A High Performance GPS Radio Occultation Instrument

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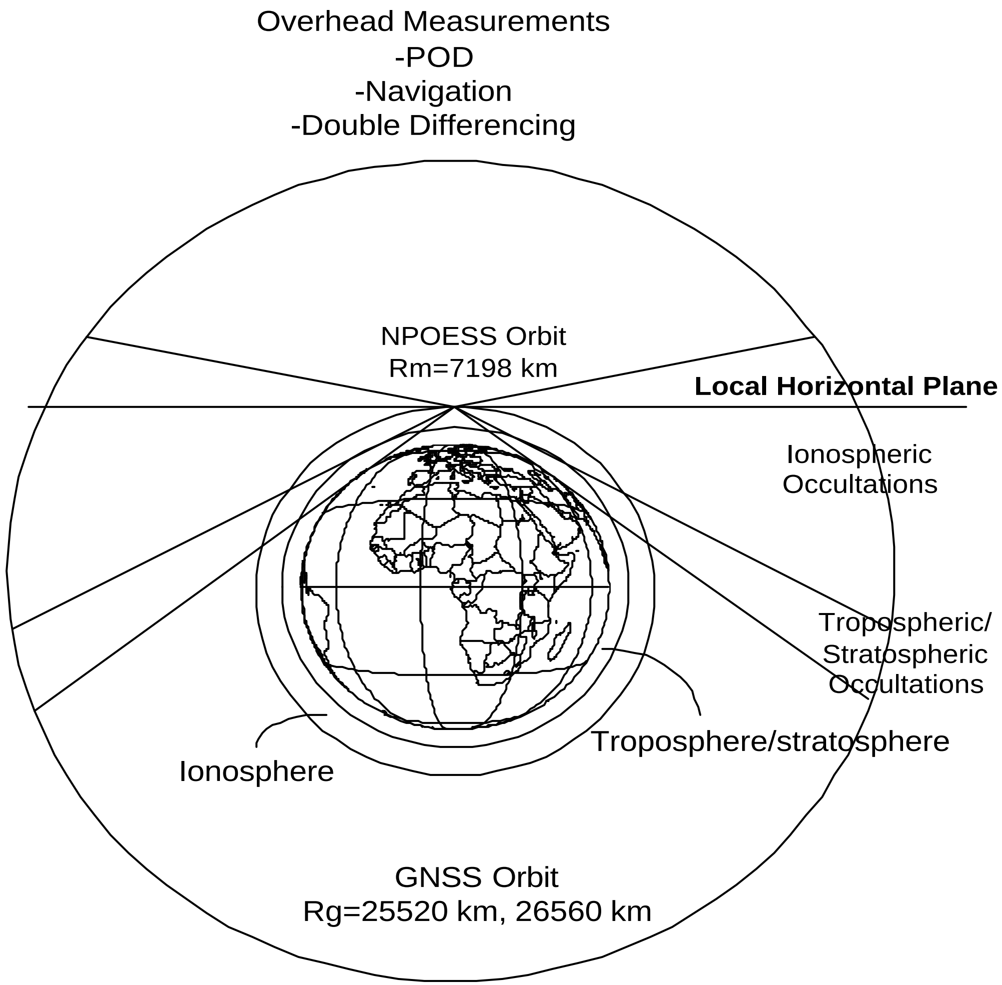
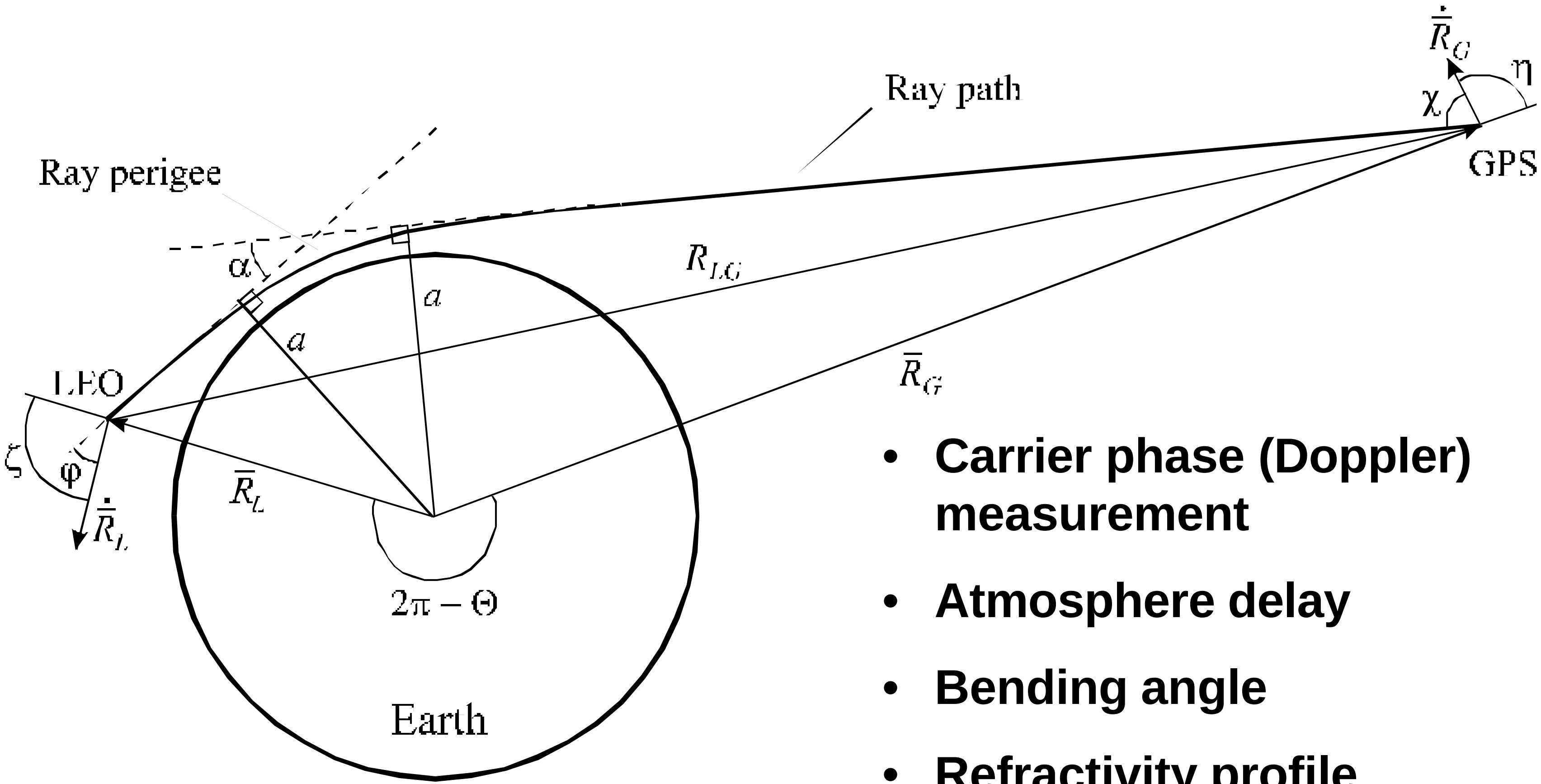
Radio Occultation

- Probing the atmosphere and ionosphere by measuring the L1 and L2 signals from raising and setting GPS S/C
- Determining the S/C position with high accuracy to extract the atmosphere/ionosphere impact
- Method developed by JPL and Stanford, for sounding of planetary atmospheres (Mariner, Pioneer and Voyager)



Occultation Geometry



- **Carrier phase (Doppler) measurement**
- **Atmosphere delay**
- **Bending angle**
- **Refractivity profile**
- **Temperature profile**

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PROGRAMMES

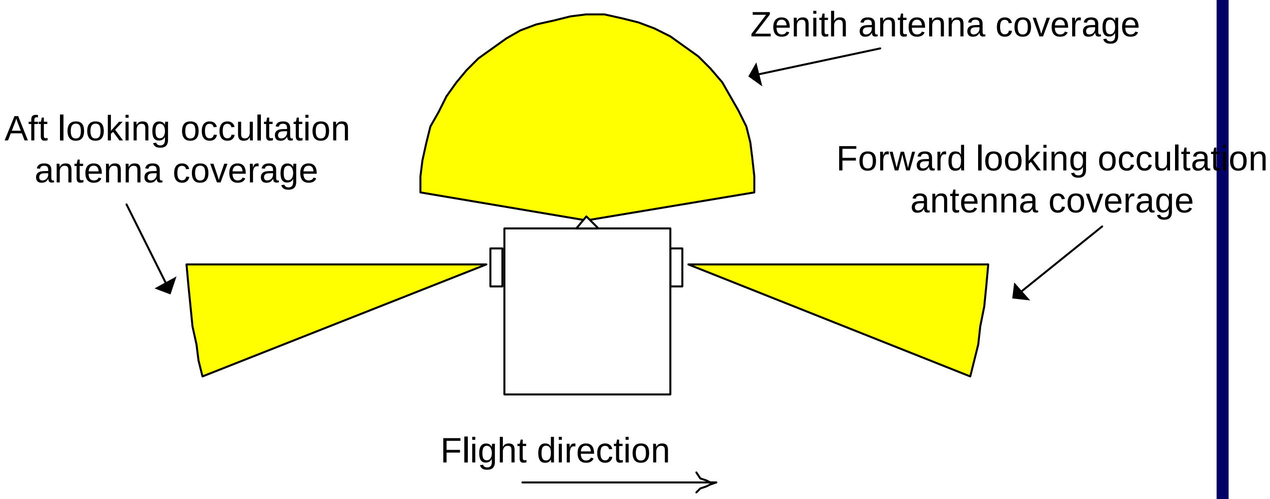
	EUROPE	US
Customer	EUMETSAT	IPO (NOAA, NASA, DOD)
Platform	METOP	NPOESS
1:st Launch	2003	2008
No of sat	3	5
Instrument	GRAS	GPSOS
Status	BB-Phase - 98	Risk Reduction Phase - 98
	C/D Phase running	EM Phase running
Service	Experiment	Operational

Occultation Instrument Objectives

- Deliver meteorological data to the scientific and meteorological communities
- Data: temperature, pressure and electron content vertical profiles of the atmosphere and ionosphere
- 500 - 1000 profiles per day and LEO S/C
- Measurements with very high accuracy and down to a few miles altitude
- Joint program between US and Europe

Instrument Accommodation

- Two occultation antennas
- Zenith antenna for navigation (Precise Orbit Determination)
- RF units placed close to antennas for best NF
- Can accommodate long IF cables to Electronics unit

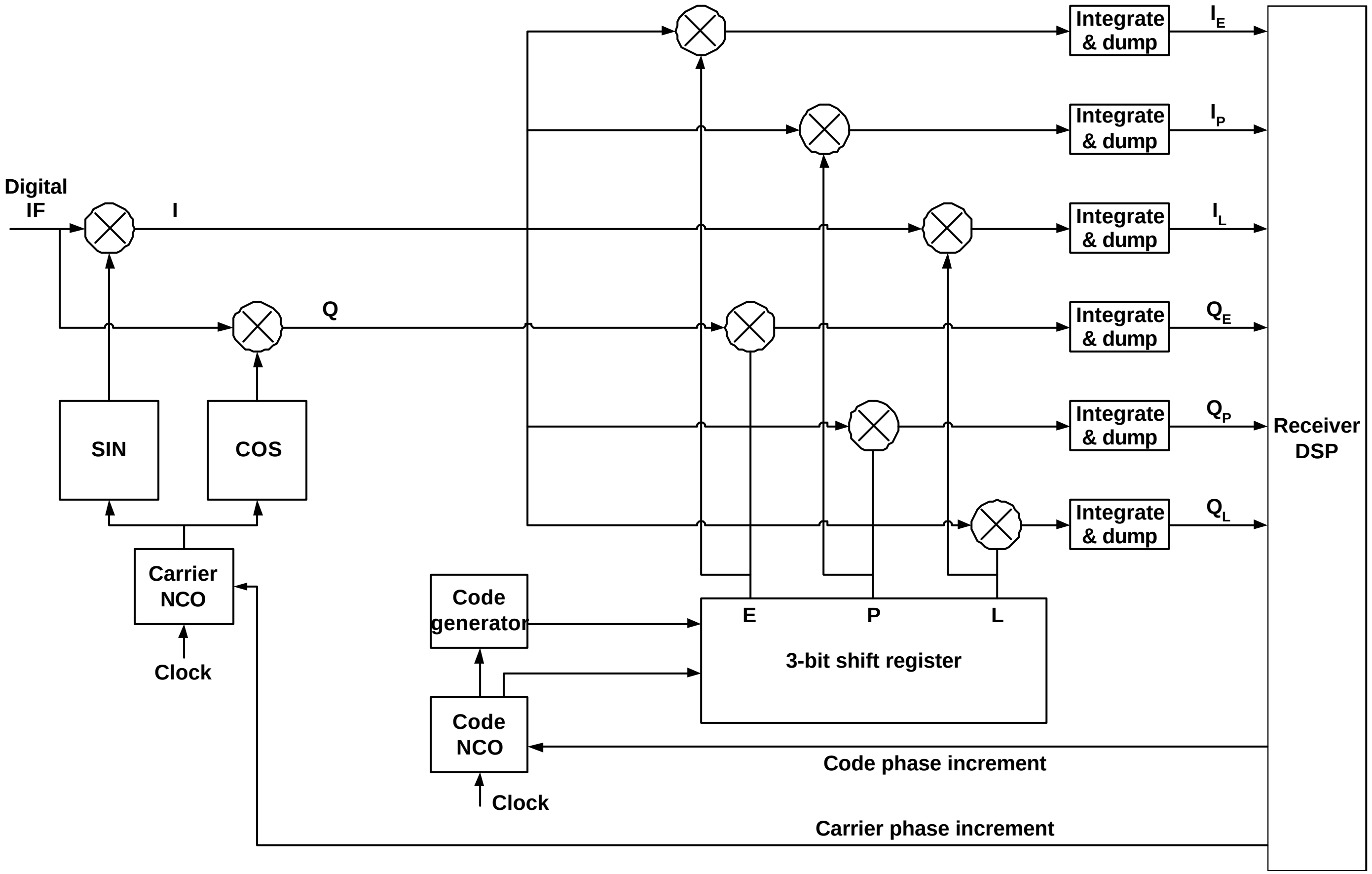


GPS System

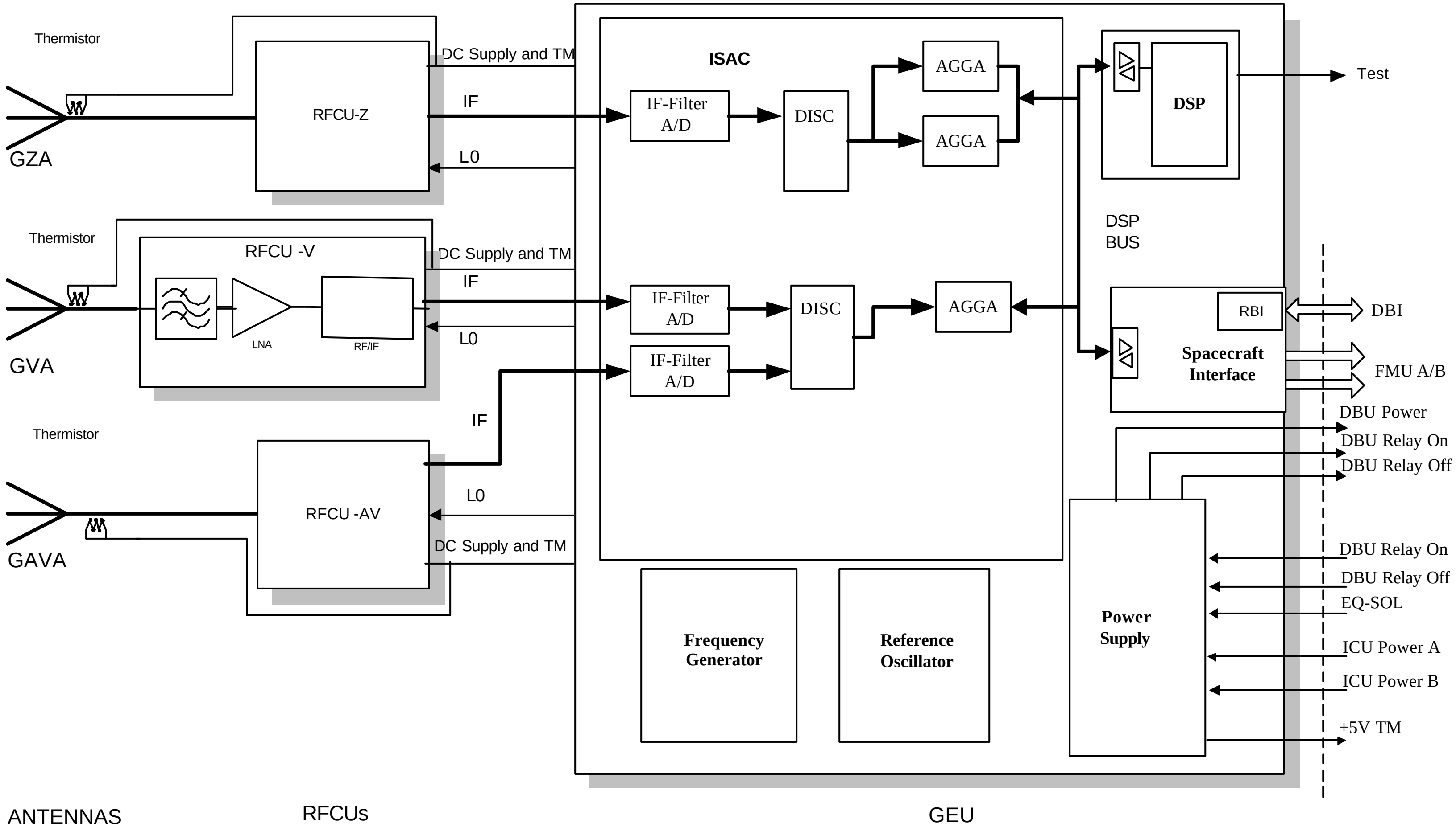
	Coarse Acquisition C/A-code	Precision P-code	
CDMA pseudorandom	1.023	10.23	Msps
BW	±10.23	±10.23	MHz
Frequencies	L1=1575.42	L1=1575.42 L2=1227.6	MHz MHz
Availability	Public	Encrypted (Y-code)	
Measurement	Atmosphere	Atmosphere Ionosphere	
End product	Bending angle	Environmental Data Records	

Generic GPS Digital Receiver

- Digital down conversion
- Correlation with Early, Punctual and Late code
- Integration (despreading)
- Locked to Numerically Controlled Oscillator



Instrument Functional Block Diagram



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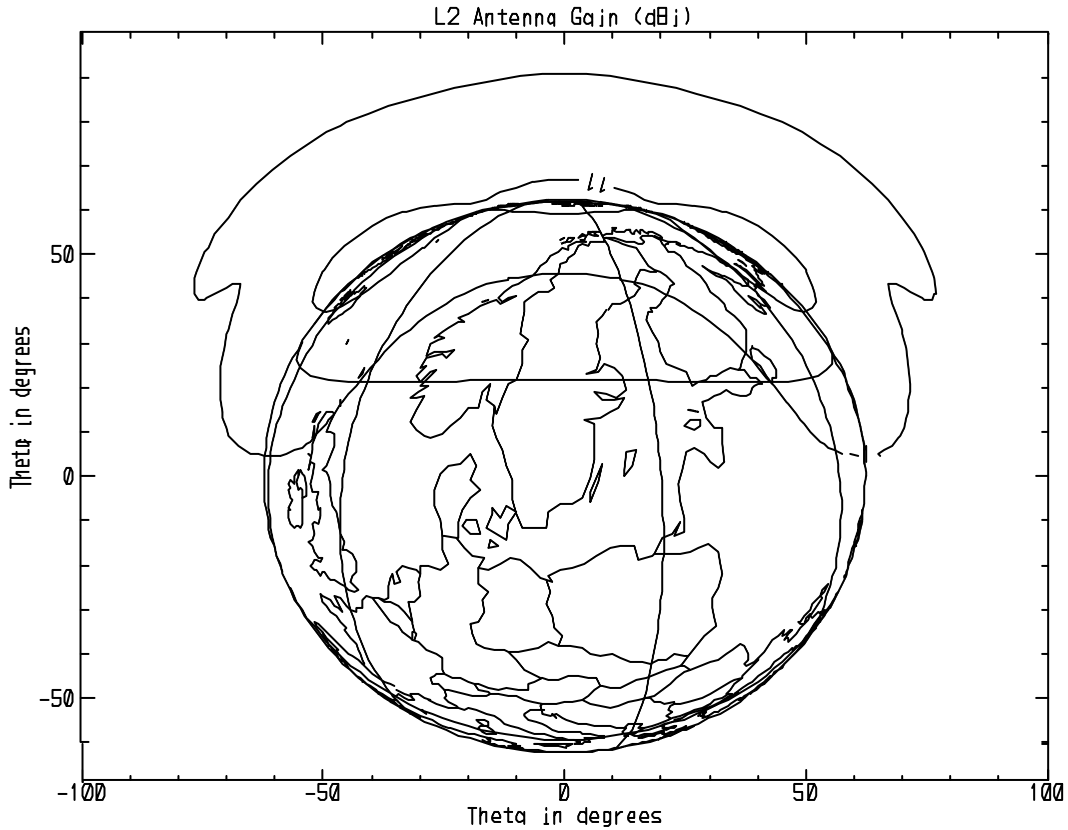
Occultation Antennas

- Dual frequency fixe beam array with resonant ring elements
- Individual feed networks in suspended QFRP microstrip
- Antenna pattern shaped to earth rim
- Coverage ±50° in azimuth (captures most of the GPS satellites)
- High antenna gain 11 dBi
- Suppressed interference and noise
- Low ohmic loss, low mass



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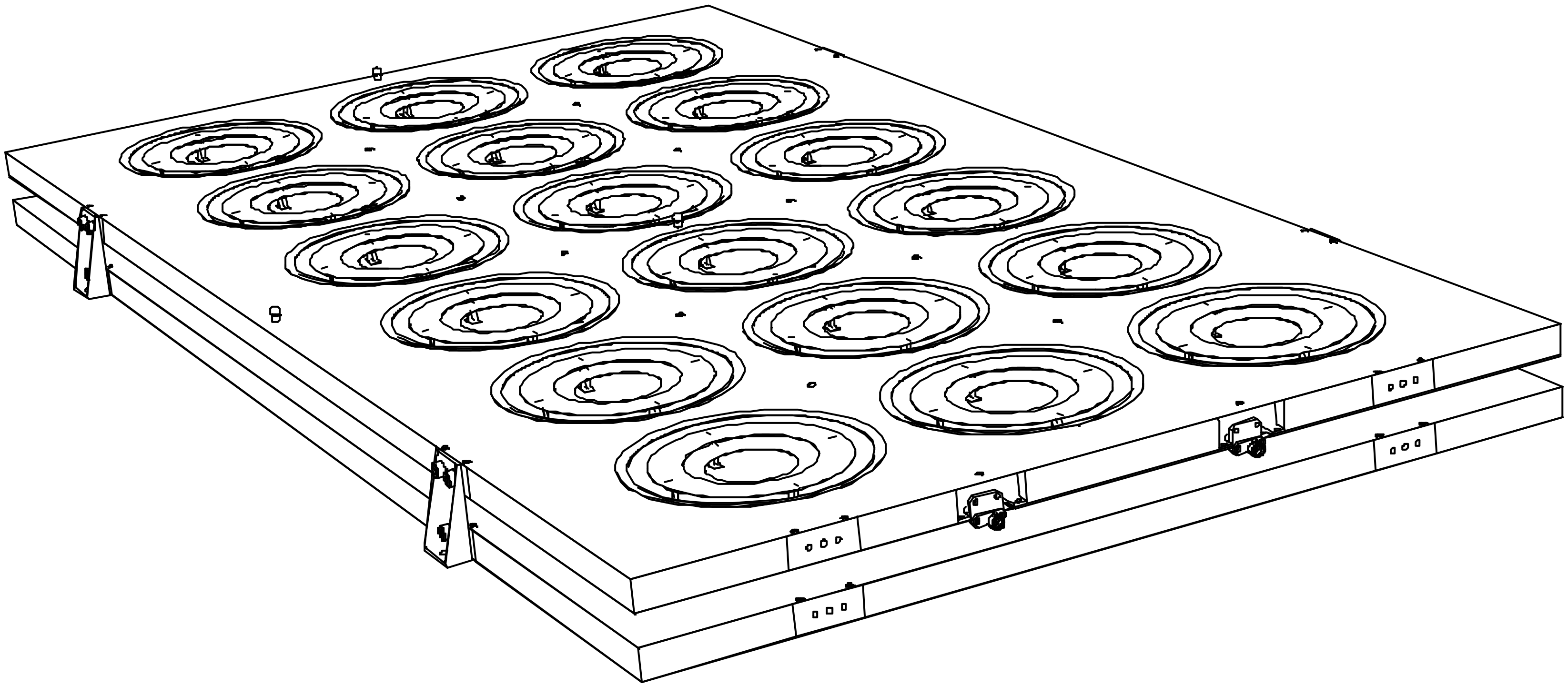
Occultation Antenna



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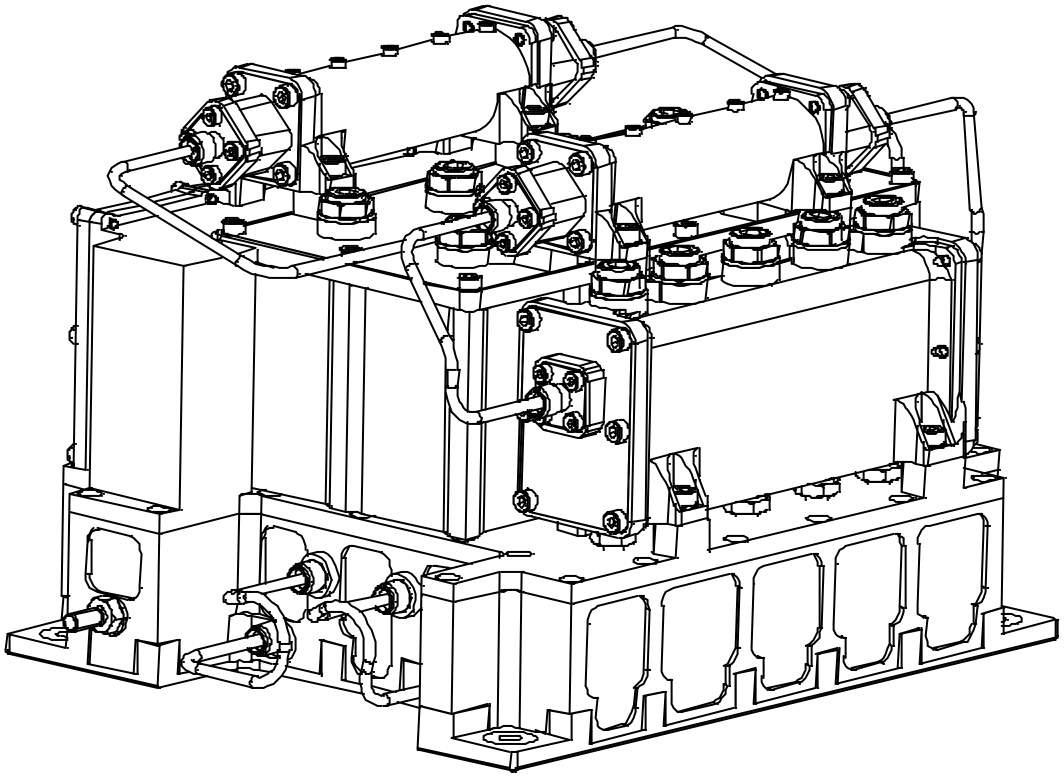
Radio Frequency Conditioner Unit

- Very highly selective RF and IF filters
- Single stage down conversion to IF
- Common LO frequency
- Recombination of L1/L2 at IF



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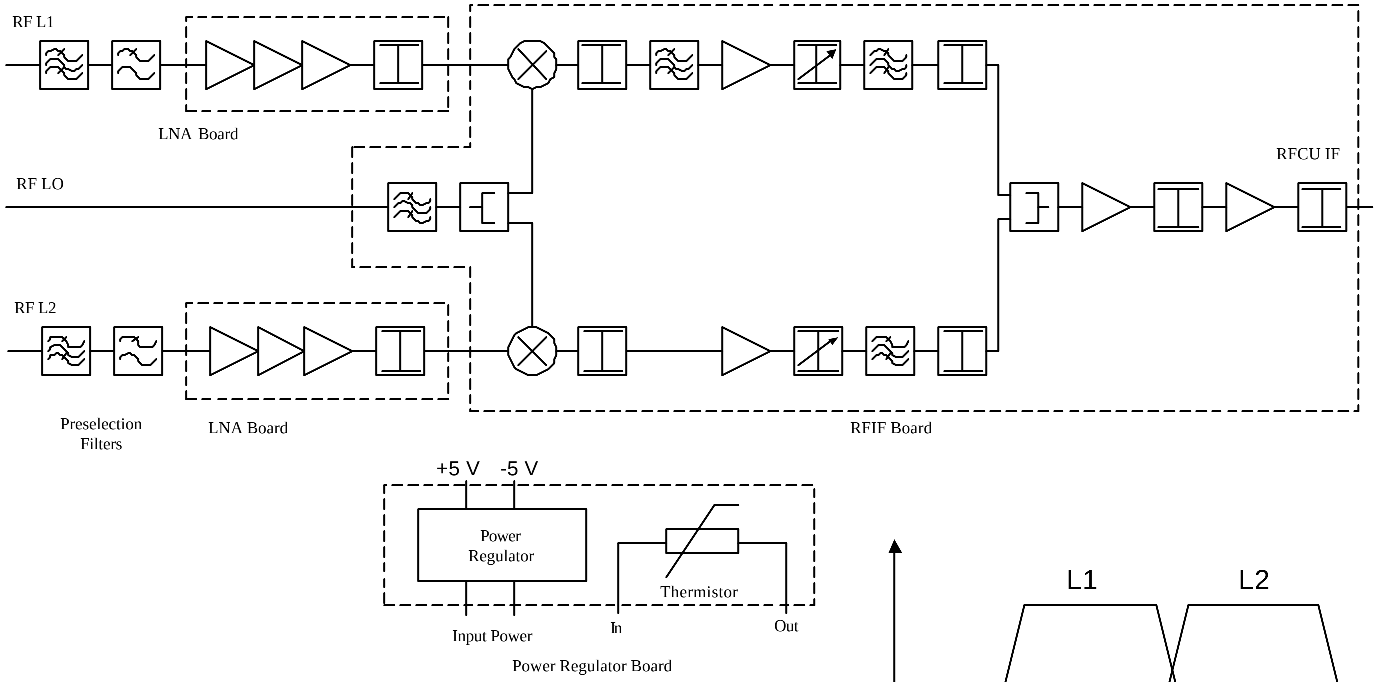
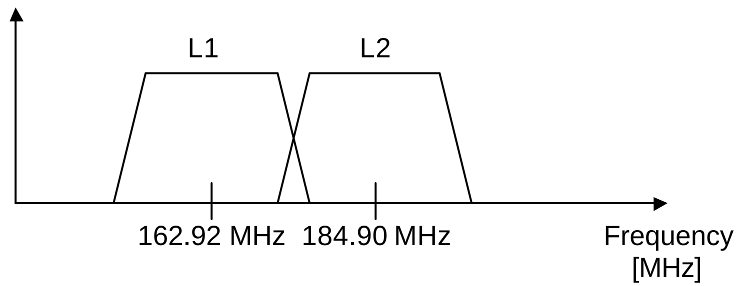
RFCU Functional Block Diagram

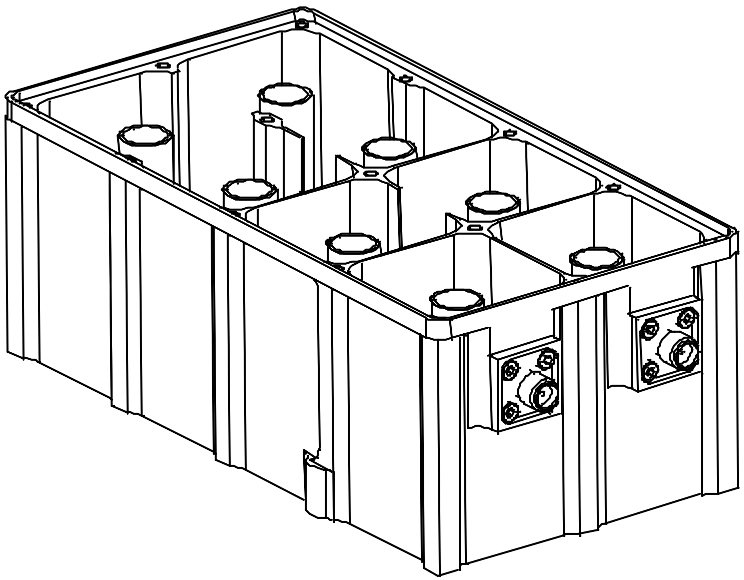




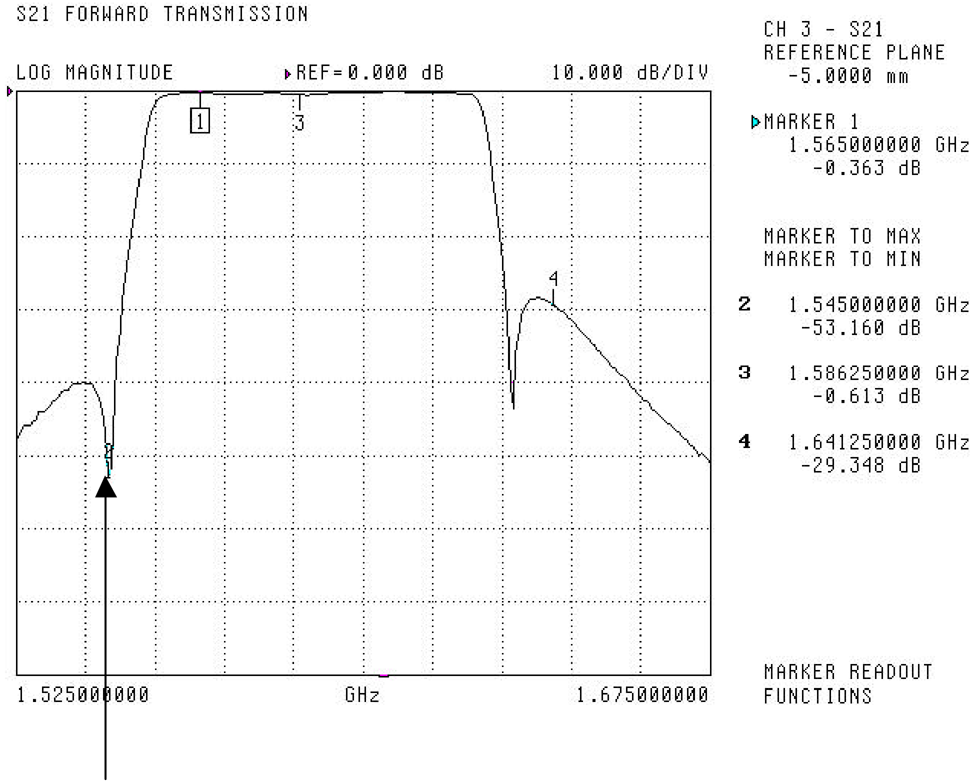
RFCU Key Features

- **Overall gain >85 dB**
- **Accommodates both GPS and GLONASS**
- **S&R transmitter located 20 MHz from L1 band edge - suppressed >95 dB**
- **LNA data:**
  - NF < 0.9 dB
  - RL > 20 dB
  - Gain > 38 dB

RFCU L1 Preselection Filter



8-pole coaxial cavity filter



S&R transmitter suppressed 53 dB

GRAS Electronic Unit

1 Power converter

2 S/C interface

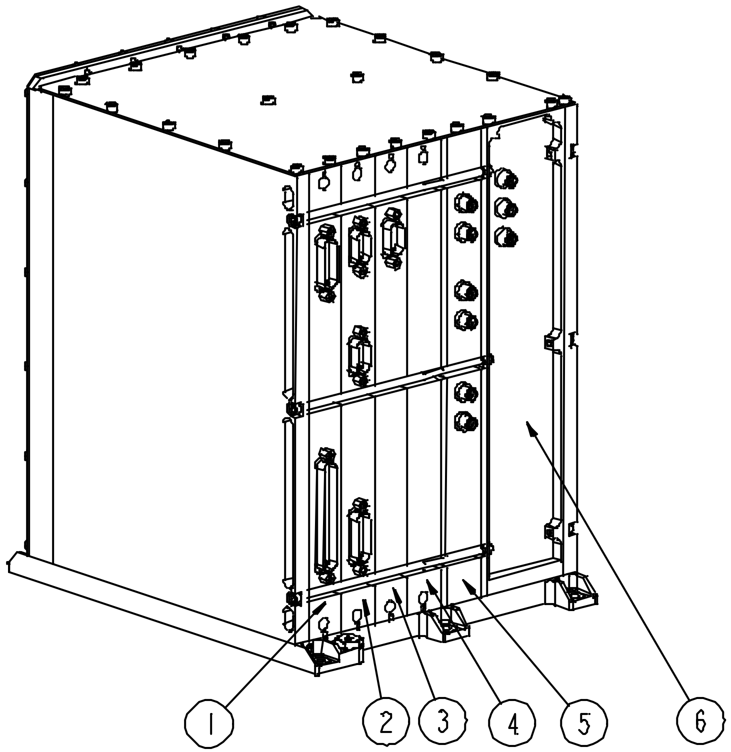
3 IF, Sampler and channel processor

4 DSP

5 Spare

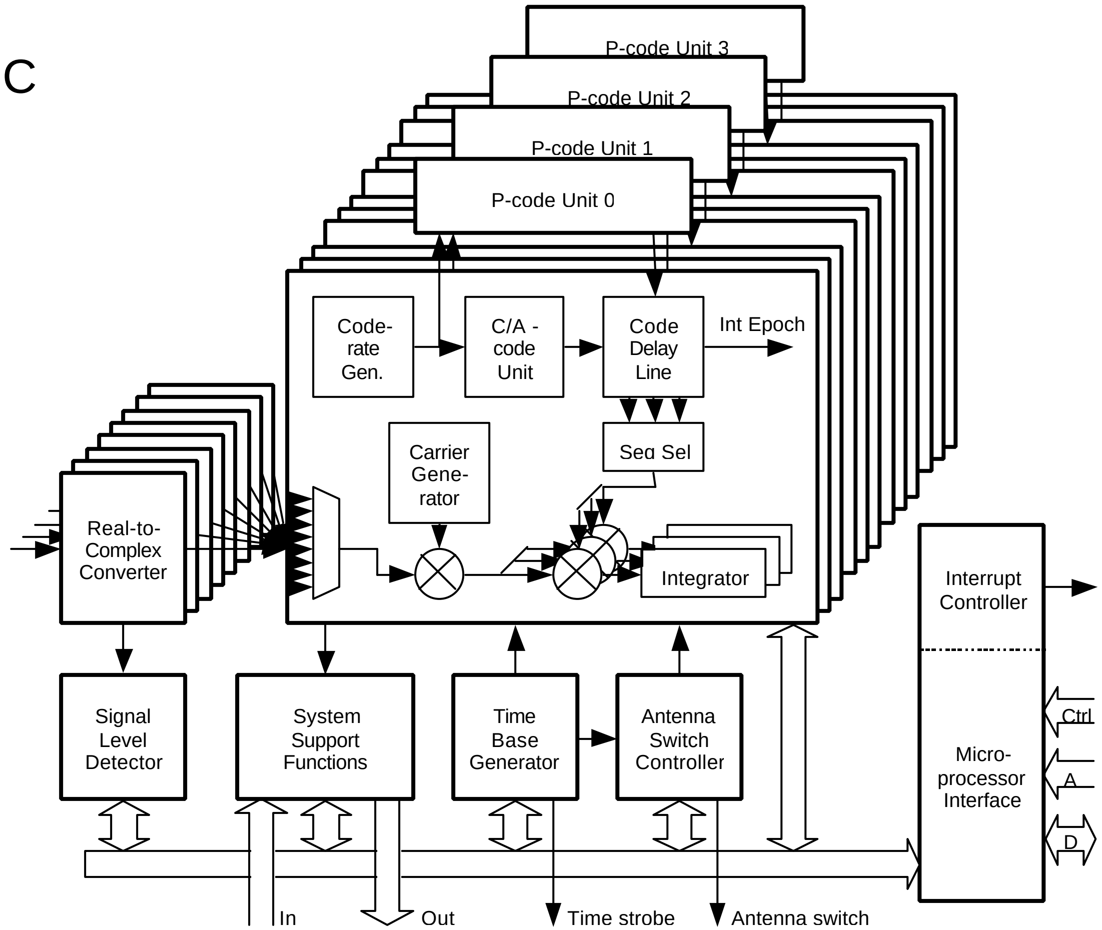
6 Frequency generator

not shown: USO (Ultra Stable Oscillator)



AGGA

- Advanced GPS GLONASS ASIC
- A custom designed ASIC for space applications developed under ESA contract
- Supports C/A, P and Y(semi) code tracking
- Twelve channels
- Application:
  - S/C control; Position, Velocity, Time and Attitude
  - Support to Precise Orbit Determination, POD
  - Atmospheric sounding
  - Reference stations



Instrument Summary

High S/N, low implementation losses	Þ	Measurements at low altitudes
Wide antenna coverage many channels	Þ	Covers a large no of occultation
Ultra stable oscillator	Þ	High measurement accuracy
RFC tolerant design Distributed front ends	Þ	Easy to accommodate
Modular design	Þ	Allows redundancy and expansion
GLONASS capability	Þ	Prepared for GNSS-2

Acknowledgements

- **IPO under which the GPSOS study has been conducted**
- **ESA under which the GRAS study has been conducted**

- **Reference:**
  - P Sinander, P Silvestrin, Development of an Advanced GPS GLONASS ASIC, ESTEC, ESA