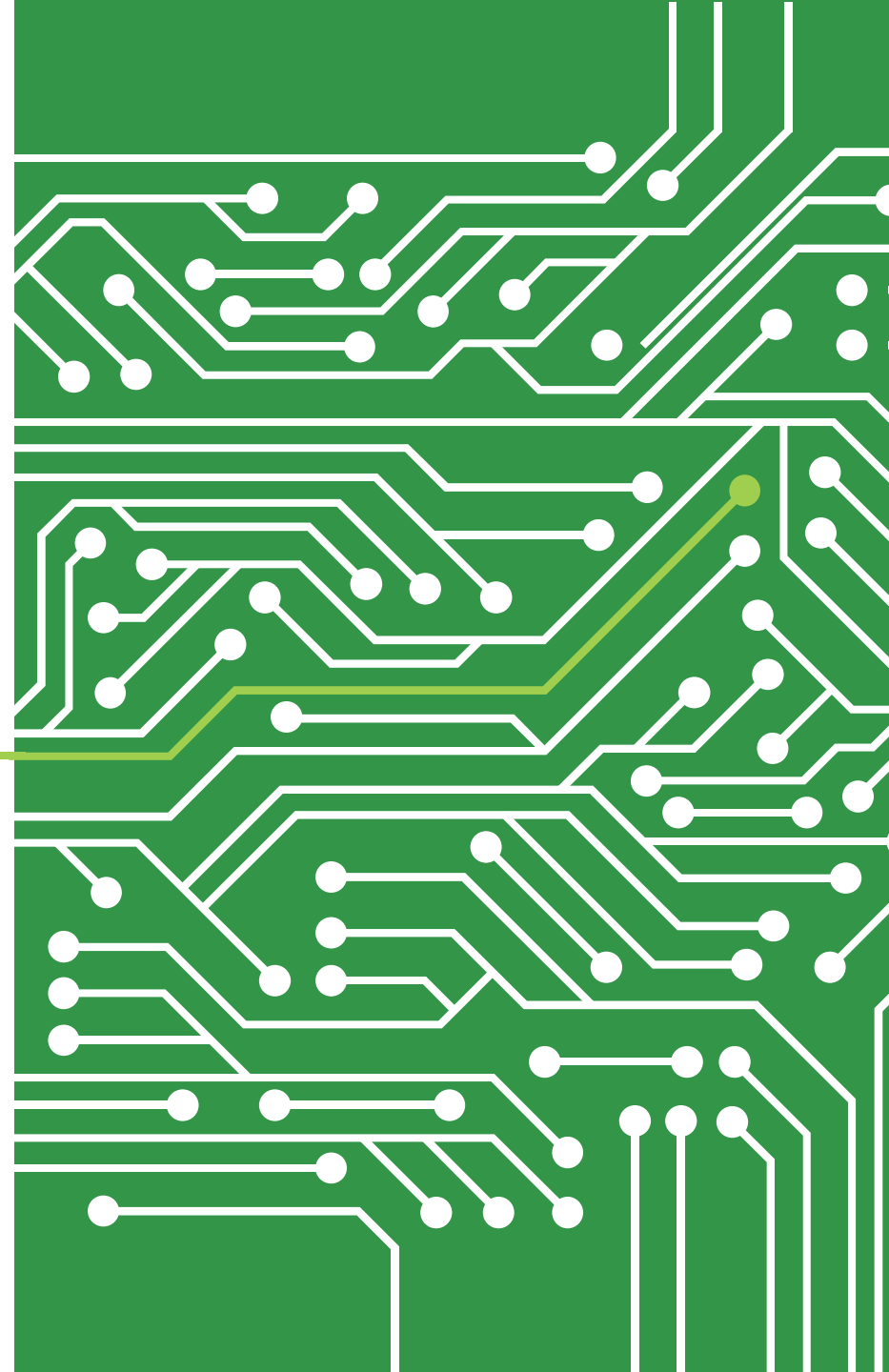




***Structure of modern SDR
Lime's field programmable RF devices***

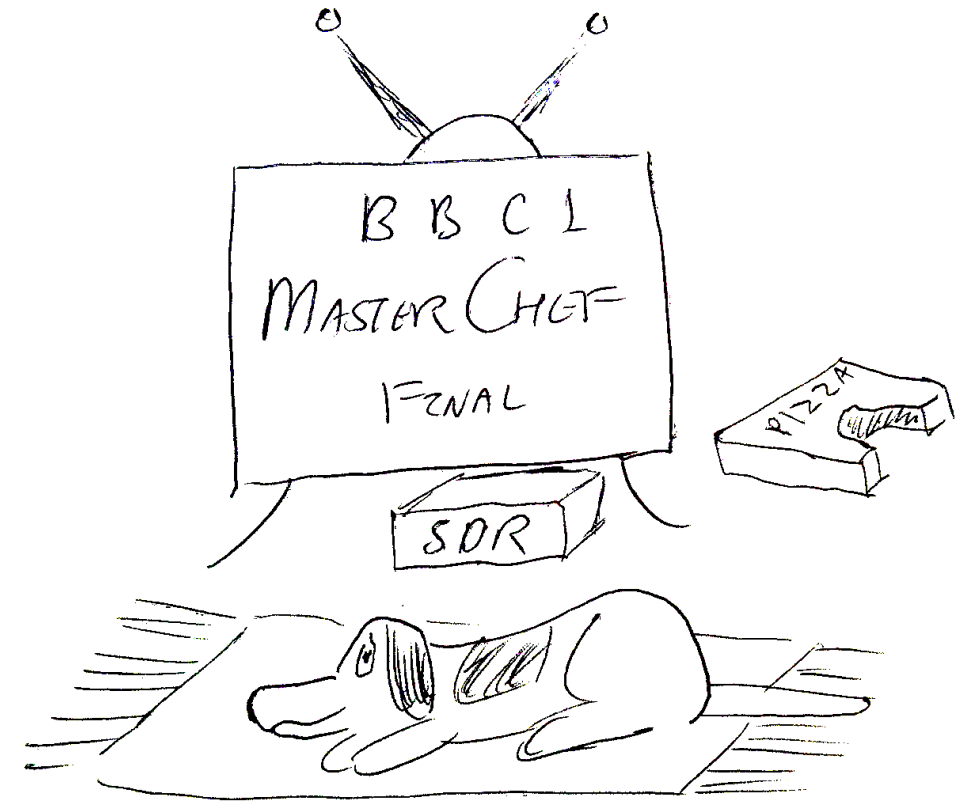
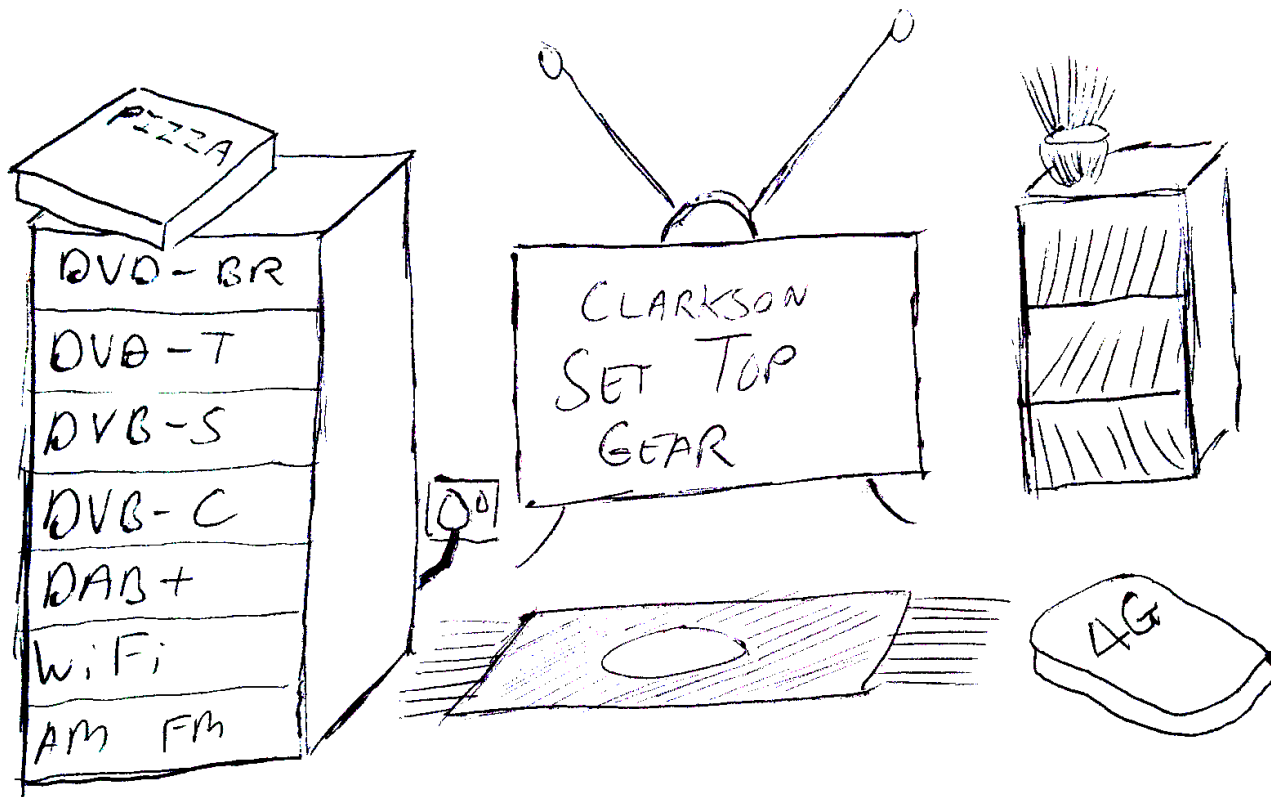
Lime Microsystems | FPRF company
Guildford, Surrey, United Kingdom



Agenda

1. Why do we need Software Defined Radio
2. What does a Software Defined Radio look like?
3. Chip architecture for Software Defined Radio.
4. Testing Field Programmable Software Defined Radio
5. mmW SDR architecture for future systems e.g. 5G

So why do we need SDR? (Consumer's View)



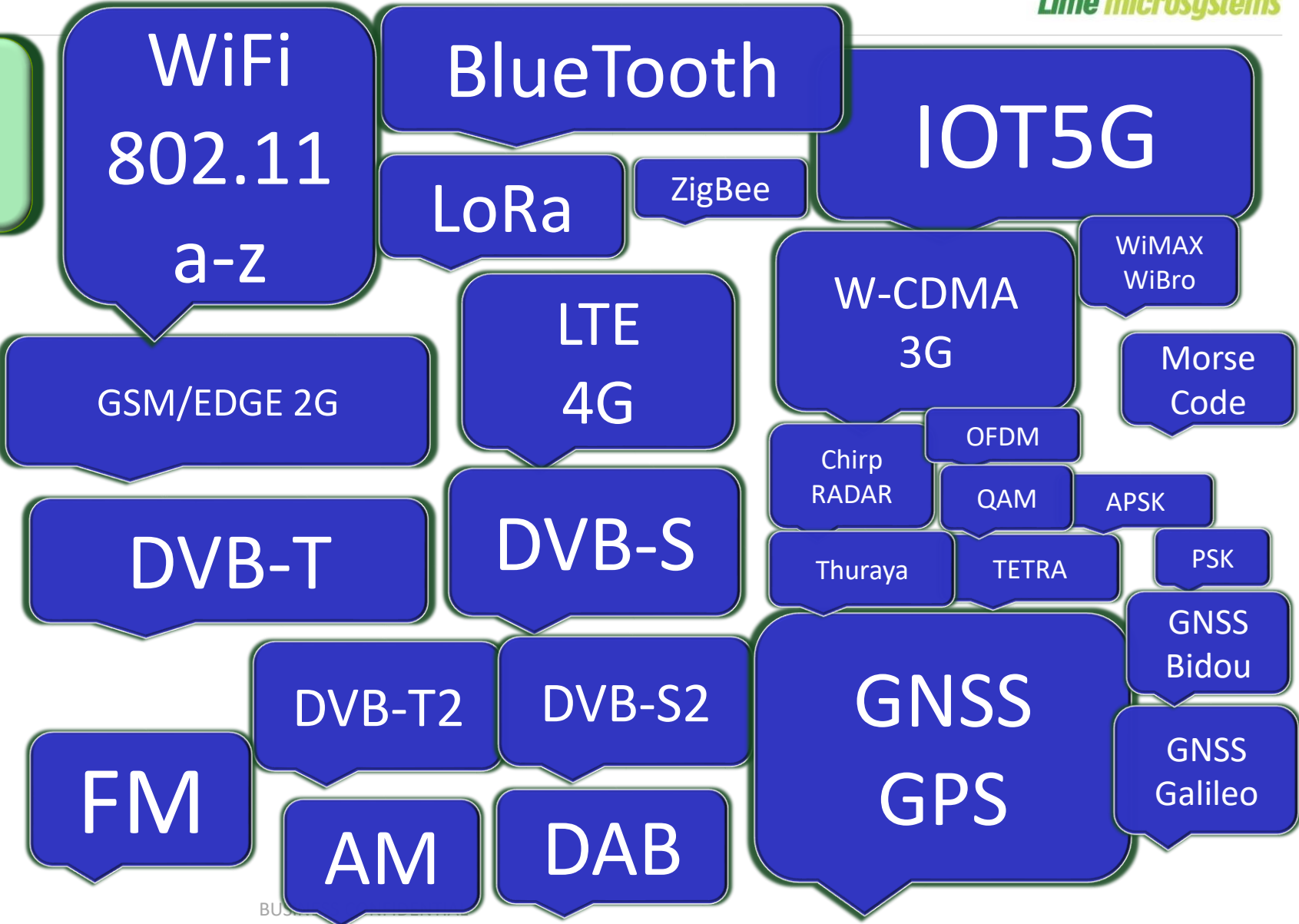
So why do we need SDR? (Engineer's View)



<1940s Morse AM FSK
1950s FM appeared
1978 Military GPS (CDMA)

Since 1991, an explosion of Radio Standards, many are GMSK, CDMA and OFDM based

We need SDR!!!



Key Components for low cost “Dongle” SDR



RF Parts

Antennas
SAW Filters
RF Switches
Power Amps

TRX RFIC

RF and DSP
Field Programmable

Open Source
Software/Apps

FPGA

Data link
Extra DSP e.g. ADPD

USB2/3

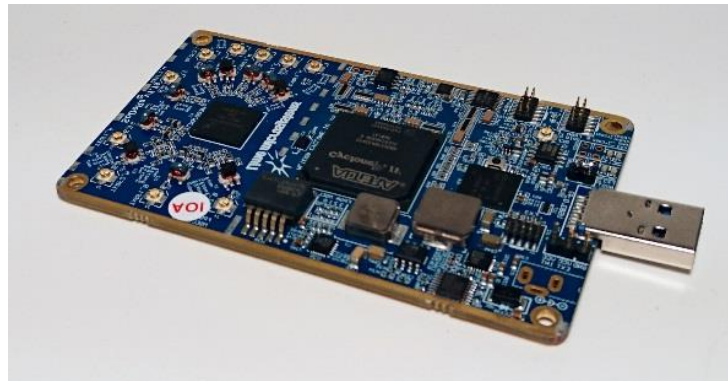
PCIe

COMPUTER

Multicore
SIMD/NEON CPU

WiFi/Ethernet/
ADSL Network

Optimal partitioning of the radio system leads to an easy to use low cost solution.



Lime Technology Overview

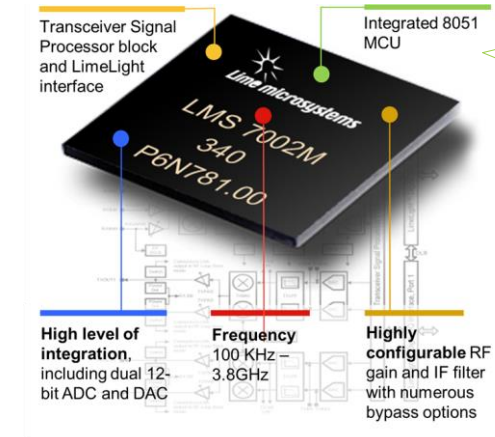


Lime brings the programmability of digital to RF and Wireless with its integrated FPRF solution

- Lime's FPRF solutions replace multiple chipsets and can be configured as basic digital, analogue and RF functions all the way to a complete transceiver for wireless systems
- Highly integrated and capable of serving a wide range of applications, standards and frequency bands from Bluetooth to 5G
- Can be programmed over the air in real-time similarly to FPGA chipsets in the digital domain
- Lime's latest FPRF transceiver consumes very little power and underpins the company's latest product; a unique wireless system platform "LimeSDR" that offers anyone the means to deploy wireless networks or connectivity anywhere quickly and at a fraction of today's cost
- Lime has also developed a companion up-down converter IC (LMS8001) which greatly extends the frequency range of its FPRF transceiver up to 12GHz
- The technology is future-proofed, with a next generation up-down converter in the pipeline which will extend the frequency range to 100GHz in 2018

Platform System Diagram

(Source: Lime 2017)



LimeSDR software enables the rapid development and deployment of an unlimited range of wireless communications applications



High performance, single-chip FPRF transceivers enable one solution for any frequency or standard

Inside The LMS7002M CMOS FPRF Transceiver



Unmatched features and functionalities; flexible, efficient and easy to use

Features

- The LMS7002M is Lime’s second generation FPRF transceiver and enhances system level performance:
 - Designed in a 65nm RF CMOS process at TSMC
 - Low operating voltages (1.25V, 1.4V and 1.8V)
 - Dual transmit and receive chains to support 2x2 MIMO on a single-chip
 - High-performance ADC/DACs that enable higher bandwidth and sampling rates (160/640 Msps)
 - The LMS7002M operates in a wide frequency range (70MHz to 3.8GHz) and supports programmable RF modulation bandwidths from 0.1MHz to 108MHz
 - The LMS7002M is packaged in an 11.5x11.5mm 261-pin aQFN

Functionality and benefits

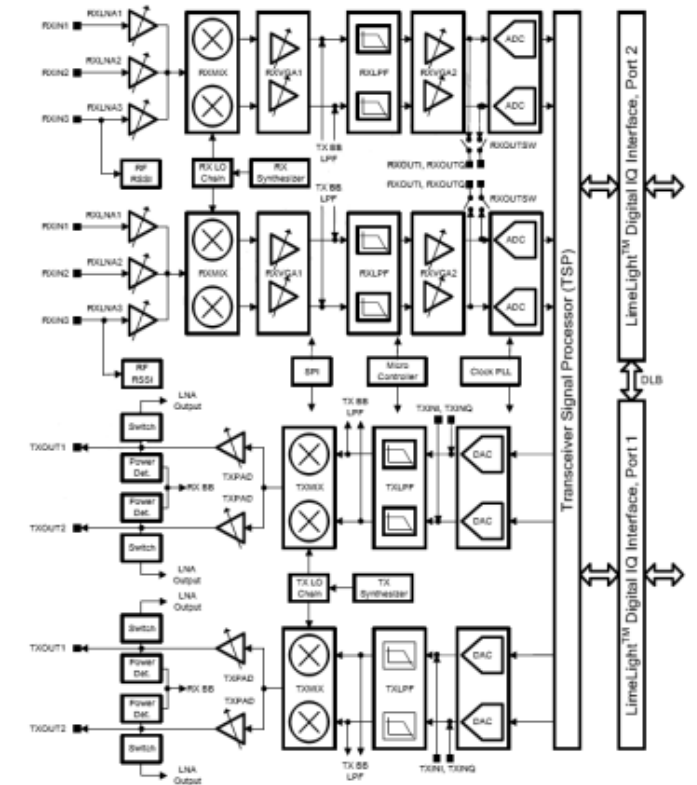
- Functionality includes:
 - Transceiver signal processor (“TSP”) for better performance
 - Clock PLL for flexible clock generation/distribution
 - MCU for simplified calibration, tuning and control, making it simple to use and set up
- Multiple bypass modes enable system designers to reference more powerful off-chip blocks
- Integrated Limelight digital IQ interfaces provide greater design flexibility
- Low operating voltages reduce power consumption to 550mW in SISO mode and 800mW in MIMO mode

Companion IC (LMS8001)

- Combining the LMS7002M with the LMS8001 up-down converter significantly extends the frequency range up to 12GHz
- Lime has a developed pipeline which will extend this up to 100GHz

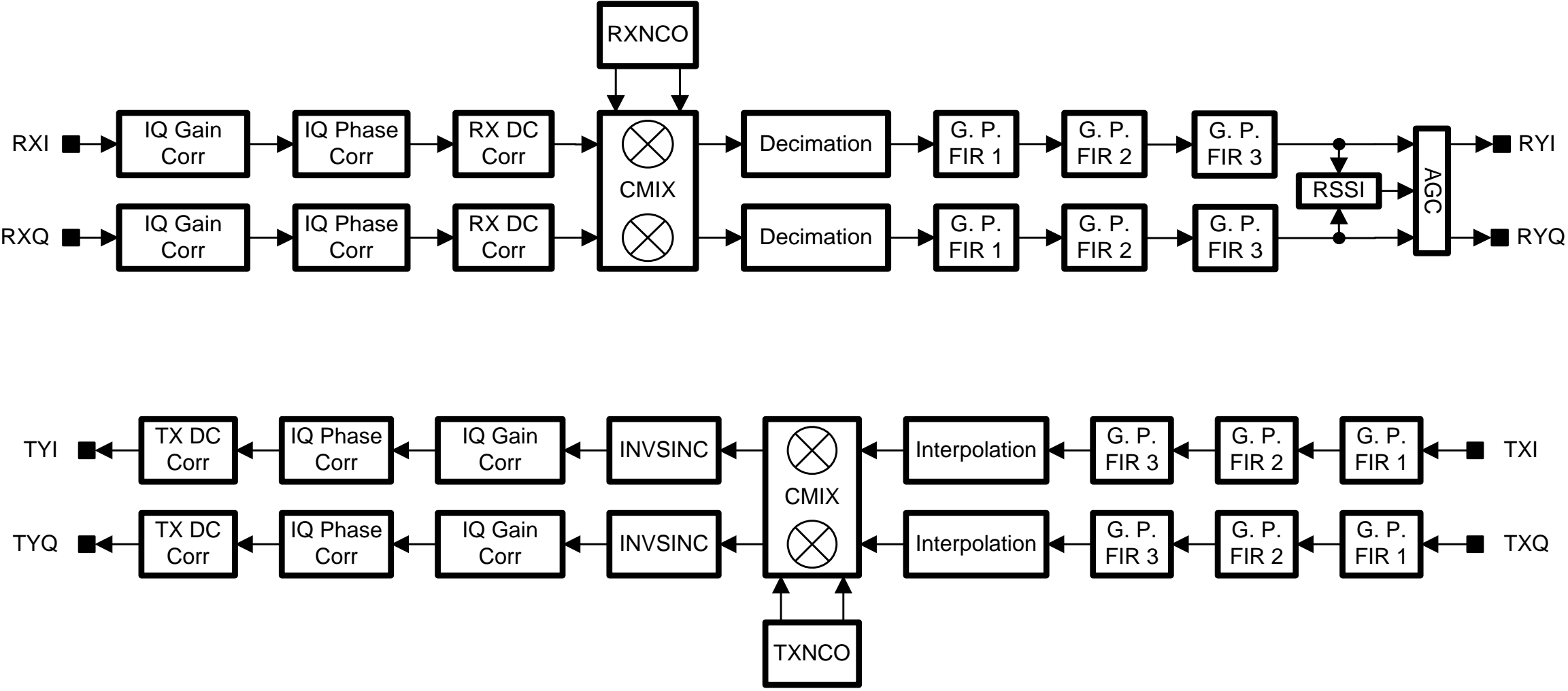
LMS7002 Block Diagram

(Source: Lime 2017)



Lime’s portfolio of transceiver ICs provides unmatched combination of frequency range and power performance

LMS7002M FPRF Signal Processing



Testing Field Programmable Software Defined Radio (Simplified)

Lime microsystems

Dual Site Testing

Maximise Parallel testing

- Analogue Blocks, Synthesisers, Digital

Maximise use of binary weighted testing

Bondwire test

Power down test

Bias Tests

Digital Blocks

- BIST with signature codes.

RF tests

- NF
- RF output power
- IP2 and IP3

Bidirectional Digital Loop Back

- I/O Testing
- High Speed ADC/DAC testing
- SNR+THD→ENOB

Baseband Loop Back

- Programmable Analogue Filter Testing
- Programmable amplifier Testing.

RF Loop Back

- LNAs, Mixers and RF Drivers.

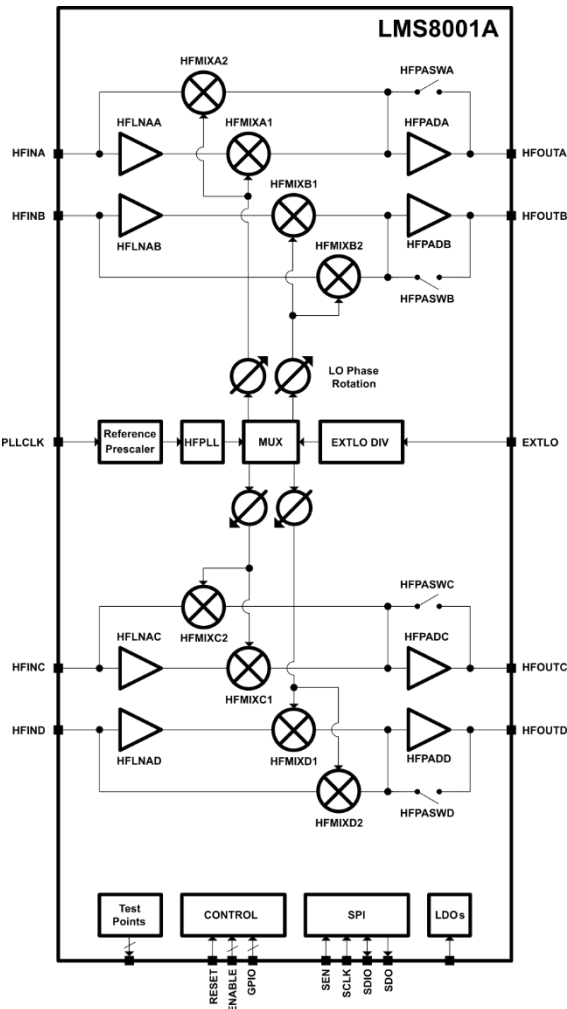
Synthesiser

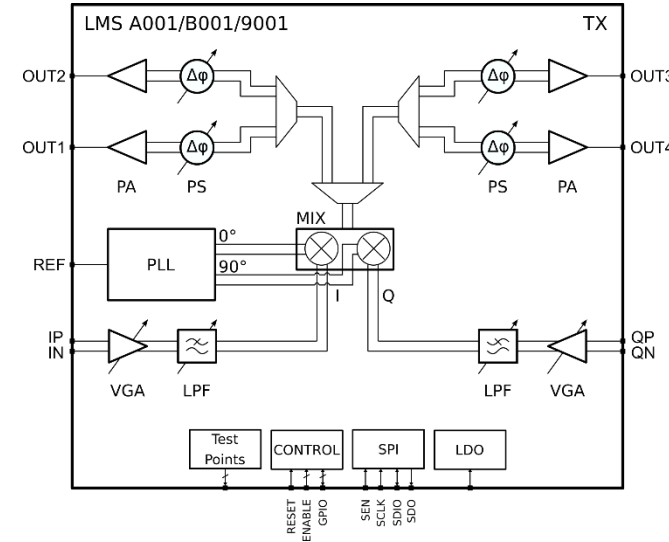
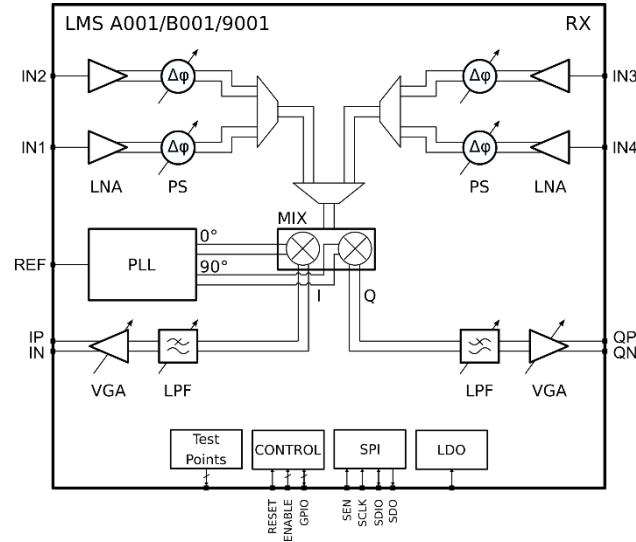
- Test for full octave coverage
- Test for VCO overlaps
- PLL Lock indicator

Calibration Tests

SUMMARY FEATURES

- Single chip up/down RF frequency shifter
- Four independent RF paths all driven by the same LO
- Quadrature LO up to 4.5 GHz
- Fully differential signals
- Few external components
- Low voltage operation, 1.2 and 1.8V.
Integrated LDOs to run on a single 1.8 V supply
- Standard 56 pin QFN package
- Serial Port Interface
- Power down control available via ENABLE pins and/or equivalent SPI registers
- Synchronous loading of pre-set operation profiles by GPIO pins. Integrated PLL loop filter
- Low power consumption

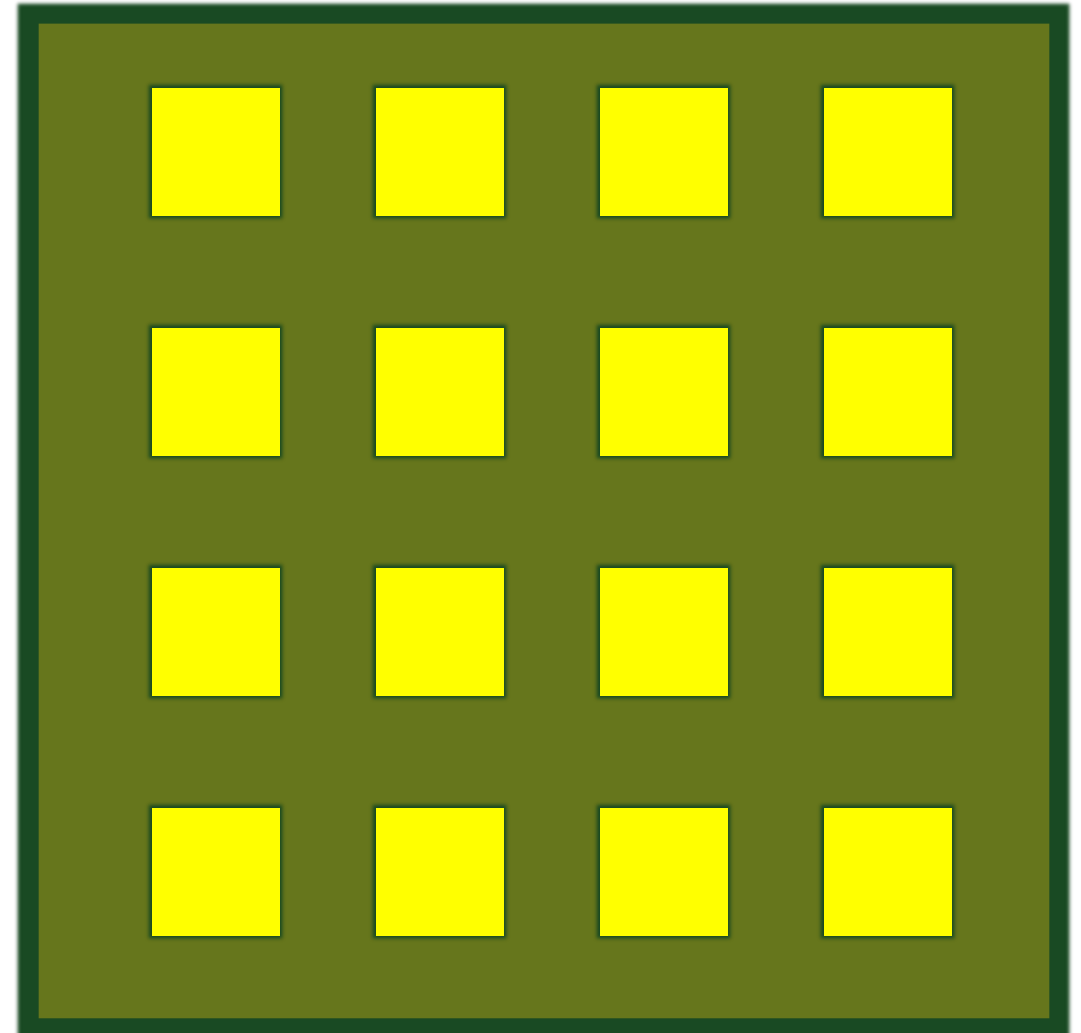
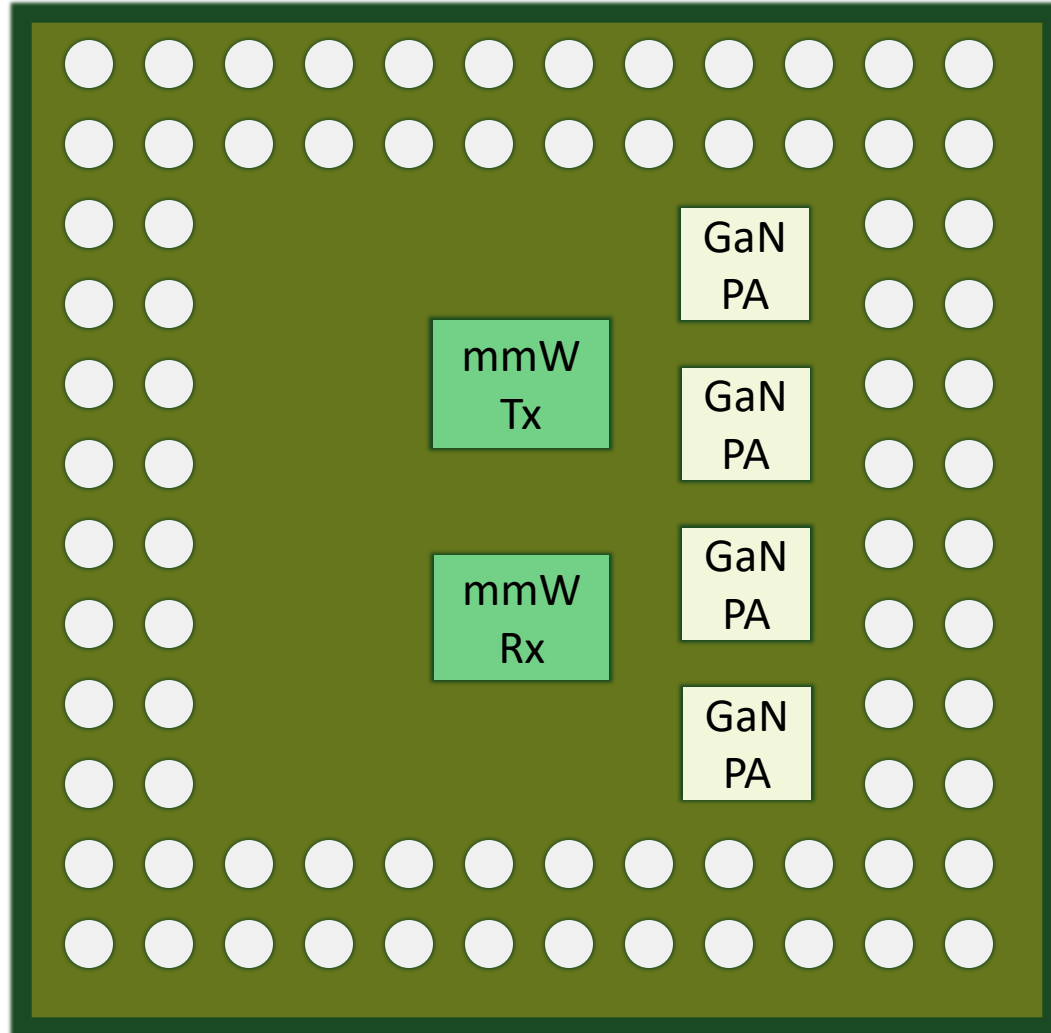




SUMMARY FEATURES

- Integrated 4-channel phased array TX/RX
- Zero-IF architecture
- Covering 23 to 95 GHz with only 3 chipsets
- LMSA001: 23 – 45 GHz
- LMSB001: 45 – 76 GHz
- LMS9001: 71 – 95 GHz
- Module with antennas
- BGA with integrated antennas (redesign)
- Modular, Flexible

BGA based mmW Beam Steering Module



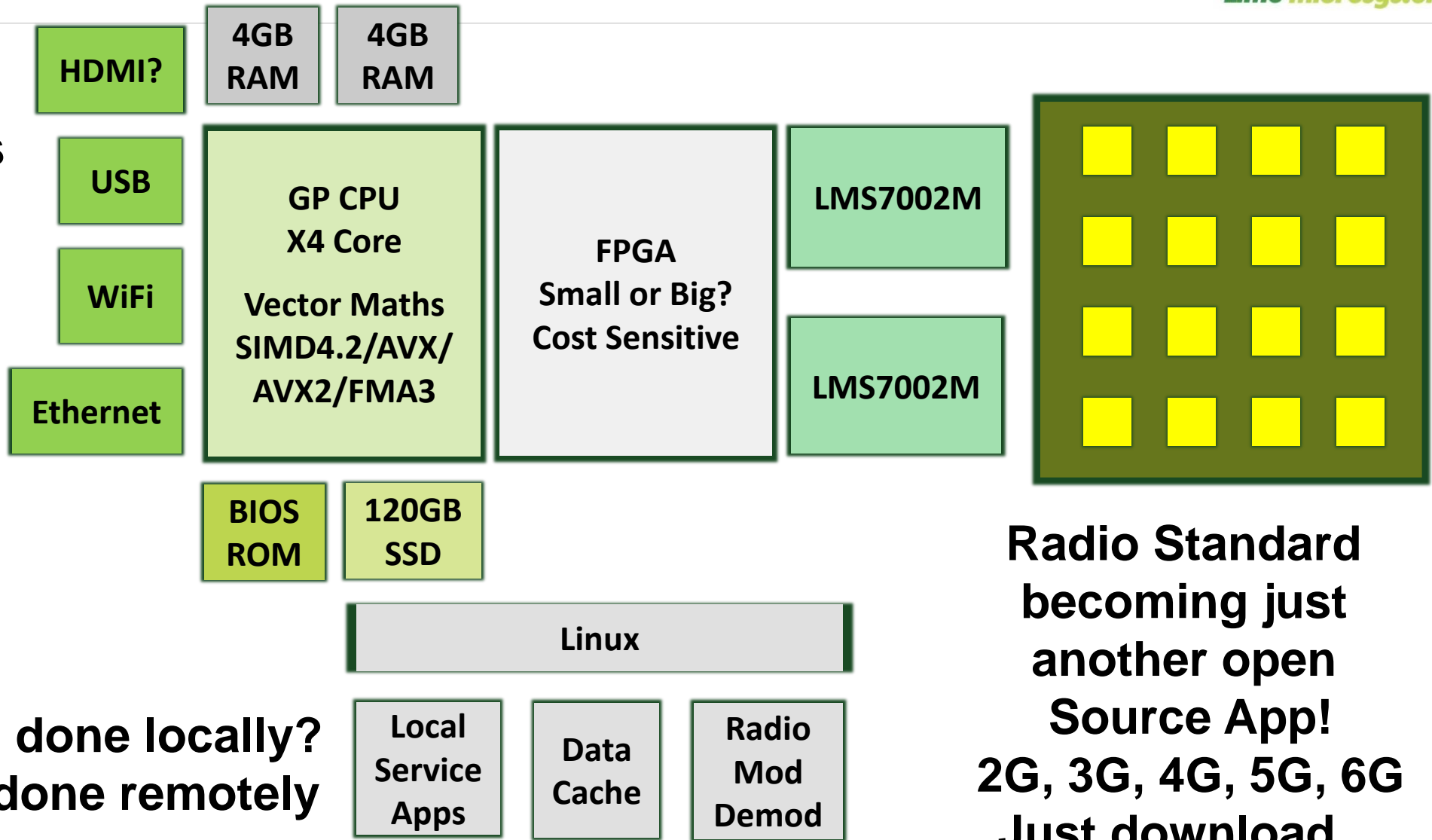
mmW MIMO SDR



4G/5G SDR Hardware Requirements Modest And low cost

Cloud Apps Data

Telecoms Core Network



**Which services done locally?
Which services done remotely**

**Radio Standard becoming just another open Source App!
2G, 3G, 4G, 5G, 6G
Just download**

“Dongle” based SDR is rapidly evolving.

SDR Radio is becoming increasingly low cost and reconfigurable.

Radio standard is just another App.

SDR concept is expanding to embrace the emerging mmW world of 5G

- Beam steering to individual users.

Up/Down convertors cost effective way to get to mmW frequencies.

Thank You

Useful links:

www.limemicro.com

www.myriadr.org

www.crowdsupply.org