Synchronization for WiMAX Networks

Alain Michaud
OEM Development Manager
Oscilloquartz SA
michaud@oscilloquartz.com

WiMAX Synchronization

Content:

- Architecture
- TDD versus FDD
- Frequency and Phase Sync
- WiMAX requirements
- BS Design requirements
- GPS Clocks
- Integration of GPS Clocks
- Evolutions

WiMAX

- Applications:
  - Fixed applications:
    - Last mile
    - 2G/3G base station backhaul
  - Portable applications (low speed): hot spots, hot zones
  - Mobile applications (up to 120 km/h)

- User data rate:
  - up to 70 Mbit/s (depends on configuration)

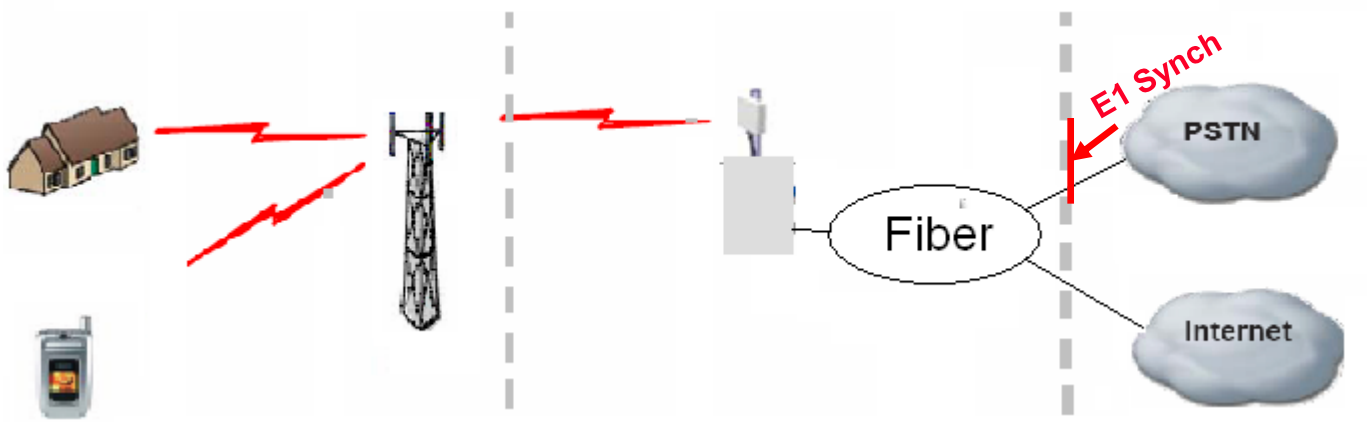
- 2 different duplexing Technics, FDD and TDD

- Supports Adaptative Antenna Systems

- Supports Non Line of sight

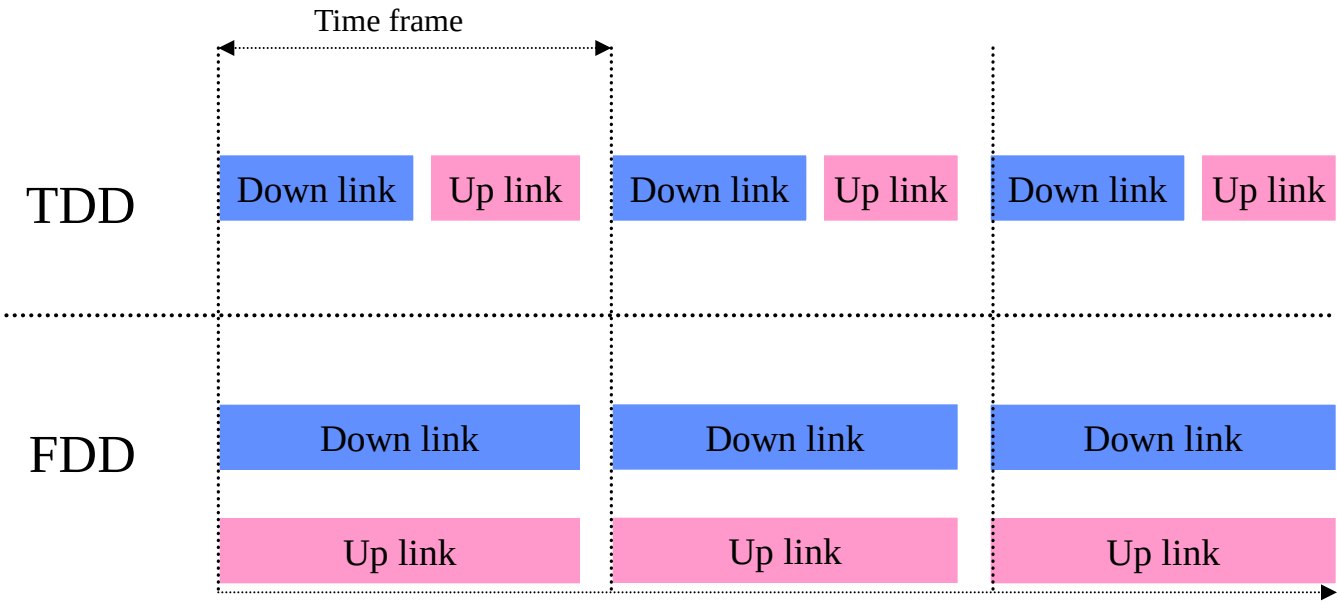
- Standards:
  - Fixed/portable **IEEE 802.16-2004**
  - Mobile **IEEE 802.16e**

WiMAX Synchronization at the edge (Access Network)



CPE Wireless Access Network WiMAX Radio	BS	IP Backhaul Network	Core Networks
NEED SYNCH		No stringent SYNCH Requirements	SDH synch does not propagate through the IP infrastructure

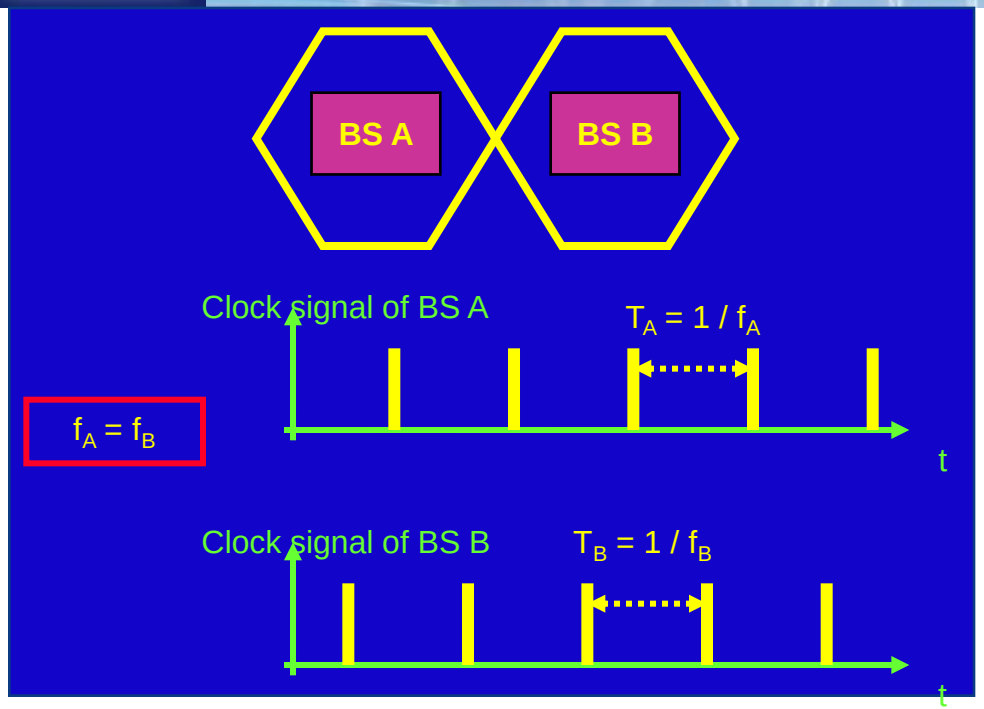
WiMAX: TDD Time Division Duplexing FDD Frequency Division Duplexing

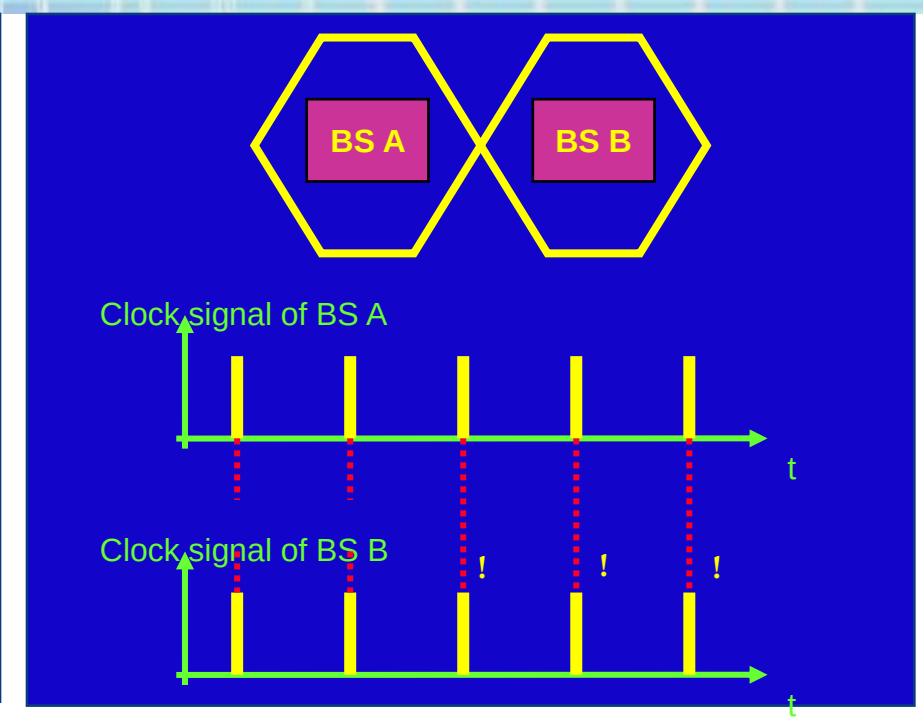


TDD is chosen for Mobile WiMAX

- Optimal for asymmetric traffic
- Can handle both Paired and non Paired Spectrum
- Better use of Adaptative Antenna System (AAS)
- Simpler duplexing mechanisms (lower cost Base station)

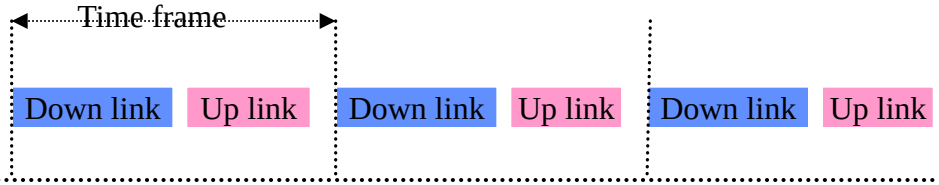
Frequency & Phase synchronisation





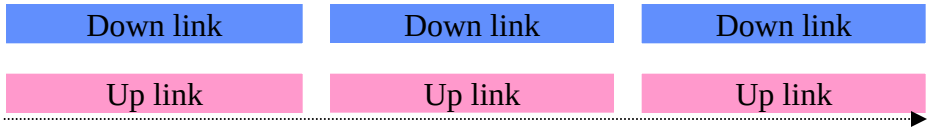
Requires frequency and Phase synchronisation

TDD



Requires frequency synchronization

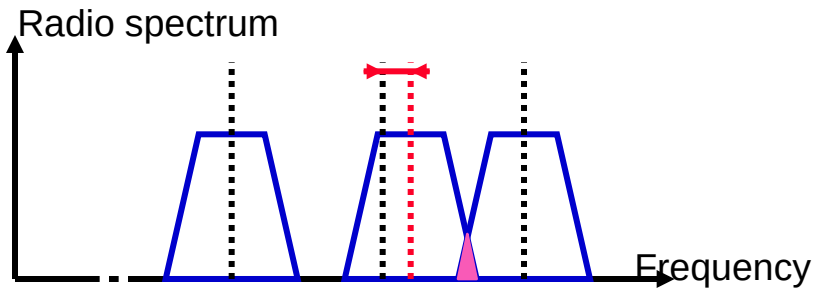
FDD



WiMAX: Why is synchronization needed?

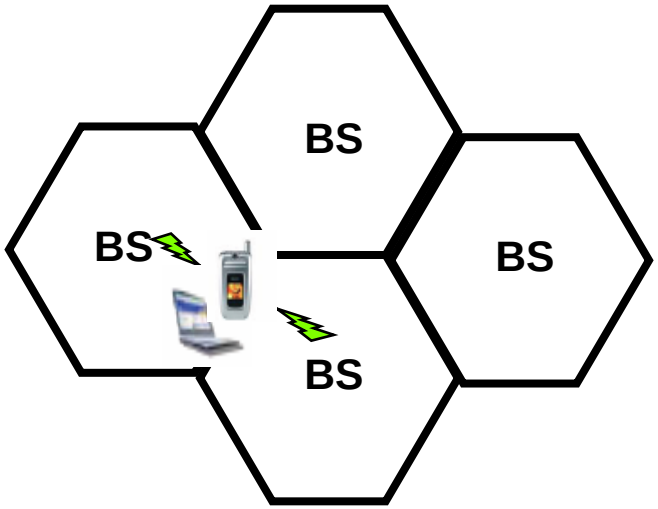
Frequency

Radio carrier frequencies must be synchronized precisely in order to prevent cross-talk



Phase

Successful handover requires synchronisation between base stations (BS)



WiMAX Synchronization requirements

WiMAX requirement IEEE 802.16

Channel Frequency Accuracy

The frequency accuracy of the base station shall be within **± 8x10^{-6}** of the selected RF carrier over an operating temperature range of -40 to +65°C, up to ten years from the date of equipment manufacture.

Frame Duration Codes (TDD)

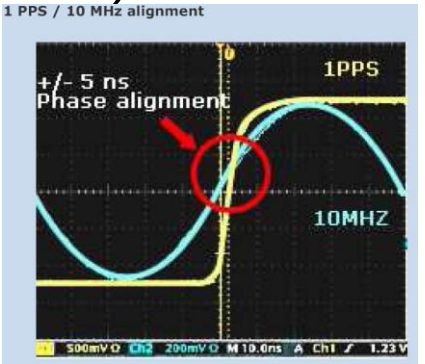
Both **RTG** and **TTG** shall be **no less than 5 µs** in duration.

RTG = Receiver Transition Gap TTG = Transmission Transition Gap

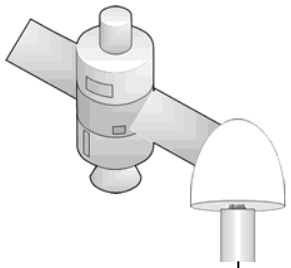
WiMAX Synchronization requirements

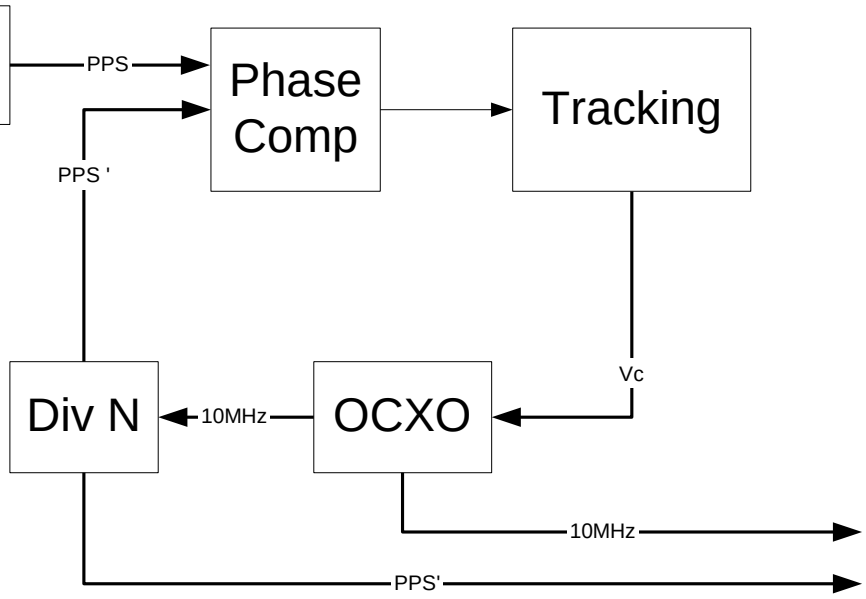
Constraints coming from the BS design and performance/cost level

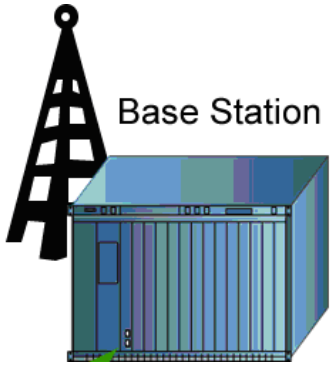
- 1PPS only or 1PPS + 10 MHz reference signals
- Several Frequency outputs (2..4) to feed directly Base Band Units
- Phase noise requirements 10 MHz reference (used to generate 3.5 GHz)
- Holdover 24 hours (High End BS for Metro area)
- Temperature profile (Outdoor BS versus Indoor Base Stations)
- Zero crossing 1PPS / 10 MHz when both are used
- Time Of Day



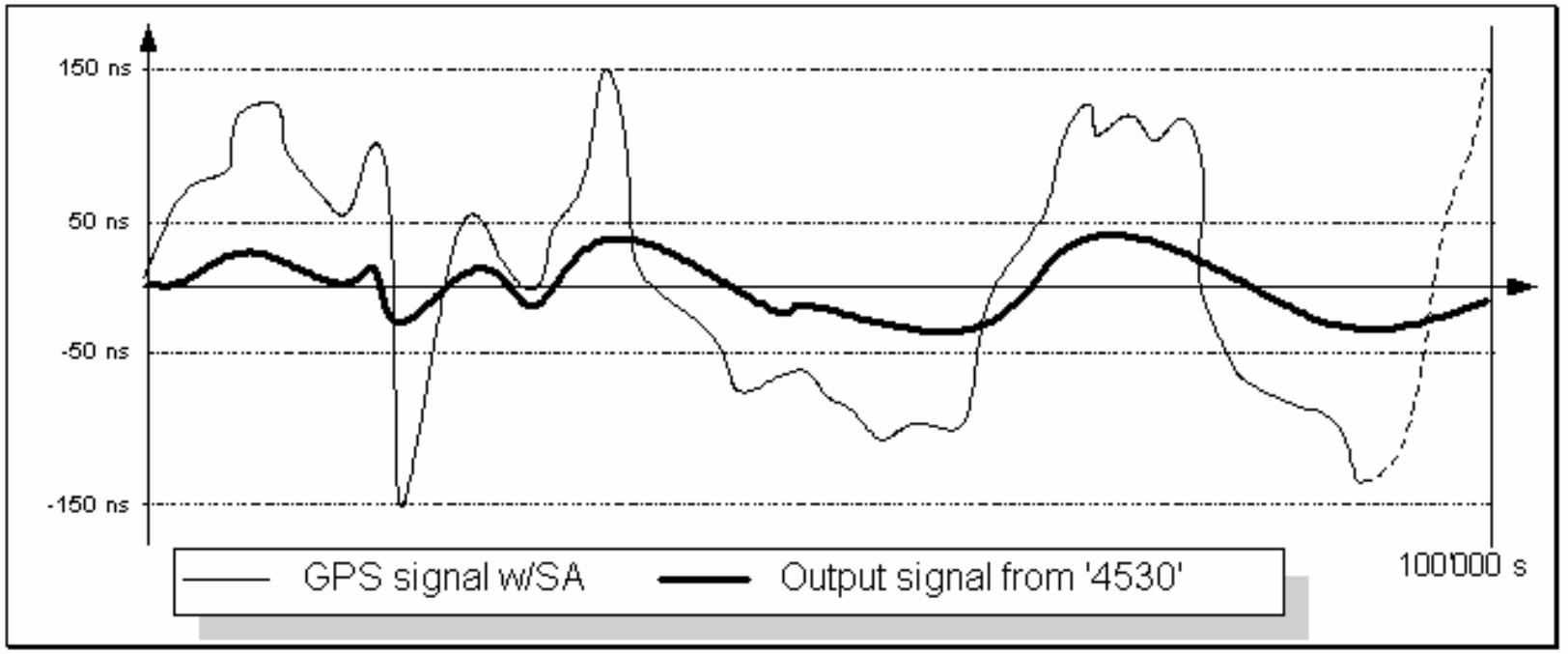
GPS Clock: Phase tracking loop







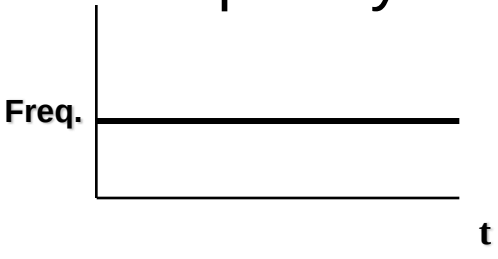
GPS Clock: Low Pass filter when Tracked to GPS

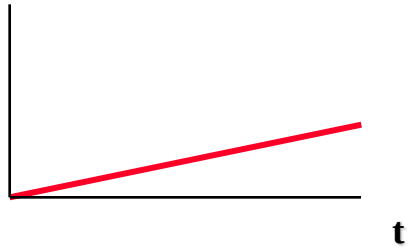


GPS Clock: Holdover

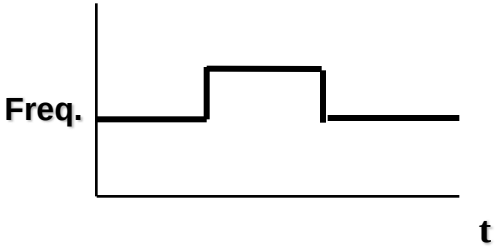
Phase deviation versus Frequency deviation

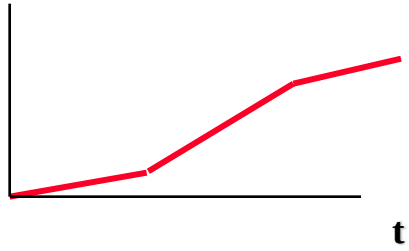
Frequency error



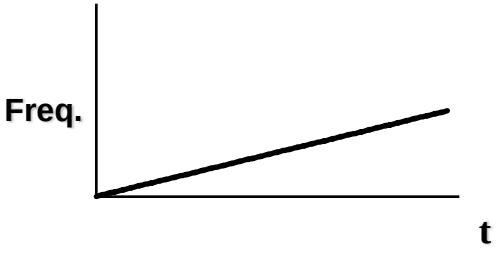


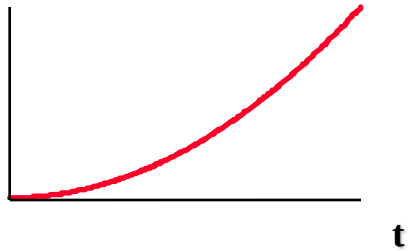
Frequency Noise





Frequency Deviation over time: Ageing and Thermal





Holdover (effect of aging and Temperature)

Holding **10 µsec (10^{-5})** phase deviation during 10'000 second requires **10^{-9}** frequency accuracy.

GPS Clock: Holdover

	dF/F vs T 0-70 °C	Ageing Per day	Phase lock time constant	Holdover @ 1 day D.T. 20°C
TCXO	1 ppm	5e-9	1s	20000 μs
DIL OCXO	5 e-8	1e-9	10s	2000 μs
SO OCXO	5 e-9	1e-10	200s	200 μs
DO OCXO	6 e-10	1 e-10	2000s	10 μs

Integration of GPS clocks

- Module level integration
  - Fast integration, external to the Base Station
  - Single frequency outputs

- Rack level integration
  - 19'' & ETSI
  - Multiple Frequency outputs Direct feed of Base Band Units
  - Immediate integration

- Board level integration
  - Minimal cost
  - Dedicated for larger scale networks reaching lowest costs
  - Single or multiple frequency outputs

WiMAX Synchronisation : Evolutions

- Toward ever lower cost **board level** integration
- **High sensitivity GPS** engines to lower installation costs
- **PTP Clocks** with strong filters for small / medium size IP networks (5 hops from P.t.P. server).
  - Oscillator with 5’000 sec constant loop to filter Wander
  - Holdover capability: mitigation of network congestion

- Thank you -

