Multi Channel FM Transponder (MCFMT)

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High Level Needs (from Jonathan's email)

- Start with:
  - Single signal path
  - VHF voice signal transponded as a UHF voice signal
- Could be a SDR w/digital radio chip
- Could be analog
- Fit onto a CubeSat board
  - Ideally 2" x 2" area
- Radiation tolerant
  - Avoid CMOS

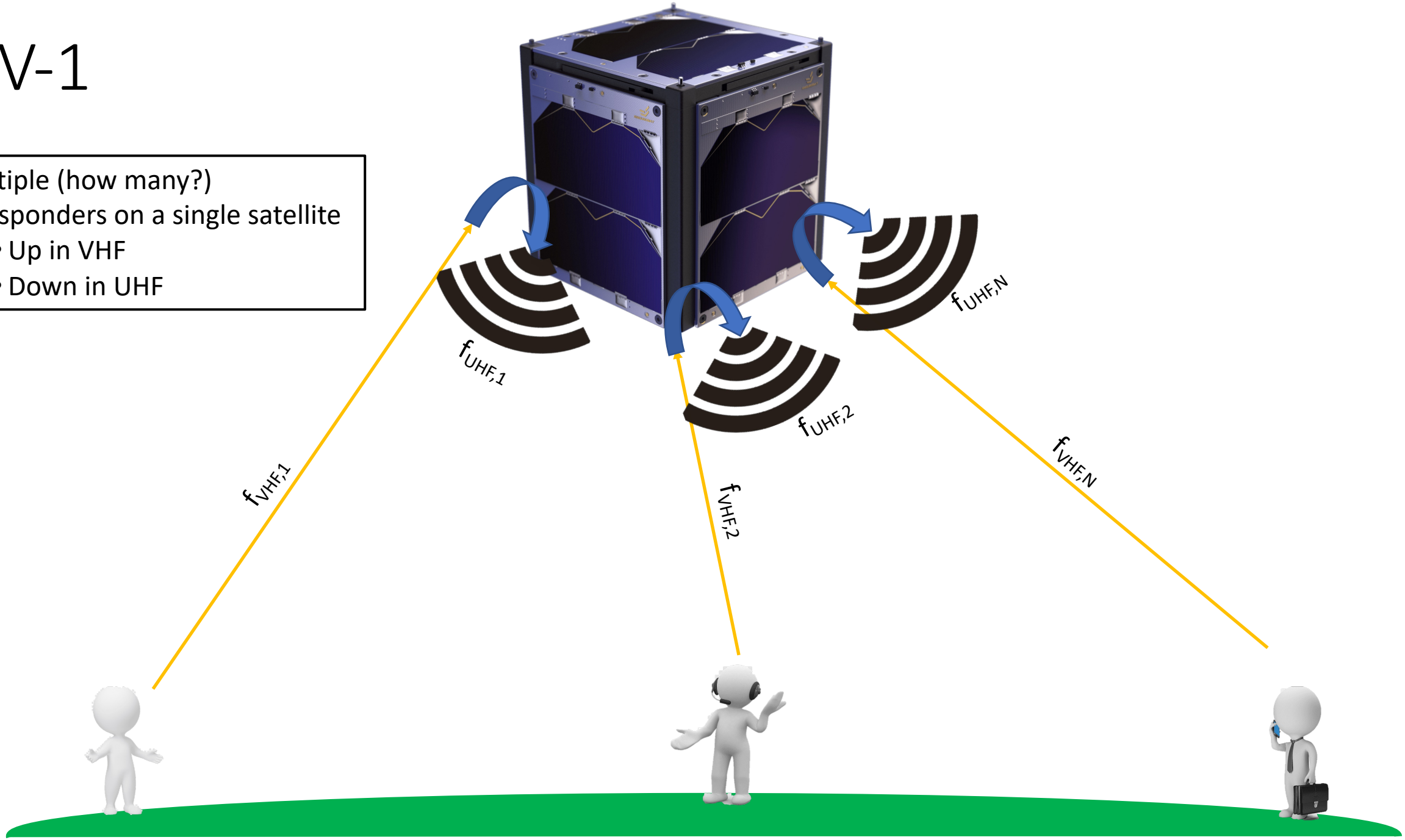
Goals

- Multiple transponders on a single satellite
- I.e., multiple up frequencies with multiple down frequencies
- Mix of U/V and V/U (?)

Are there other goals? Added capabilities? Lower SWaP-C?

OV-1

- Multiple (how many?) transponders on a single satellite
  - Up in VHF
  - Down in UHF



Tasks

- Survey of open-source designs

High-Level Questions

#	Question	Response
1	Are there any desired additional capabilities that we can enhance with a digital design or a SDR design?	
2		
3		
4		
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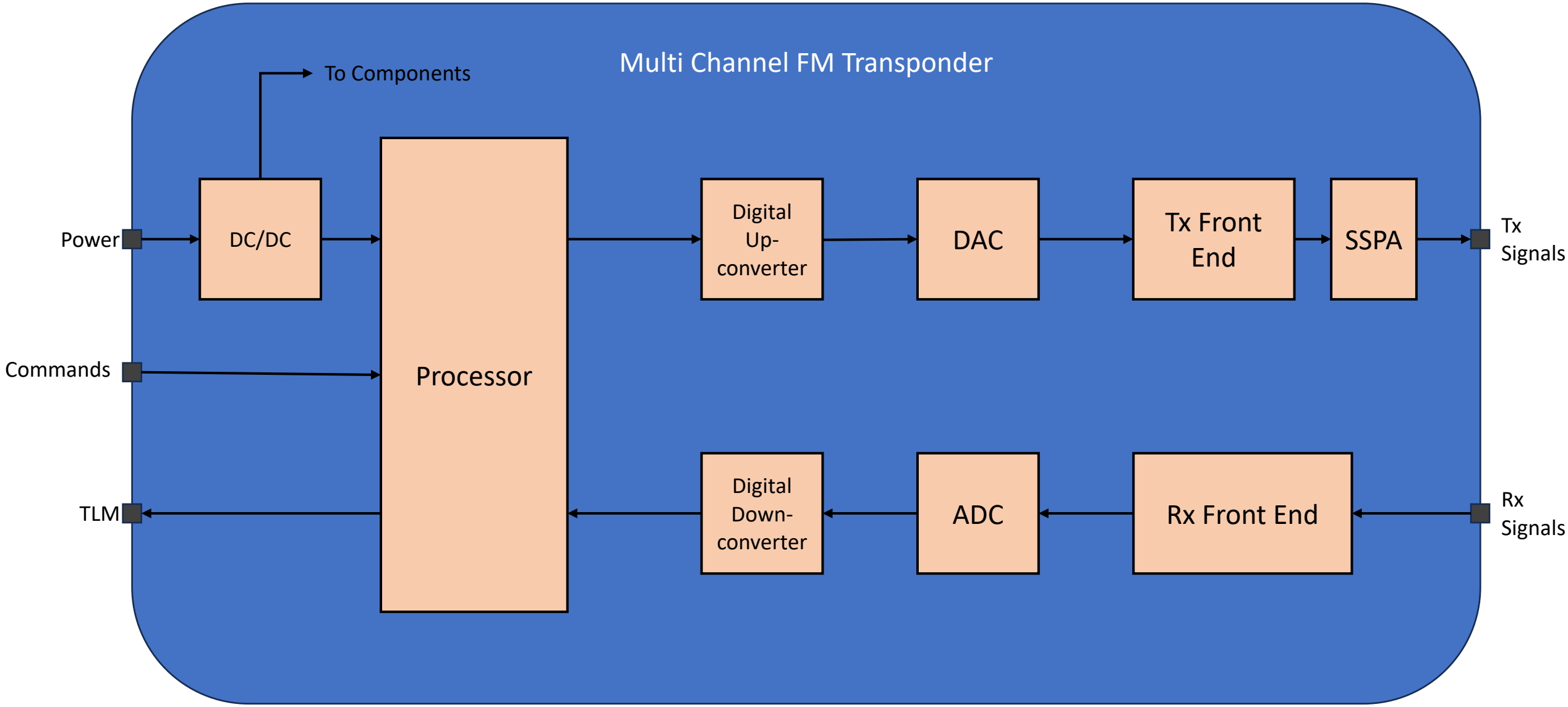
Assumptions

Requirements(-ish)

Architecture

Will the Bus have a comm system for TLM D/L or will the MCFMT be used?



Reference signal: needed?
(probably) → internal or external?

Receive Front End

Functions → Form:

- Amplify incoming RF signals → LNA
- Convert to an IF signal → Mixer and a LO
- Filter IF signal (i.e., image filtering if needed?) → Filter

Notes/Questions/Observations:

- Need a Front End for each signal?
- Can this be “tuneable?” How do COTS SDRs cover such a wide range (e.g., 50 MHz to 3 GHz)?

Analog-to-Digital Converter (ADC)

Functions → Form:

- Convert the IF signal input to a digital output → ADC (?)

Notes/Questions/Observations:

- Need to figure out the drivers for this, e.g., resolution needed, etc.

Digital Downconverter

Functions → Form:

- Take the digital IF signal and convert it to a digital baseband signal

Notes/Questions/Observations:

Processor

Functions → Form:

- Demodulate and modulate the signal? Or is this just a bent pipe function?
- Collect TLM, status, TBD from the pieces of the MCFMT
- Process incoming commands from the Bus

Notes/Questions/Observations:

Digital Upconverter

Functions → Form:

Notes/Questions/Observations:

Digital-to-Analog Converter (DAC)

Functions → Form:

- Convert the digital IF signal to an analog IF signal

Notes/Questions/Observations:

Transmit Front End

Functions → Form:

- Convert the analog IF signal to the RF signal

Notes/Questions/Observations:

Solid State Power Amplifier (SSPA)

Functions → Form:

- Amplify the RF signal

Notes/Questions/Observations:

- What power is required to close the link?
  - Frequency, aperture, altitude dependent?

Design-y Questions

#	Question	Response
1	What TLM is typically collected?	
2	How many signals?	
3	What is a good power draw to shoot for?	
4	Are reference signals (e.g., PPS, 50 MHz) available from the bus or should they be accounted for on the MCFMT?	
5		
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Assumptions

#	Title	Assumption
1	Input Power	A single source of power will be received from the bus Conversion and distribution of power is a function of the MCFMT
2		
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Acronyms

Acronym	Definition
ADC	Analog to Digital Conversion
COTS	Commercial Off The Shelf
D/L	Downlink
DAC	Digital to Analog Conversion
DC	Direct Current
FM	Frequency Modulation
IF	Intermediate Frequency
LNA	Low Noise Amplifier
LO	Local Oscillator
MCFMT	Multi-Channel FM Transponder
RF	Radio Frequency
Rx	Receive
SDR	Software Defined Radio
SSPA	Solid State Power Amplifier
TLM	Telemetry
Tx	Transmit
U/L	Uplink

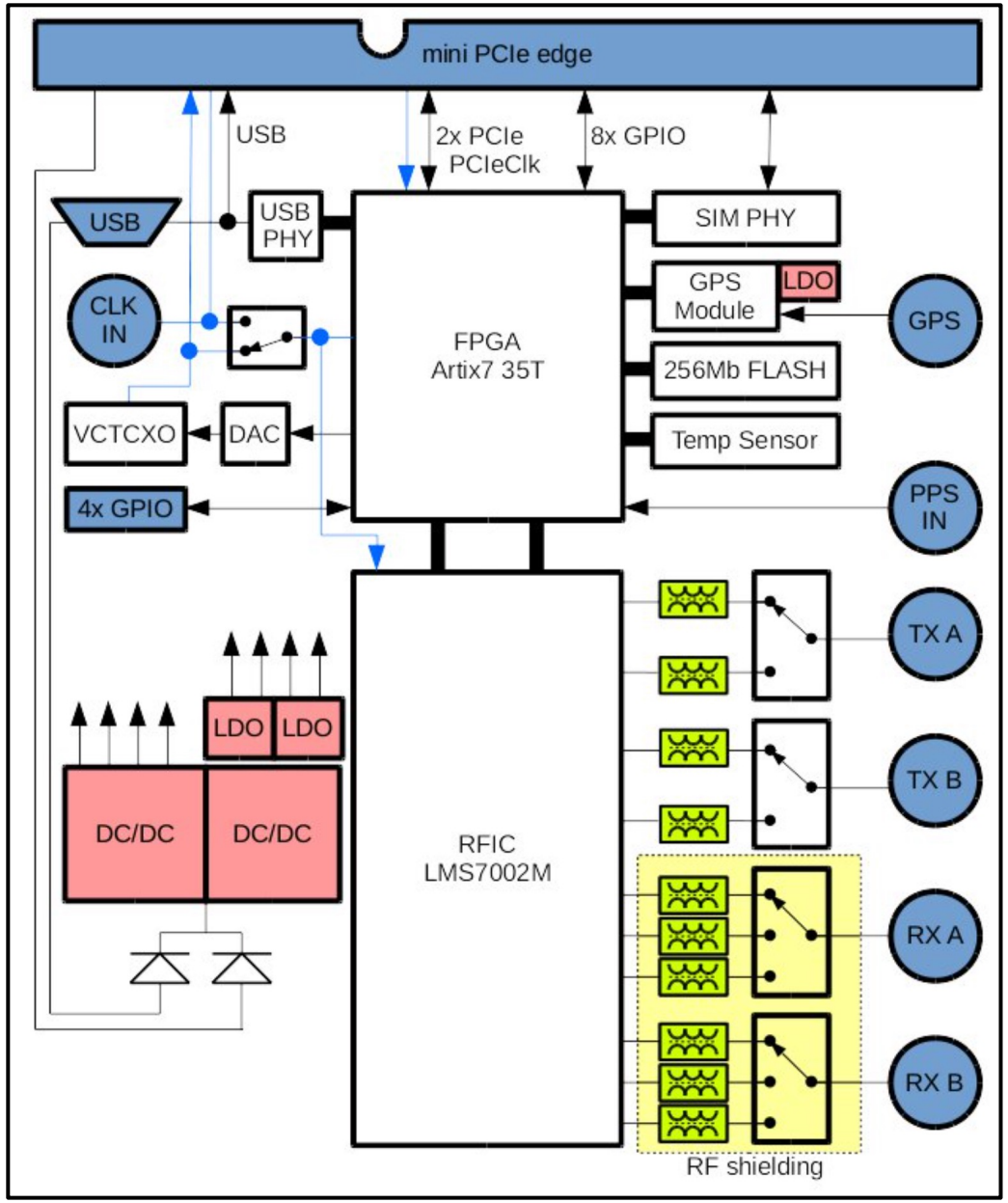
Backup

SDR

- Fairwaves
- XTRX

Features & Specifications

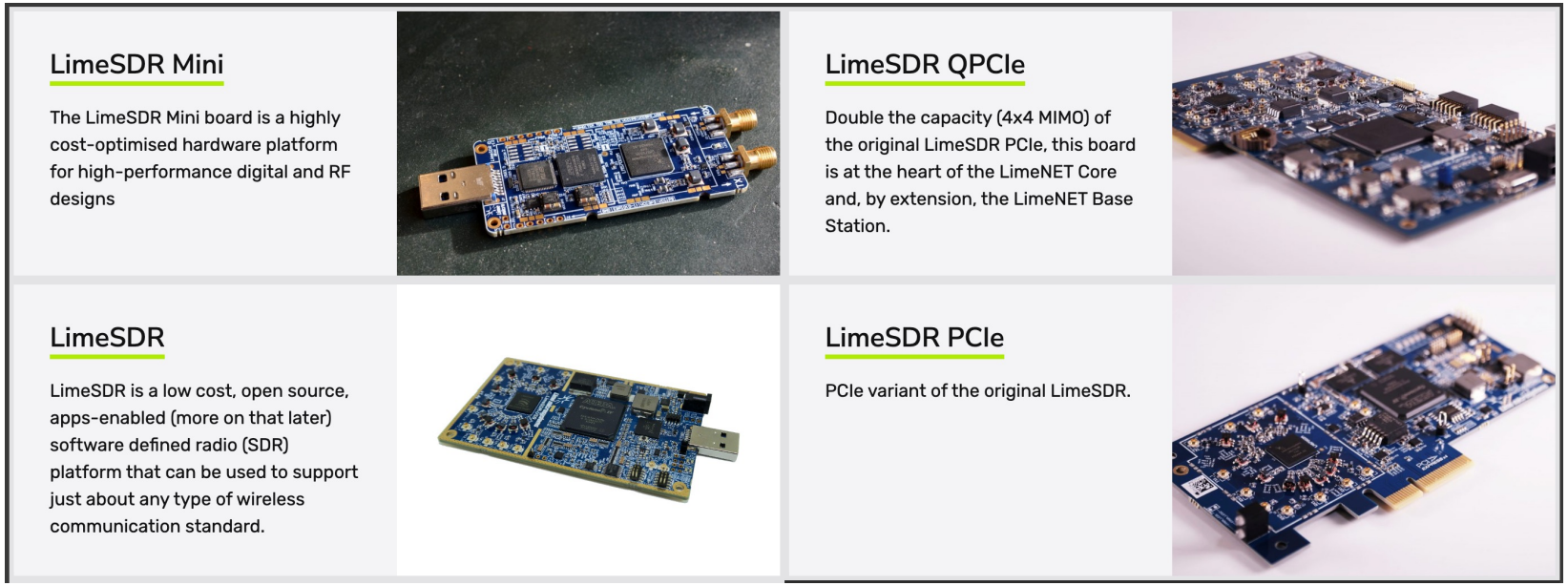
- **RF Chipset**: Lime Microsystems LMS7002M FPRF
- **FPGA Chipset**: Xilinx Artix 7 35T
- **Channels**: 2 × 2 MIMO
- **Sample Rate**: ~0.2 MSPS to 120 MSPS SISO / 90 MSPS MIMO
- **Tuning Range**: 30 MHz - 3.8 GHz
- **Rx/Tx Range**:
  - 10 MHz - 3.7 GHz
  - 100 kHz - 3.8 GHz with signal level degradation
- **PCIe Bandwidth**:
  - PCIe x2 Gen 2.0: 8 Gbit/s
  - PCIe x1 Gen 2.0: 4 Gbit/s
  - PCIe x1 Gen 1.0: 2 Gbit/s
- **Reference Clock**:
  - Frequency: 26 MHz
  - Stability: <10 ppb stability after GPS/GNSS lock, 500 ppb at start up
- **Form Factor**: full-size Mini PCIe (30 × 51 mm)
- **Bus Latency**: <10 µs, stable over time
- **Synchronization**: synchronize multiple XTRX boards for massive MIMO
- **GPIO**:
  - FPC Edge Connector: four lines (usable as two diff-pairs)
  - Mini PCIe Reserved Pins: eight lines (including two diff-pairs, 1pps input, 1pps output, TDD switch control, and three LEDs)
- **Accessories**:
  - Antennas + Cables
  - USB 3 Adapter with Aluminium Enclosure
  - PCIe x2 + Front End Adapter
  - PCIe Octopack



Source: https://www.crowdsupply.com/fairwaves/xtrx

SDR

- Lime Microsystems took over the XTRX (?)
- Additional Options:



Source: https://limemicro.com/products/boards/

Repeater Basics