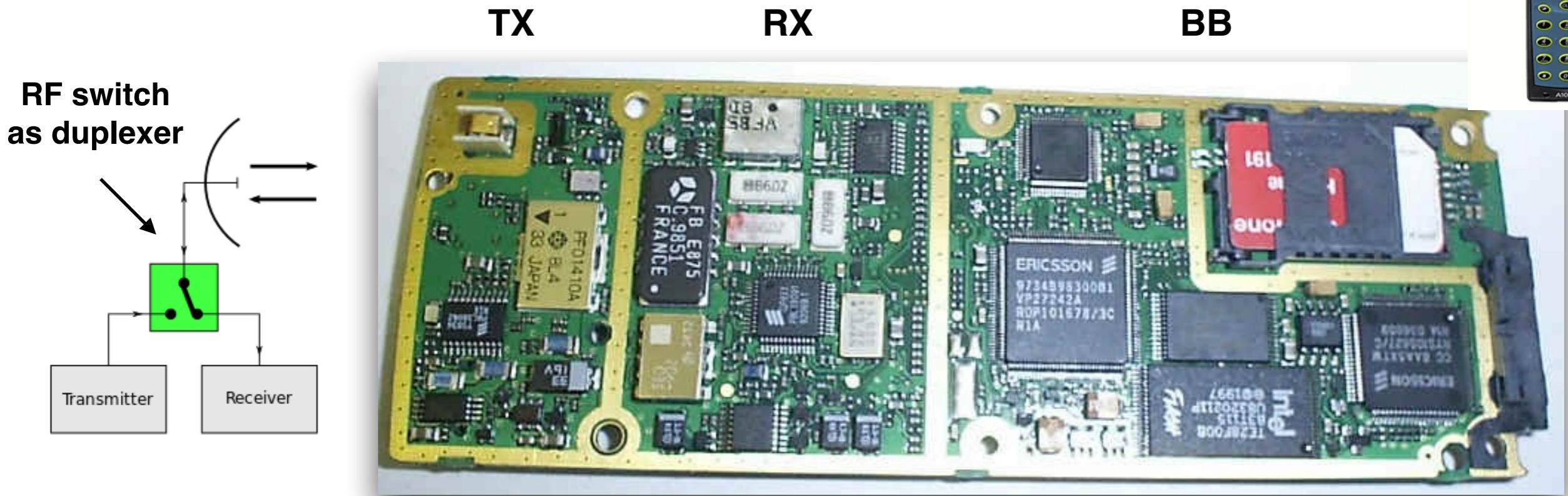
2020/2021

TACS Phone



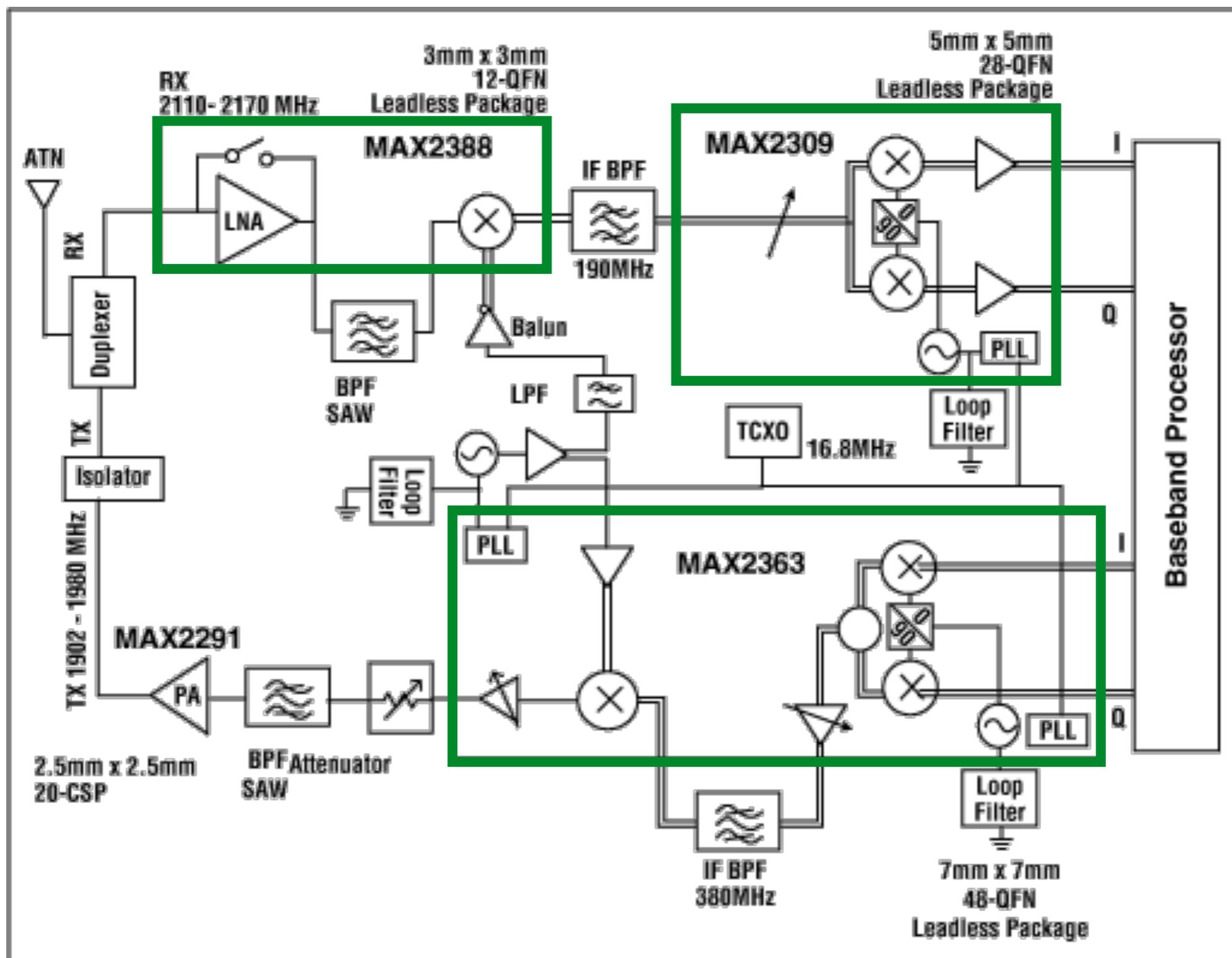
- **Analogue units** transmit/receive at the **same time**
- **Diplexer filter** implements frequency-domain MUX (separates transmit signal from sensitive RX, which handles signals billions of times weaker than TX)

2G Phone



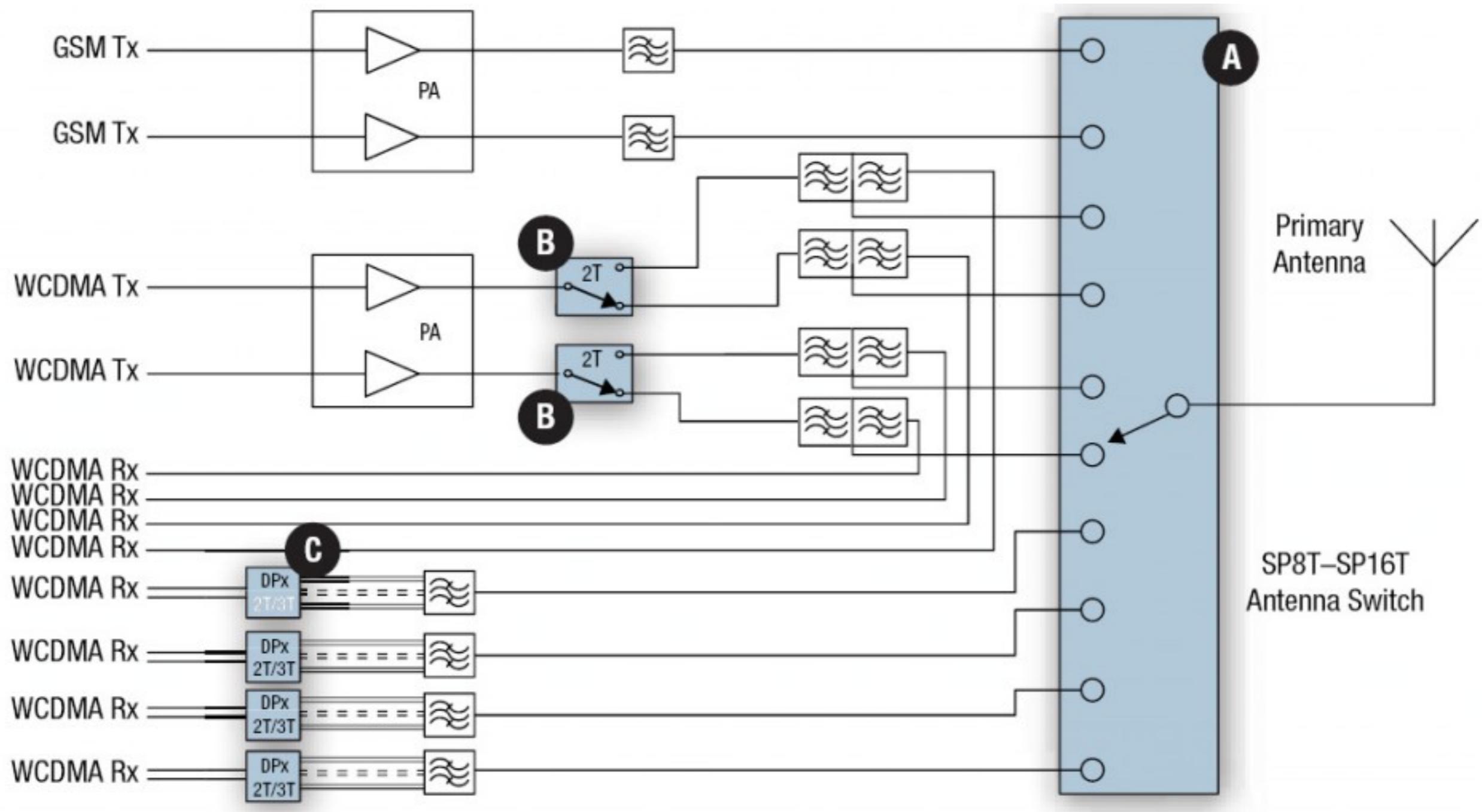
- **Digital** phones enable **TDD** operation
- **TX section** (left) with the RF power amplifier module.
- **RX section** (centre), several large filters, temperature-compensated crystal oscillator.
- **Analog/digital signal processing** (right): main processor, flash program memory (1MB), working RAM (32Kb), signal processing circuitry, analogue (speech) sections.

Radio of 3G Phone

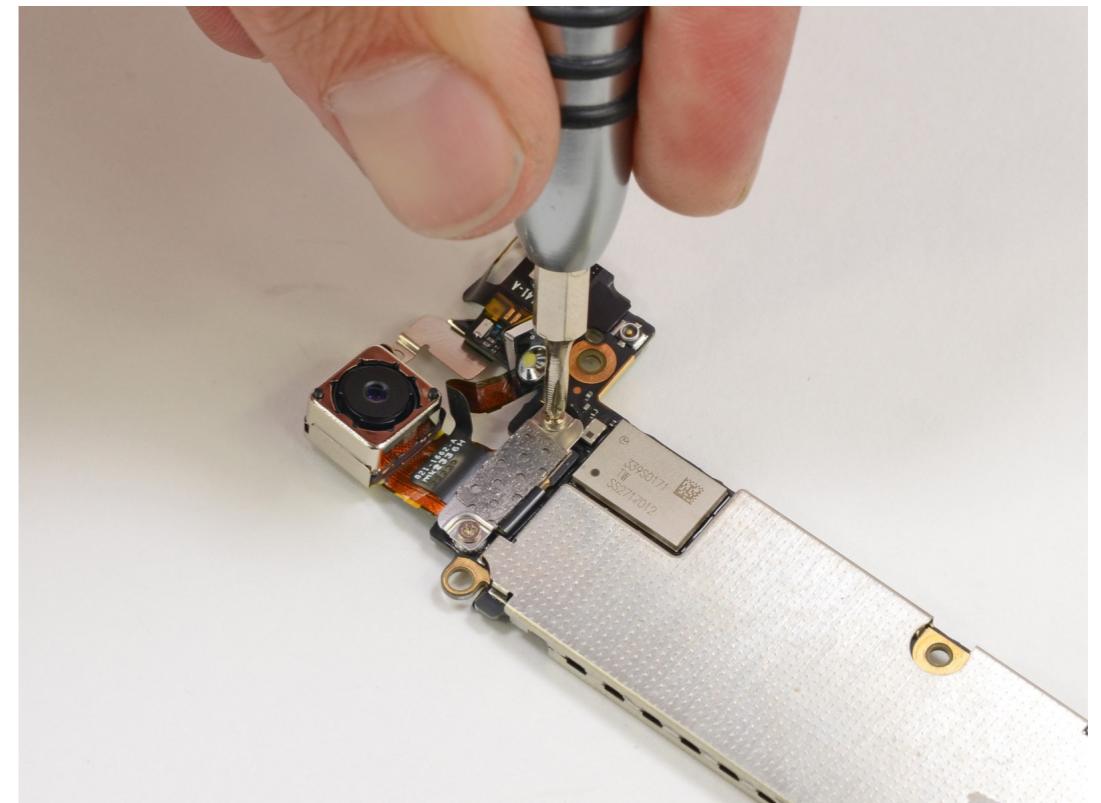


Multi-Standard Phones

RF Front-end of GSM/WCDMA Case

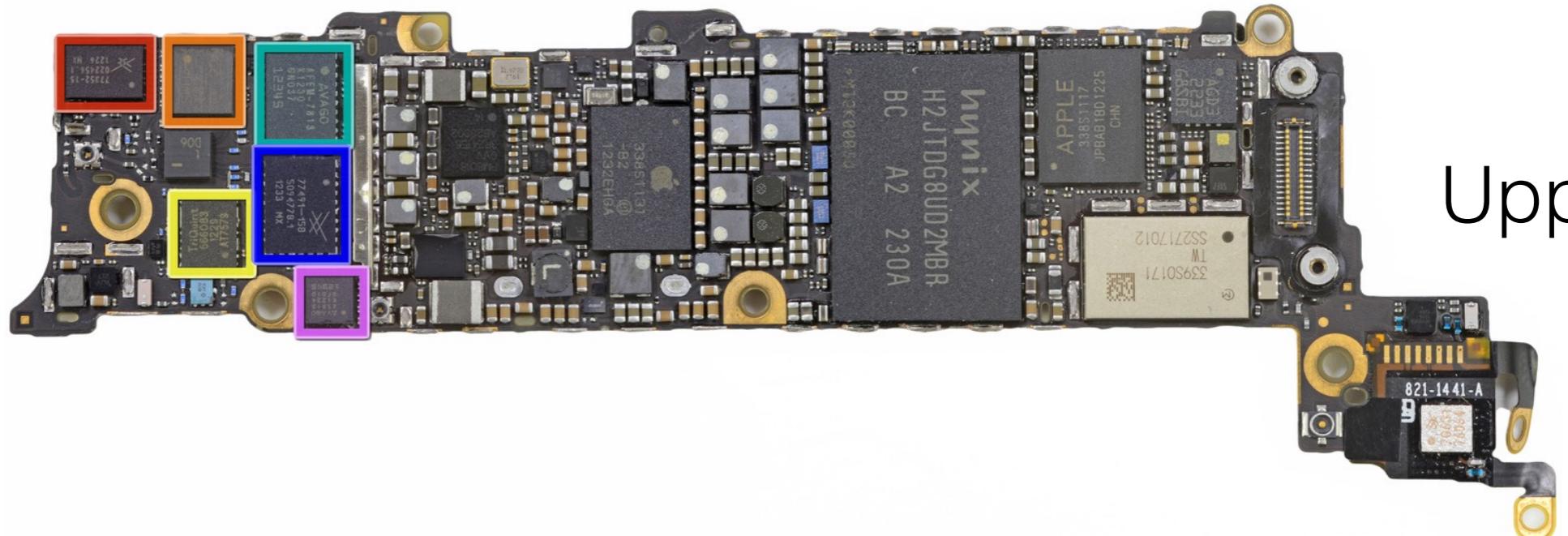


Modern 4G smartphone



Rear Side (Lower End)

Lower

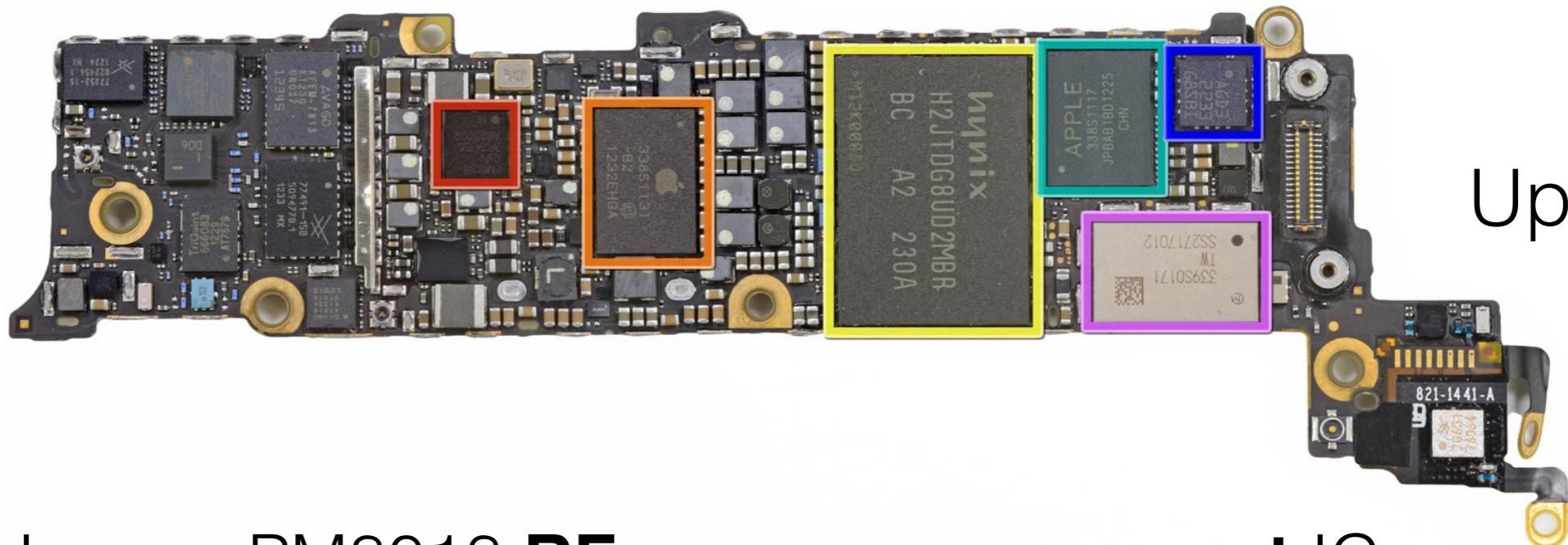


Upper

- Skyworks 77352-15 GSM/GPRS/EDGE **power amplifier**
- SWUA 147 228 **RF antenna switch module**
- Triquint 666083-1229 WCDMA / HSUPA **power amplifier/duplexer** module for the UMTS band
- Avago AFEM-7813 dual-band LTE B1/B3 PA+FBAR **duplexer** module
- Skyworks 77491-158 CDMA **power amplifier** module
- Avago A5613 ACPM-5613 LTE band 13 **power amplifier**

Rear Side (Mid and Upper)

Lower

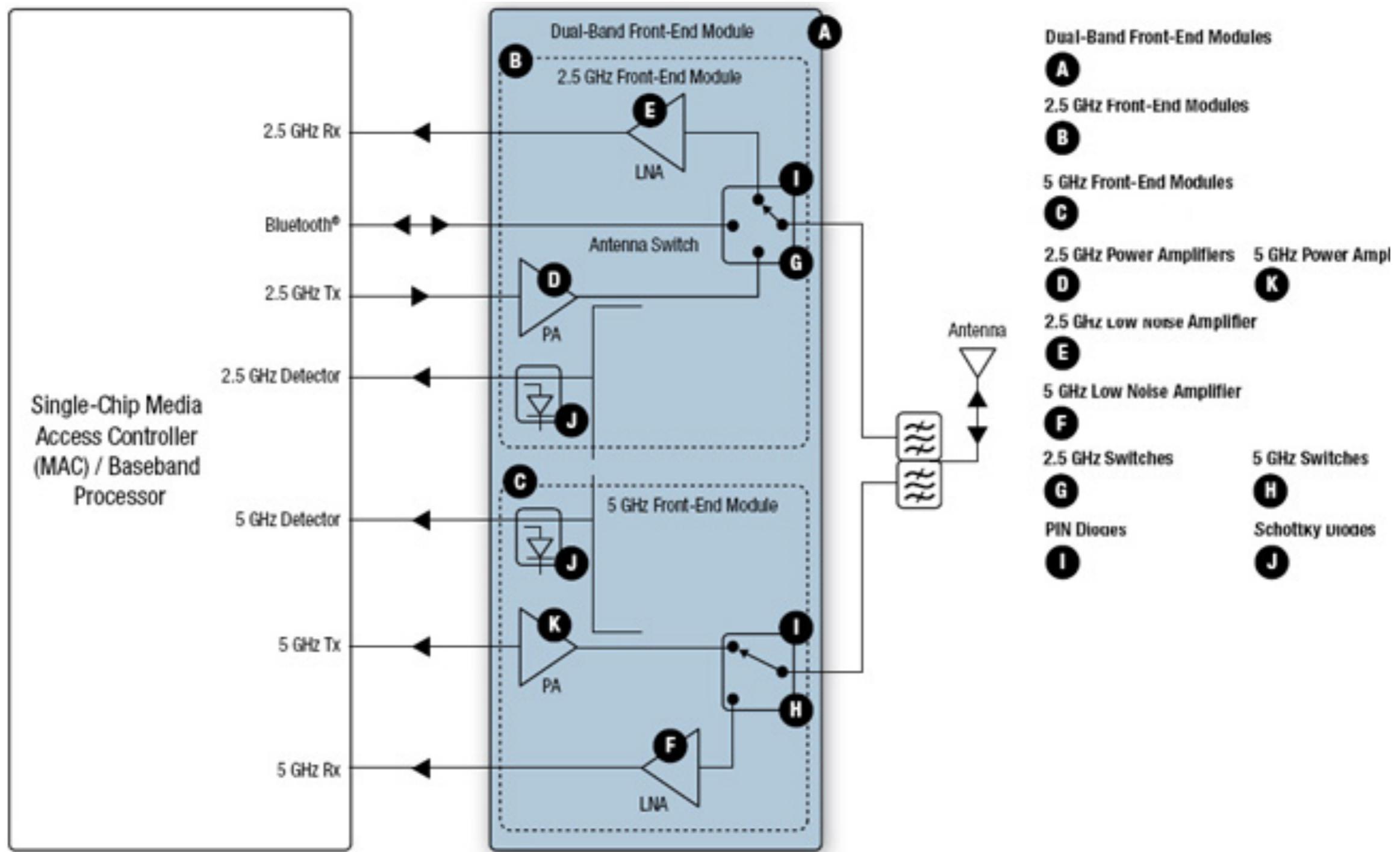


Upper

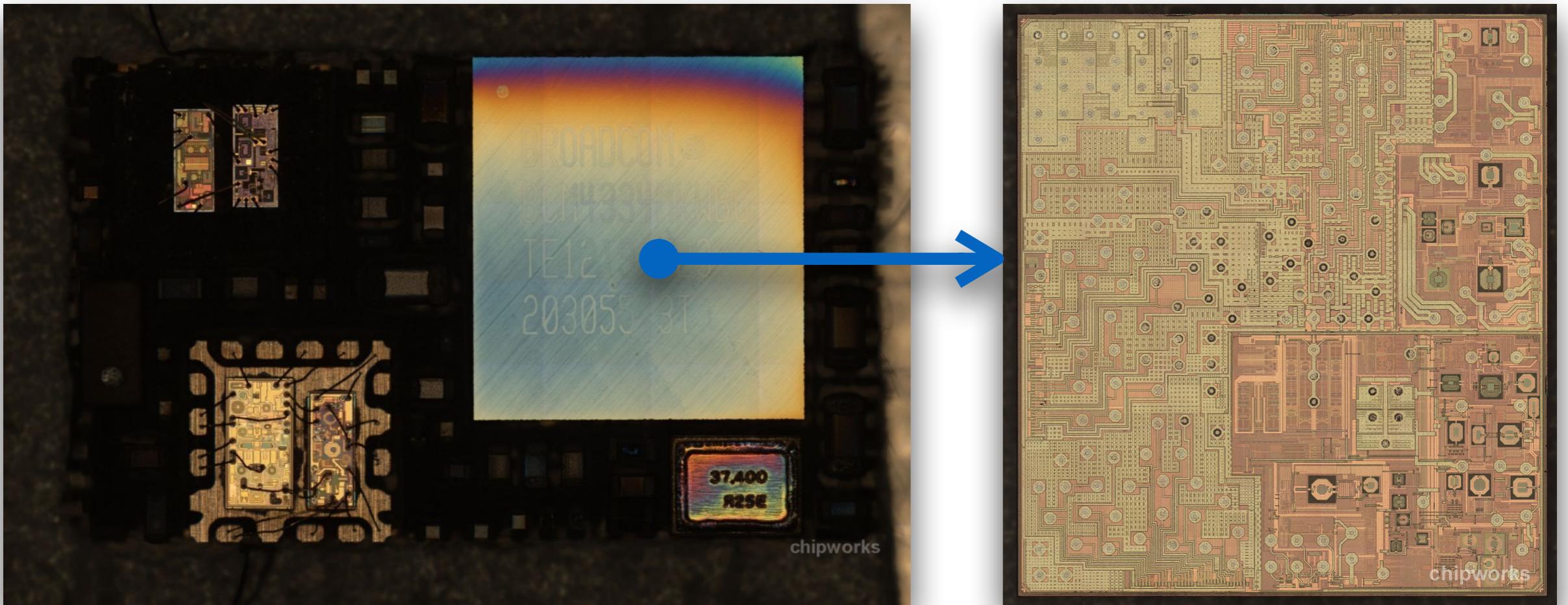
- Qualcomm PM8018 **RF power management IC**
- Hynix H2JTDG2MBR 128 Gb (16 GB) **NAND flash**
- Apple 338S1131 dialog **power management IC**
- Apple 338S1117 Cirrus Logic **Class D Amplifiers**
- STMicroelectronics L3G4200D (AGD5/2235/G8SBI)
three-axis gyroscope
- Murata 339S0171 (based on Broadcom BCM4334)
Wi-Fi module

Wi-Fi Front-End

802.11/Bluetooth



Wi-Fi Module

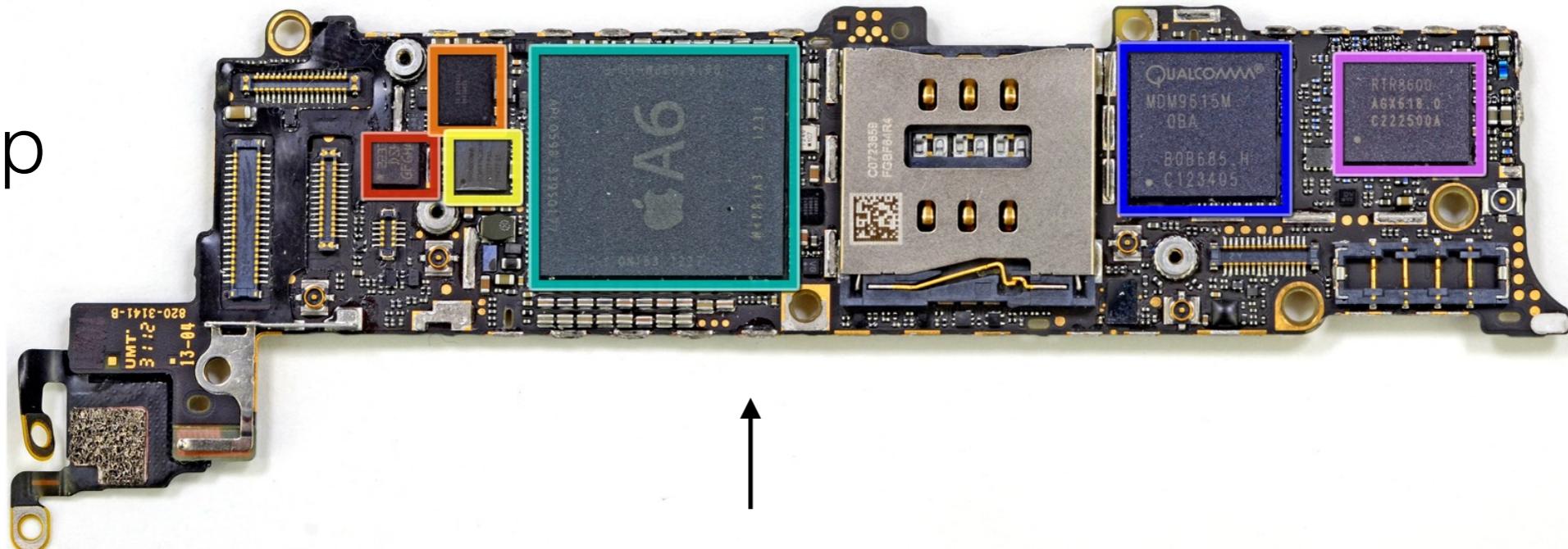


- Multi-chip module including **antenna SPDT switches, LNAs, PAs, crystal** and **dual-band combo transceiver**
- Broadcom BCM4334 transceiver is fabricated in **40nm LP RF-CMOS** process from TSMC ($4.07 \times 4.48 \text{ mm}^2$) supports 802.11n, Bluetooth 4.0+HS & FM Receiver

Front Side

Up

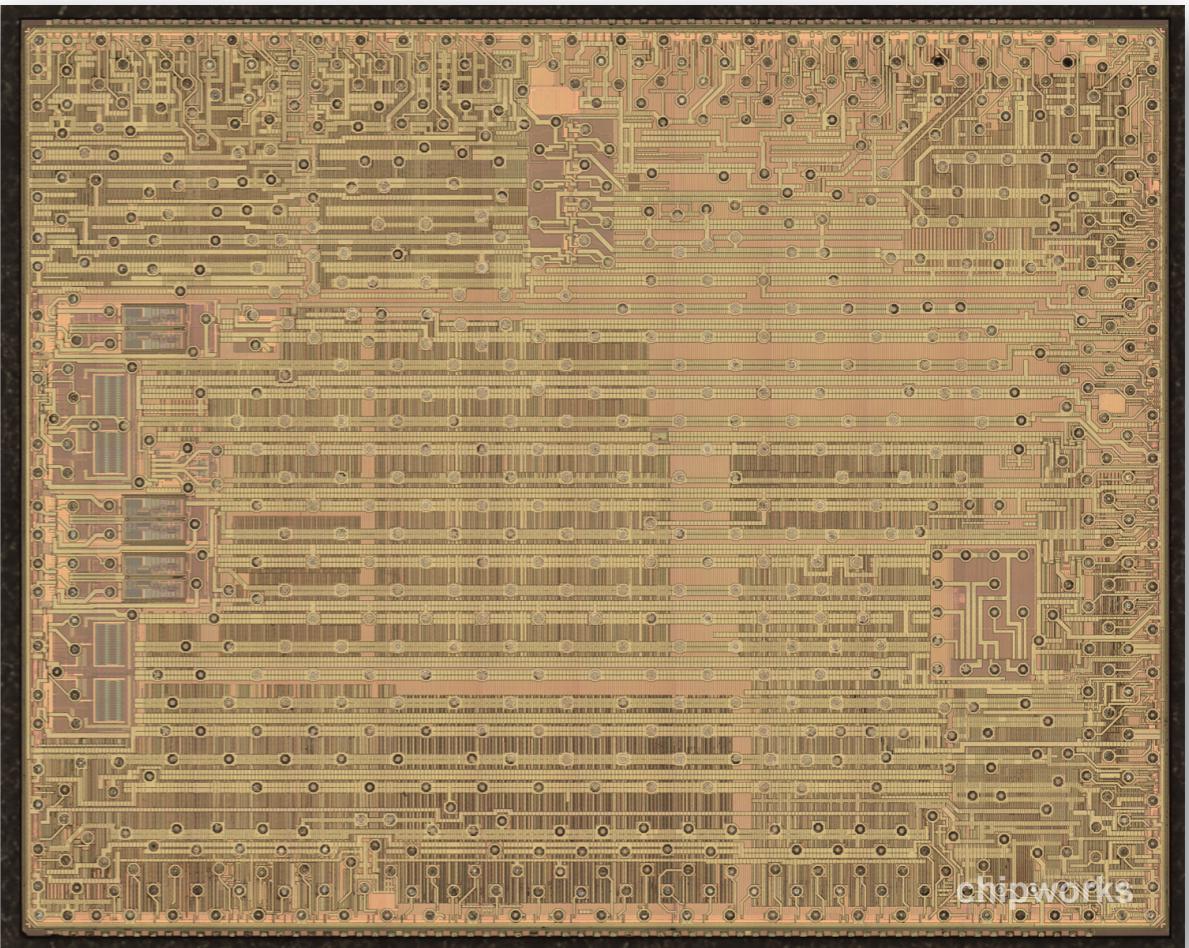
Down



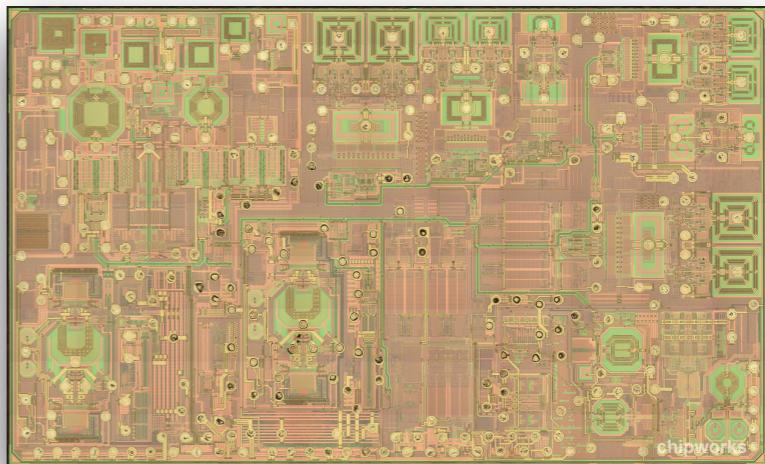
- STMicroelectronics LIS331DLH (2233/DSH/GFGHA) **three-axis linear accelerometer**
- Texas Instruments 343S0628 **touch screen SoC**
- Broadcom BCM5976 **touchscreen controller**
- Apple A6 **application processor**
- • Qualcomm MDM9615M **LTE modem**
- • Qualcomm RTR8600 **Multi-band/mode RF transceiver**

Qualcomm Chipset

Qualcomm MDM9615 multi-chip package including 1 Gb Samsung DRAM memory and **4G LTE Modem**, that is 28-nm CMOS LTE (FDD/TDD), HSPA+, EV-DO Rev B, TD-SCMA modem



Qualcomm RTR 8600 is **multi-band/mode RF transceiver** supports 4 EDGE bands, 5 UMTS bands, 5 LTE bands



What's next?

