Low-cost
(*under $1000*),
Flexible, High-performance
(T_{SYS} < 100 ^{0}K & *Δf/f better than* ≈ $1:10^{11}$ -$1:10^{12}$)
X-band (10.45 GHz) Receive Terminals for AMSAT's GEO, HEO and Lunar Missions

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Some Design Considerations that I Adopted

- Most Amateurs do not have microwave hardware & test equipment,
- Most Amateurs have little microwave expertise,
- Most Amateurs are cheap bastards,
- AMSAT wants to appeal to a wide range of Amateur Interests,
- AMSAT has a vision to revolutionize “First Responder” EMCOMM
- Any design must be easily replicable in order to be widely acceptable,
- High-performance SDRs have become commonplace and are in daily use by amateurs,
- And Vendors like AMAZON stock lots of useful widgets including small dishes & Ku-band LNBs (complete LNA+LO+Feed modules)

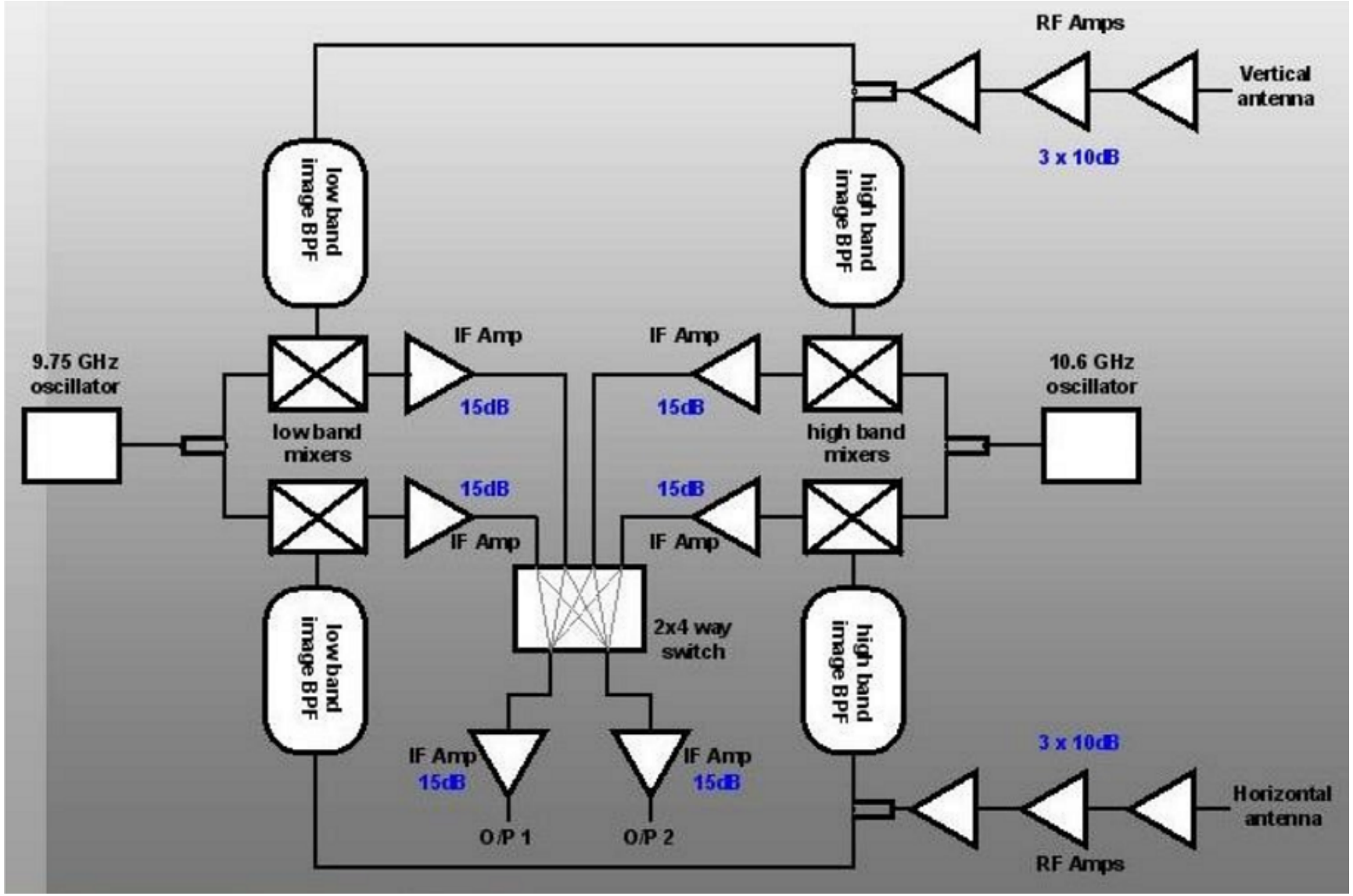
And further, especially for the GEO case,

- Spacecraft will be visible 24/7 & required antenna motion is small.
  - This means that “Armstrong Rotors” with manual pointing updates are feasible.
  - Therefore no mechanized “prime movers” have been incorporated.
  - Mechanically-minded “hackers” are welcome to innovate !
- The current GEO mission calls for a C-band TX uplink; the C-band TX frequency is ≈ ½ of the X-band downlink.
  - Full duplex TX/RX operation will be HIGHLY desired.
  - The PHEMT transistors in the front-end of the LNB are quite zappable (like -40 dBm)
  - TX/RX crossband isolation in C/X dual-mode feeds is likely to be woefully inadequate.
  - Therefore I recommend isolated, separate small TX & RX dish antennas.
- Implement the X-band RX terminal first, listen to the GEO bird, and then if you are still interested build the the C-band uplink TX system.
- The X-band RX terminal will also allow you to participate in telemetry gathering and tracking to support POD of the Lunar Cubesat mission (listen to Luigi Balarinni & Ragnarok in an hour+ for more details).

Using Ku-band LNBs at X-band

- The “FTA” TVRO market in Europe & the Middle East has led to the development of low-cost Ku-band Dual-band LNBs costing $8-25.
  - Advertised at 0.1-0.2 dB NF, but in reality more like 0.5-1.0 dB with PHEMT LNA
  - Advertised Low-band = 10.7-11.9: Apply +12v and 1st LO = 9.75 GHz, xtal controlled. 10.45 comes out at 700 MHz IF down ~10 dB (our of 70 dB) in gain
  - Advertised Hi-band = 11.5-12.75: Apply +18v & 1st LO = 10.6 GHz (same xtal)
- Single channel linear polarized feed, or dual channel with 2 LNAs dual polarized. Dual costs ~$5-10 more but it gives you a hot spare.
- Be sure to get “PLL” xtal controlled version. Older versions (including old Dish & DirectTV) used a free-running 10 GHz DRO/cavity LO and had poorer LNAs
- These LNBs with 60 cm dishes have copied signals off the moon on 10.368 MHz

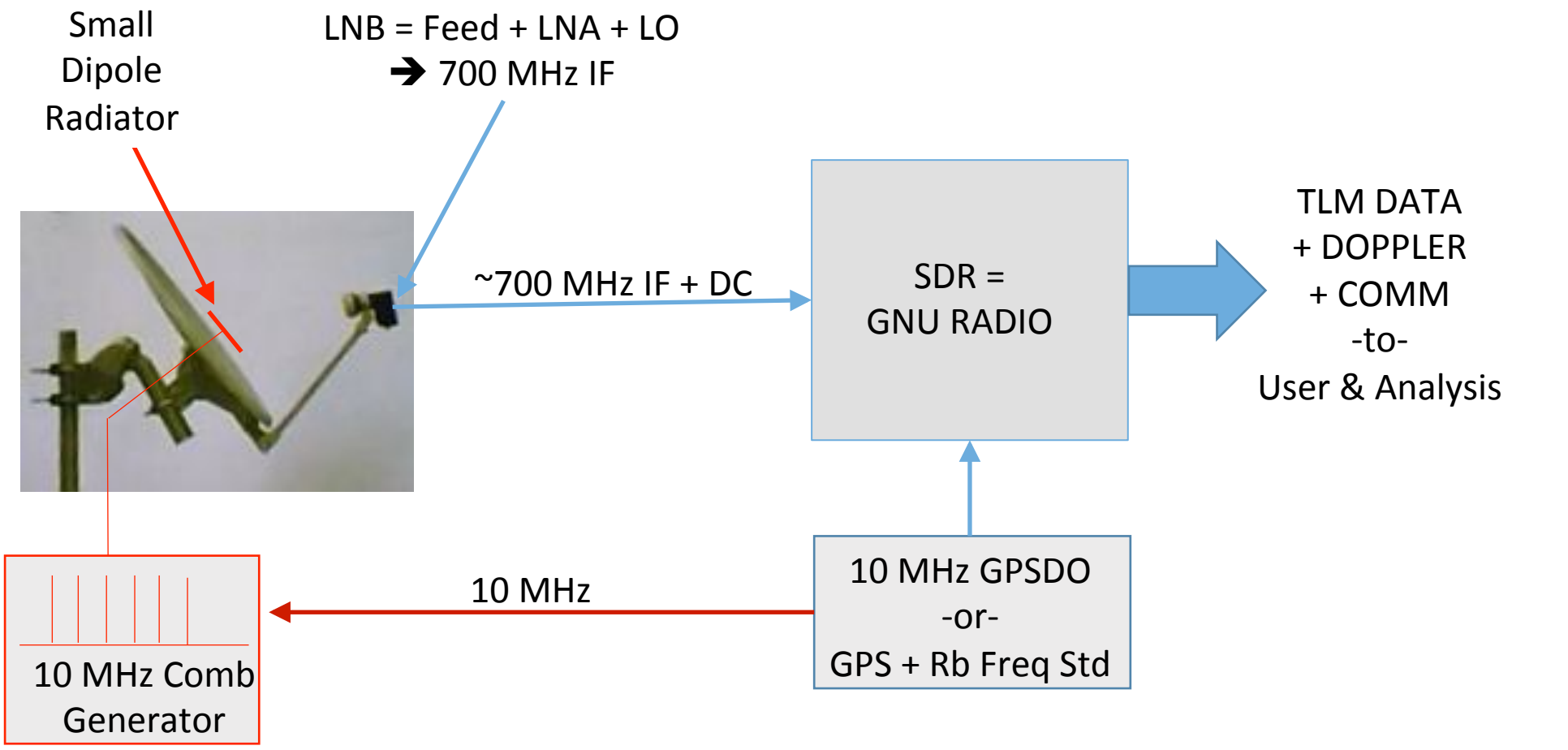
Typical LNB Bloc Courtesy http://www.earf.co.uk/sat.pdf



High Accuracy Frequency Addition for Lunar Quest

- Make unipolar short pulses from a precision 10 MHz frequency reference (i.e. GPSDO or Rb standard)
- Duration of pulses ~20 psec makes harmonics every 10 MHz up to 10 GHz.
- Pulses can be made in high-speed (i.e. PECL) logic or tunnel diodes or step-recovery diodes.
- Radiate signals into the LNA continuously
- Process these “rails” in SDR in parallel with desired X-band signals.
- Voila – your frequency standard (GPSDO) is now providing the “real” LO signal thru the entire receive chain with little/no degradation of accuracy.

Putting it all together



Transportable Terminal for First Responders

- AMSAT wants to develop EMCOMM as a major focus of the GEO mission
- FEMA & ARRL have signed an MOU for mutual assistance
  - FEMA Director Fugate is a ham.
  - ARRL is assembling 100 Rapid Response Communications “Go Boxes” to be made available for FEMA use in major emergencies
- FEMA is “supporting” GEO mission with USAF to secure rideshare ride
  - AMSAT is on the hook to develop 100 GEO terminals for “Go Boxes”, with $1k cost target. The design presented here is a prototype for RX half.
  - Design and/or copies will be made available to amateur community (following the “TAPR Model”)
  - COTS Tailgate special dish, COTS LNB, GNU-radio clone SDR, Software is being developed in San Diego

73 de K3IO