ABBA
ADC Backend for Bolometer Arrays

Documentation

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Contents

1 Introduction 3

2 Hardware Description 3

3 Operation Modes 4

4 Remote Control 5

5 Error Conditions / Messages 7

6 UDP Messaging 7

7 ABBA Raw Data Format 7

8 Time Syncronization 9

9 IRAM 30m Control Software for ABBA 9

10 Online FITS Merger 10

11 ABBA Operation Instructions 10

11.1 Starting the ABBA PC 10
11.2 Restarting the ABBA process 10
11.3 Shutting down the ABBA PC 11

12 Appendix 12

12.1 Hardware list 12
12.2 Connections at the signal distribution box 13
12.3 Connections at the 19 inch PC 13
12.4 Software list 13

1 Introduction

For many years, the digitization of the MPIfR bolometer signals was done with backends based on voltage to frequency converters (VFC) and counters. With increasing numbers of bolometer pixels this technique reached its limits because multiplexing is not possible. This leads to rather large systems with thermal problems due to power dissipation. Furthermore, new observing techniques like "fastscanning" require higher sampling rates which would decrease the dynamic range of a VFC based backend.
Modern 16 bit AD converters combined with multiplexers are available now on PCI-bus cards with up to 64 input channels and show excellent noise performance. The bolometer development group has therefore built a new continuum backend called ABBA (ADC Backend for Bolometer Arrays) which provides currently 128 input channels to accommodate the new generation of bolometer cameras like the 117 channel version MAMBO-2. ABBA is based on a standard PC technology with plug-in PCI-bus ADC cards. The stream-to-disk concept of the software allows sampling rates up to more than 1 KHz. Instant averaging is used in the conventional 2 Hz wobbler observation modes to achieve an effective dynamic range of 21 bit. This backend was integrated into the IRAM 30 m control system and acquires the data of MAMBO-1, MAMBO-2 and HUMBA since June 2001. Observations of the faintest mm sources ever detected were made during the 2001/2002 winter bolometer session and have confirmed the capability of ABBA as a backend for high sensitive bolometer arrays. A second version of ABBA is used in the MPIfR laboratory in Bonn for test purposes and was temporarly installed at the HHT during the POLKA observing run (Jan. 2002) to acquire polarimetry data.

2 Hardware Description

The current version of ABBA is a PC in a 19 inch industrial case with two National Instruments PCI 6033 E [2] cards. Each card has 64 analog input channels plus several digital and trigger inputs. The two (or more) cards are syncronized by using the RTSI bus feature of the PCI 6033 E. Furthermore, the backend has a PCI time sync card with IRIG-B input (Brandywine SyncClock32PCI [4]) and a signal distribution box with 120 active anti-aliasing filters (Walter Esch, MPIfR). At the IRAM 30 m telescope, ABBA is located in the receiver cabin, close to the bolometer array. Control and data transmission is done via ethernet using the TCP/IP protocol. National Instruments provides a professional software development system named LabVIEW [3], in which the control of National Instruments hardware is fully integrated. The current version of the ABBA control software is a compiled LabVIEW program developed by the author and is running under Windows NT 4.0 (sp6).

3 Operation Modes

ABBA can handle three different main observing modes.

- **Wobbler mode:**

  For focus, pointing, chopped skydip, on-off, and maps with wobbler.

  In this mode, there is one time stamp and one integer number per channel for each wobbler phase. It is an externally triggered acquisition and uses the blank signal at the PFI0 line to start sampling into a buffer. The sync signal is fed into the DIO0 line of the PCI 6033 E to determine the wobbler status. The size of the acquisition buffer is determined by the sampling rate (default 180 Hz) and the integration time (wobbler phase minus blank time). When this buffer is full, the data for each channel are averaged to one number per channel. To avoid non-integer numbers, a factor of 100 was introduced, and the result is a 4 byte integer number per channel. Due to this oversampling, the dynamic range is increased. With the default settings, an effective range of about 21 bit is achieved.

- **Total power skydip mode:**

  For skydips in the total power mode (with 300 K hot load paddle).

  This mode writes a data format similar to the wobbler mode. ABBA repeatedly integrates for a given phase duration without an external trigger. This mode can be used to simulate wobbler observations without an external wobbler sync signal. For example for system noise measurements with an absorber in front of the bolometer window.

- **Fastscanning mode:**

  For maps without using the wobbler.

  In this mode, there are no wobbler phases! There is only one time stamp at the beginning of the subscan-file (see below) and then one number per channel every 8 milliseconds (in case of 125 Hz sample frequency).

  This mode can be used to acquire the bolometer signals with a high sampling rate ("fast sampling") in any observational mode. For example in On Off measurements with wobbler where the observer wants to measure the true signal shape during a wobbler phase in order to get a better information about sky noise. For this reason ABBA channel 121 is always connected to the wobbler position signal from the encoders.

4 Remote Control

The ABBA control program contains a TCP/IP server that listens on port 2055 for a connection of a client (=BEORGA on the Vax). At the IRAM 30 m telescope, the address of ABBA TCP/IP server is mrt-abba.iram.es. To start or stop a measurement (=subscan) the client needs to send a string of 30 characters to the above port of this address.

Examples:

"wb_s250_b27_c001_g020_1234_005" for wobbler mode

"tp_s500_b00_c020_g020_1234_005" for skydip or total power mode

"fs_f125_b00_c120_g020_1234_005" for fastscanning mode

The substrings between "_" are:

s250	-wobbler period in msec (format: "s%3.3d")
b27	-blanking time in msec (format: "%b2.2d")
f125	-sample rate in Hz (format: "f%3.3d")
c120	-number of channels (possible values: 1-128) (format: "c%3.3d")
g020	-linear gain factor (possible values: 1,2,5,10,20,50,100) (format: "g%3.3d)
1234	-scan number (format: "%4.4d")
005	-subscan number (format: "%3.3d")

The ABBA-PC will send back a confirmation that the measurement has been started

"1234_005 started"

and will begin dumping the acquired bolometer data to a file on its own hard drive (ftp directory "/ard", "D:{}ard" under windows). The file contains the date, scan number, and subscan number. In the above example it would be: 20020924d1234s005.ard (extension: ard = Abba Raw Data). ABBA continues to fill this file with data until it receives the string

"stop!"

on this socket connection. The ABBA program confirms by sending the string:

"1234_005 finished"

The subscan file is closed. From now on this file can be accessed at any time via ftp. In addition, AFTER having finished a subscan, ABBA sends the data of the selected bolometer channel (normally channel #1) via the above socket connection back to the client (currently the VAX) for the observer's display (pointing & focus corrections, skydips, etc.). The data format for the center channel data is ASCII/hexadecimal:

Wobbling mode:

ASCII time stamp (13 Characters), 4 hex digits (1. phase)
ASCII time stamp (13 Characters), 4 hex digits (2. phase)
ASCII time stamp (13 Characters), 4 hex digits (3. phase)
...
ASCII time stamp (13 Characters), 4 hex digits (n. phase)
;
The data sent to the client is blocked in pieces of 1700 bytes. The final character indicating the end of data transmission is a ";".
NB: There are no <CR> or <LF> characters between the lines. They were only added here for easier reading.

Example:

12:20:59.123400FF12:20:59.27340031 ... 12:20:59.52340044;

Fastscanning mode:

ASCII time stamp (13 Characters), space (char(32)), 4 hex digits per dump

Example: 12:20:59.1234 00FF00EF00FF0011005500A1 ...
NB: This feedback is currently (October 2002) not activated because the online display cannot yet reduce fastscanning data.

The time stamps are given for the beginning of an integration period for wobbler mode and for the beginning of the integration period for fastscanning mode.

5 Error Conditions / Messages

Besides the confirmation messages above, ABBA replies: "unknown command" if a bad string was received. If ABBA doesn't reply at all to either the "stop!" or any of the setup messages, even after several seconds, the process on the ABBA PC has to be restarted (see section "Restarting the ABBA process").

6 UDP Messaging

In order to get informations about the status of the bolometer and about sky conditions even when ABBA is idle (no measurement started), ABBA sends an UDP message every 3 seconds and between each subscan to the UDP broadcast server at the 30 m telescope. This message contains the timestamp and the signals of one DC and one AC channel of the bolometer array.

7 ABBA Raw Data Format

The ABBA files have an ASCII header followed by the data in binary format.

Example of wobbling mode ABBA raw data file:

ABBA_DATA_FILE
ABBA_VERSION: abba020924.vi
MODE: WOBBLING
NUMBER_OF_PHASES: 2
WOBBLER_PERIOD: 250
BLANK_TIME: 40
NUMBER_OF_CHANNELS: 120
GAIN: 020
SCAN: 1234
SUBSCAN: 005

DATE: 24.09.2002
START_UT: 12:20:59.1234
DATA_DESCRIPTION: time stamp, channel 1, ..., channel N
DATA_FORMAT: "%2.2d:%2.2d:%7.4f", NUMBER_OF_CHANNELS times 4 byte IEEE signed integer (big endian)
END_OF_HEADER
ASCII time stamp (13 Characters), then 2 bytes per channel (EEEI signed integer),
ASCII time stamp (13 Characters), then 2 bytes per channel (EEEI signed integer),
ASCII time stamp (13 Characters), then 2 bytes per channel (EEEI signed integer),
... and so on

Example of a skydip mode (total power) ABBA raw data file:

ABBA_DATA_FILE
ABBA_VERSION: abba020924.vi
MODE: SKYDIP
NUMBER_OF_PHASES: 1
PHASE_TIME: 500
BLANK_TIME: 00
NUMBER_OF_CHANNELS: 120
GAIN: 020
SCAN: 1234
SUBSCAN: 005
DATE: 24.09.2002
START_UT: 12:20:59.1234
DATA_DESCRIPTION: time stamp, channel 1, ..., channel N
DATA_FORMAT: "%2.2d:%2.2d:%7.4f", NUMBER_OF_CHANNELS times 4 byte IEEE signed integer (big endian)
END_OF_HEADER
ASCII time stamp (13 Characters), then 2 bytes per channel (EEEI signed integer),
ASCII time stamp (13 Characters), then 2 bytes per channel (EEEI signed integer),
ASCII time stamp (13 Characters), then 2 bytes per channel (EEEI signed integer),
... and so on

Example of fastscanning mode ABBA raw data file:

ABBA_DATA_FILE
ABBA_VERSION: abba020924.vi
MODE: FASTSCANNING
SAMPLE_RATE: 125
NUMBER_OF_CHANNELS: 120
GAIN: 020
SCAN: 1234
SUBSCAN: 005
DATE: 24.08.2002
START_UT: 12:20:59.1234
DATA_DESCRIPTION: channel 1, ..., channel N
DATA_FORMAT: NUMBER_OF_CHANNELS times 2 byte EEEI signed integer big endian)
END_OF_HEADER
2 bytes per channel (EEEI signed integer),
2 bytes per channel (EEEI signed integer),
2 bytes per channel (EEEI signed integer),
2 bytes per channel (EEEI signed integer),
... and so on

8 Time Syncronization

ABBA uses the IRIG-B time code signal from an GPS receiver which is installed at the telescope. This signal is fed via BNC connection to the Brandywine SyncClock32PCI card. The ABBA program reads the UT time from this board. In the wobbler mode, the time is latched in the external time tag register of the board each time a blank trigger occures. For this reason, the blank signal is connected to the ExtTrigger input of the SyncClock32PCI card (for details see the SyncClock32PCI manual [4]).

9 IRAM 30m Control Software for ABBA

See separate report by W. Brunswig [1].

10 Online FITS Merger

ABBA scans are written in the new FITS format developed for continuum data. Data reduction programs like NIC and MOPSI are able to interpret those FITS files. The VAX triggers copying the TH/TP files to an HP workstation after each subscan. Subsequently, a script is executed on the HP which checks whether this is an ABBA or heterodyne scan. For ABBA scans, it runs the FITS merger program developed by D. Brougière and H. Wiesemeyer. The resulting FITS and NMB files are updated after each subscan so that one can continuously check the progress of the current scan.

11 ABBA Operation Instructions

11.1 Starting the ABBA PC

The ABBA PC has a 19" case (white front panel) and is mounted in the rack between mirror 4 and (bolometer) mirror 5.

1. Switch on the ABBA monitor.
2. Press the "POWER" button to start the PC. (If it doesn't start, check the power cables and the main power switch at the back.) The computer should boot WinNT now and will automatically launch the ABBA process. You will see the ABBA control panel window on the monitor. ABBA is ready and waiting for the client computer.
3. Switch off the monitor.

11.2 Restarting the ABBA process

If there is no response from ABBA to VAX commands (watch the messages in the operator's "MRT Reciever & Backend Info" window), and restarting the backend process on the VAX doesn't help, the ABBA process probably needs to be restarted.

There are two possibilities:

- In the receiver cabin

1. Switch on the ABBA monitor. You will see the ABBA control screen.
2. Click with the mouse on the red stop button (second button in the left upper corner of the ABBA control panel window, with octagonal stop sign).
3. Start the ABBA process by clicking on the start button (first button in the left upper corner of the ABBA control panel window, with arrow sign).
4. Switch off the monitor (the radiation of the monitor could create noise in the bolometer signals).
5. Restart the backend process hereafter!

- Remotely

   1. Start "vncviewer" (e.g. on mrt-lx1).
   2. VNC server: mrt-abba, (the operator knows the password)
      You will get the ABBA screen as on the monitor in the receiver cabin.
   3. Click with the mouse on the red stop button (second button in the left upper corner of the ABBA control panel window, with octagonal stop sign).
   4. Start the ABBA process by clicking on the start button (first button in the left upper corner of the ABBA control panel window, with arrow sign).
   5. Close the vncviewer in the upper LEFT corner of the VNC window.
   6. Restart the backend process hereafter!
   7. ATTENTION: Don't let the vncviewer running during observations! It might interfere with the VAX to ABBA communication. Open the vncviewer only to restart ABBA if necessary, and close it right after!

11.3 Shutting down the ABBA PC

1. Stop the process by clicking the stop button with the mouse (see before).

2. Close the ABBA control panel window (click on "x" in the upper right corner).

3. Shut down Windows NT and switch off the ABBA PC.

12 Appendix

12.1 Hardware list

- 19" industrial case 4 HU, with 300 W power supply
- Mainboard Shuttle-AI61 ATHLON ATX/K7
  5xPCI, 1xAGP, 3xDIMM, UDMA-66
- CPU AMD K7 ATHLON 600 MHz Slot A
- RAM 128 MB DIMM PC100
- Network adapter PCI Level-1 10/100 TX, Realtec chip
- Graphic adapter ATI Xpert 2000 Rage 128 16 MB
- HDD 40 GB West.Dig. 7200 RPM
- CD-ROM 40x
- FDD 1.44 MB
- Standard PS2 Keyboard and Mouse
- Monitor Standard VGA 15"
- PCI SyncClock32PCI BrandyWine Communications
- ADC device 1 PCI 6033 E National Instruments
- ADC device 2 PCI 6033 E National Instruments
- SH100100 Shielded Cable 1, 1 m
- SH100100 Shielded Cable 2, 1 m

- Signal distribution box with 120 active anti-aliasing filters (W. Esch, MPIfR)
- Sync-Blank delay-box (MPIfR)

12.2 Connections at the signal distribution box

- 1 Sync input (BNC)
- 1 Blank input (BNC)
- 1 Wobbler position signal (sub-D 9)
- 5 Bolometer signals input (sub-D 25), 24 channels per input
- 2 Signals output (SH100)

12.3 Connections at the 19 inch PC

- 2 Signals input (SH100)
- 1 IRIB-B input (BNC)
- 1 Time tag input (DB26)
- 1 Ethernet connection
- 1 Keyboard
- 1 Mouse
- 1 Monitor

12.4 Software list

- Operating system: Windows NT 4.0 service pack 6
- National Instruments driver NIDAQ 6.9.2
- PCI SyncClock32PCI WinNT driver 1.6
- VNC server 3.3.3.9

- NTP client Automachron
- LabVIEW 6 runtime engine
- ABBA control program version 2002-09-24

References

[1] Brunswig W., Project ABBA Control,
http://www.iram.es/Technical/telescope/tcs/bcs/abba/pr_bcs_abba_control.pdf, 2001

[2] National Instruments, PCI E Series User Manual,
http://www.ni.com/pdf/manuals/320945d.pdf

[3] National Instruments, LabVIEW,
http://www.ni.com/labview

[4] Brandywine Communications,
PCI-SyncClock32 Operation & Maintenance Manual,
http://www.BrandywineComm.com