Advanced GPS/GLONASS ASIC (AGGA2)

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M a r t i n H o l l r e i s e r

Head of Microelectronics Section
Tel. +31-71-565-4284
Fax. +31-71-565-4295
Martin.Hollreiser@esa.int

Overview

- *History of the AGGA Development*
- *Related Activities*
- *AGGA Functionality*
- *Applications*
- *Current Developments Based on AGGA*
- *Conclusions*

History of the AGGA Development

- 93 - 95: GPS/GLONASS receiver bread-boarded, eight dual-frequency channels, with 20 FPGAs (50W) by the Institute of Navigation (ISN), University of Leeds (UK) (EOPP)
- 94 - 96: IMEC to study miniaturisation the digital part of above receiver by means of microelectronics (EOPP WO)
- 96 - 98: Redesign of ISN Receiver with functional enhancements into a highly integrated ASIC by IMEC (B), with support from ISN and ESA (jointly EOPP / TOS-ESM (ARTES 5)
  - → ***First iteration AGGA0 samples (commercial technology) Q4 1997***
- Full Validation by Austrian Aerospace and ESA Q1 1998 (EOPP)
- 98 - mid 99: Complete redesign of a flight worthy AGGA-2 (2nd generation) ESTEC internally by TOS-ESM, jointly funded by EOPP, METOP and TOS-ES.
  - → ***Second iteration AGGA2 samples Q4 1998***
- Full Validation by Austrian Aerospace and ESA Q1 1999 (EOPP)
- Q1/Q2 2000: P-Code Bug Fix in AGGA-2 by Saab-Ericsson Space, jointly funded by EOPP and METOP.
  - → ***Third iteration AGGA2a samples Q3 2000***
- Full Validation by Austrian Aerospace and ESA Q4 2000 (EOPP)

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History of the AGGA Development

- ***Companies contributing to functional specification of AGGA2***
  - → Austrian Aerospace (A)
  - → ASTRIUM (D)
  - → ASTRIUM (F)
  - → Laben (I)
  - → Saab-Ericsson Space (S)

esa ESTEC CONTROL and DATA DIVISION [TOS-ES]
M. Hollreiser TOS - ESM

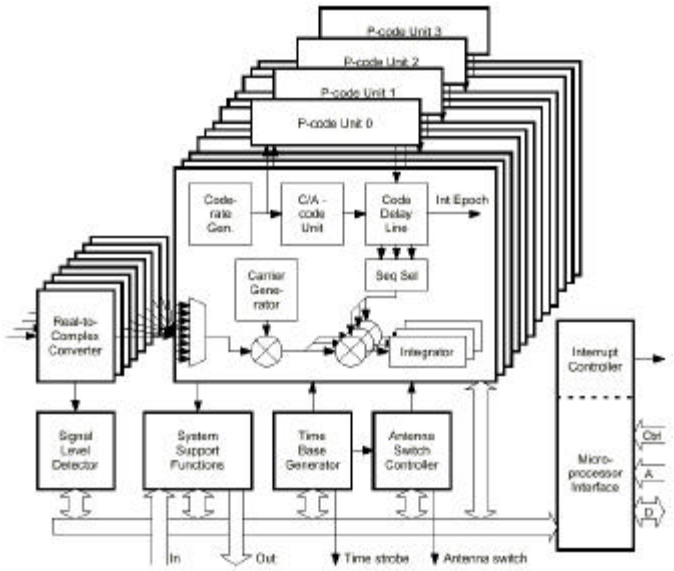
Related Activities

- "AGGA Modelling and Simulation", to model the AGGA in C and validate functionality (acquisition, tracking, etc.) by simulation. (EOPP) (Austrian Aerospace)
- "AGGA Validation", to validate AGGA0, AGGA2 and AGGA2a (EOPP) (Austrian Aerospace)
- "GPS/GLONASS ASSP Evaluation", to evaluate the AGGA for Spacecraft Control (incl. Attitude determination) (TRP) (ASTRIUM D/F)
- "GPS/GLONASS Receiver Technology" based on AGGA0, a highly integrated frontend and a DSP, a ground receiver is being developed (ARTES 5) (IMEC)
- "Integrated Front-End for GNSS Sensors" fully monolythic integrated FrontEnd based on CMOS technology (EOPP) (Saab_Ericsson/VLSI Solutions)
- GreFe, GReCo development (ARTES 4) (Septentrio)
- Future, AGGA3, fully integrated receiver to further reduce cost and size (EOPP)

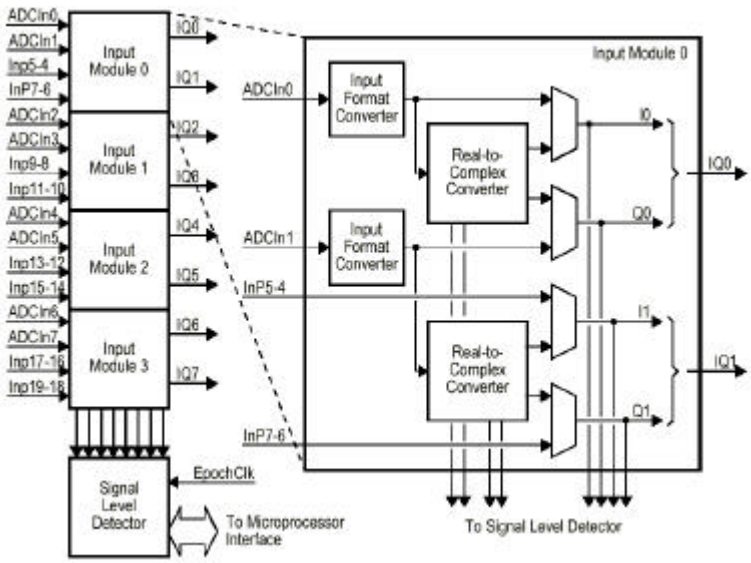
AGGA Functionality

- 12 single frequency channels (36 complex correlators) each capable of tracking any GNSS C/A code signals
- 4 P code units for dual-frequency operation and codeless tracking
- supports IF sampling (fs/4), R2C conversion, final down-conversion,
- highly configurable and programmable, e.g.
  - → *pairs of single frequency channels configured for attitude determination (Hybrid Parallel Multiplex Architecture)*
  - → *slaving of three single frequency channels together with P-Code Unit into one dual frequency channel capable of tracking GNSS C/A Code on L1 and P-Code on L1 and L2 (using semi-codeless tracking techniques)*
  - → *slaving of up to nine channels for fast acquisition*
  - → *slaving for multi-path mitigation (also supports time-multiplexed multi-path mitigation)*
- either eight real inputs or four complex inputs, each 2 bits, different input formats supported
- Signal level detector, Clock and Time-base generator and Antenna switch controller
- 32-bit microprocessor interface with interrupt controller and basic IO port
- Features for multipath mitigation and adaptive semi-codeless tracking of GPS Y- Code
- System Support: parallel I/O (monitoring & redundancy), Clk Output, Reset handling,

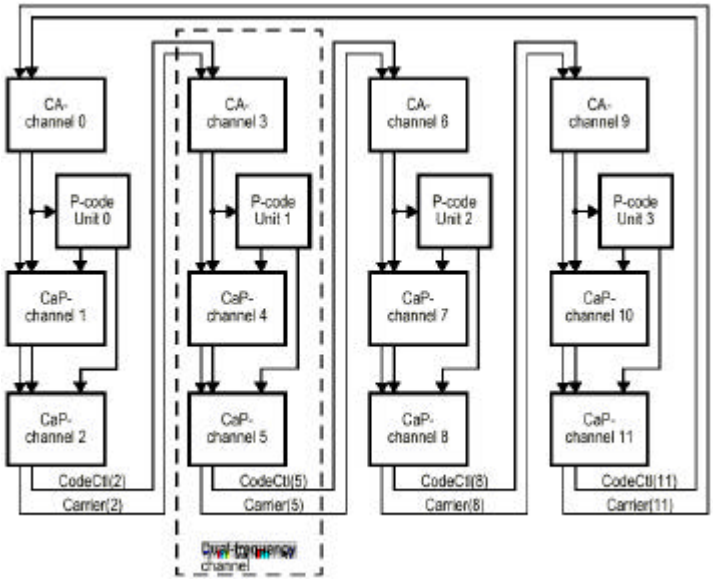
AGGA Block Diagram



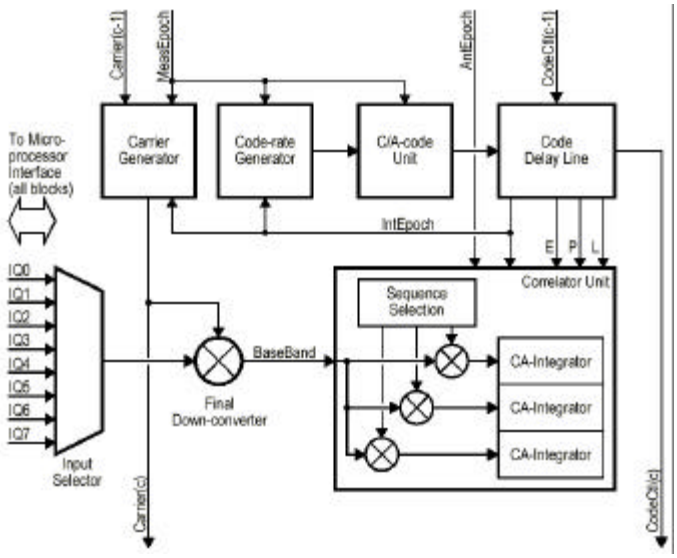
Front End Interface



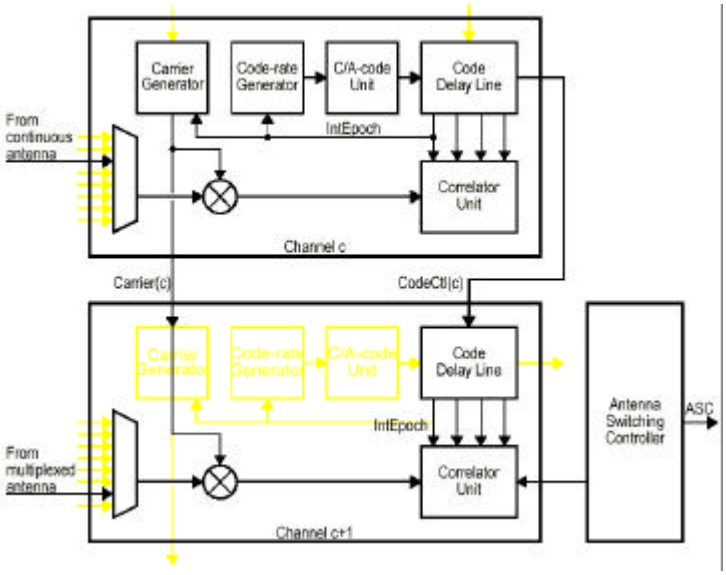
Channel Matrix with Slaving Connections



CA-Channel

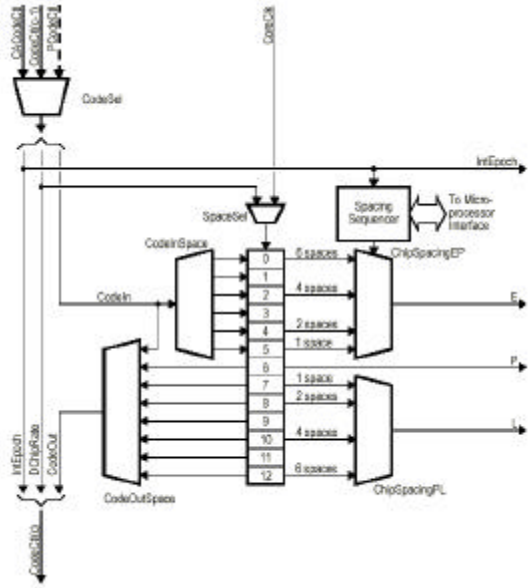


Two Channels Slaved

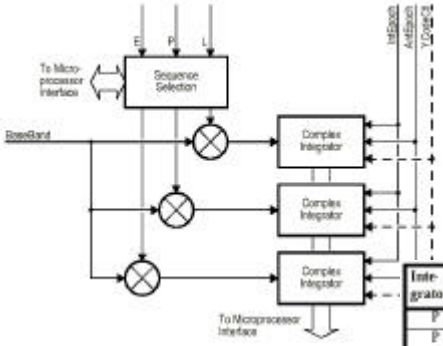


- for Hybrid Parallel Multiplex Attitude Determination
- Can mix slaving: e.g. 3 dual-frequency channels + 2 (single-fq) channels + 1 (single-fq) channel with 3 channels slaved for fast acquisition in one AGGA

Code Delay Line

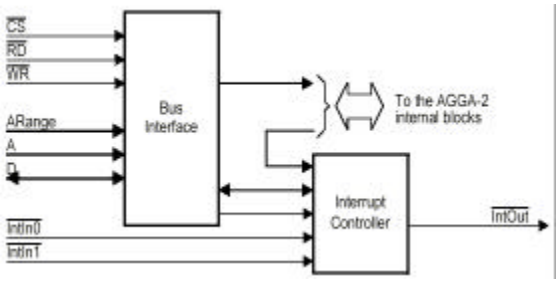


Correlator Unit



Integrator 0	Integrator 1	Integrator 2	Description
P	E-L	Off	For tracking when separate E or L correlation values are not needed
P	E	L	For fast acquisition, for measuring the absolute E, P and L correlation values for multipath identification, and for tracking with separate E and L correlation values
P	E-L	E	For tracking with multipath identification, providing a separate E correlation value
P	E-L	L	For tracking with multipath identification, providing a separate L correlation value
P	P	Off	For Hybrid Parallel-Multiplex attitude determination for the slaved channel, only using the P sequence with special updating
P	Off	Off	For Parallel attitude determination for the slaved channel, only using the P sequence
E	Off	Off	For calibration, with no despreading and only one integrator being used
Off	Off	Off	To save power when channel is not used

Microprocessor Interface



- ***generic, memory mapped***
  - → 10b address (A), 32 data (D), chip select ($\overline{CS}$), read ($\overline{RD}$), write ($\overline{WR}$)
- ***directly compatible with:***
  - → ERC32 SPARC chip-set, ERC32SC/TSC695E, *TSC21020*
- ***two Interupt inputs allow multiple AGGAs in tree configuration***

- ***Interrupt Controller (six types of interrupt)***
  - → Integration Epoch Interrupts (one per channel)
  - → Measurement Epoch Interrupts (one)
  - → Antenna Switch Epoch Interrupt (one)
  - → Pulse-Per_second Interrupt (one)
  - → Signal Level Detector Interrupt (one)
  - → Daisy Chain Interrupts frpom other AGGAs or external devices (two)
- ***18 interrupt sources, all equal priority***

Technology

- *ATMEL MG2-RT sea of gates using MG2-265 matrix*
- *200 kgates*
- *160-pin MQFPL package with 25 mil pitch*
- *Directly compatible with ERC-32 and TSC21020*
- *CoreClk 30MHz (ClkIn 60MHz)*
- *Power Supply: 2.7 V - 5.5 V, Core supply can be reduced*
- *Temperature Range -55 - 125 ºC*
- *Power consumption at room temperature:*

		3.3V	5V
after reset	**3 MHz**	**90mW**	**220mW**
after reset	**30 MHz**	**900mW**	**2200mW**
GPS/GLONASS full operation, 4 dual frequ. Ch.	**30 MHz**	**1200mW**	**3000mW**

Applications supported by the AGGA

- ***Spacecraft Control*** (on-board determination of the spacecraft position, attitude and time in real-time)
- ***Precise Orbit Determination*** (on-board receiver, L1, L2 carrier phase, in combination with reference stations on ground and with post-processing on ground (cm accuracy))
- ***Atmospheric Sounding*** (limb sounding technique, on-board receiver with post-processing on the ground, to determine temperature and humidity profile up to 50 km, based on variations in refraction)
- ***Reference Stations*** (ground-based receiver with real-time processing, to compensate for intentional and non-intentional errors)
- ***Standard Precision Positioning*** **-** low cost
- in general high performance receivers supporting ***GPS, GLONASS, EGNOS (Europe), WAAS (US), MTSAT (Japan)***

Current Developments Based on AGGA

- ***Saab Ericsson Space / Austrian Aerospace***
  - → GRAS (GNSS Receiver for Atmospheric Sounding) on METOP
  - → GPSOS (GPS Occultation Sensor) for DoD/NOAA/NASA
- ***LABEN***
  - → EGNOS RIMS Receiver
  - → LAGRANGE (Precise Orbit Determination)
- ***ASTRIUM***
  - → MOSAIC GNSS Receiver
- ***IMEC***
  - → development of a fully integrated FrontEnd
  - → combine the RF-FE together with AGGA and a DSP for a complete ground based Receiver
- ***Septentrio***
  - → offer products based on the AGGA (GReCo®1A01)

Conclusions

- ***AGGA2 successfully developed and validated***
- ***a number of receivers have been developed and tested based on AGGA2***

  (Saab Ericsson Space, Astrium, Austrian Aerospace, Laben, IMEC, Septentrio)
- ***Several Instruments for several Missions are based on AGGA2 GRAS on METOP (ESA), GPSOS on NPOESS (DoD)***
- ***Complete Data Sheet and relevant publications are available***
- ***Device is available through ATMEL Wireless & Microcontrollers***