Continuum backends
at the 40 m radiotelescope

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Revision history

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Contents

1 Introduction

We describe the continuum backends in use at the 40 m radiotelescope, its current instalation in the IF chain and tests performed on them. We also provide some information on the control software. The PBE continuum backend is on loan from the MPI in Bonn and was delivered with partial documentation. The authors took part in at least one of the previous tasks listed before.

2 Continuum backend OAY-14

Since first observations in 2007, the telescope has used a single channel continuum detector, the OAY-14, built at the OAN (Gallego et al. 1996) which was in use previously at the 14 m telescope. The characterization and commissioning of the 40 m described in several reports in 2008, 2009 and 2010 was performerd with this detector.

The OAY-14 is a continuum detector which accepts signals between 10 MHz and 1500 MHz. It integrates the input signal and produces an analog voltage proportional to the input power in the whole band. Two output signals are available at the rear. The OAY-14 has a knob in the front part that allows to control the input attenuation. If the voltage is above 10 volts a red led will illuminate indicating that the detector is saturated. A small hole in the front, above the on/off switch, with an inside screw allows to set the zero. A thin screwdriver may be used for that purpose. The zero depends on the environment temperature and it may drift up to 8 mV per degree. The backend room temperature is controlled and kept within a range of 2 degrees around 20 C.

The DC voltage from the OAY-14 is injected into a Keithley 2701 multimeter, which can be controlled and monitored using an ethernet connection. The Keithley displays voltage with a resolution of 7 digits. This multimeter is versatile and can be used in many different ways, but we have restricted ourselves to the functions that we need for monitoring the continuum voltage: initialization, setting an integration time, starting a single shot measurement and reporting the measured value. This functionality has been implemented using a software ACS component as with the rest of the devices.

The most important problem we found with the OAY-14 was the dead interval time, which elapses between the end of the integration time, and the presentation of the result, which was around 200 ms without optimization. Such a value is very large compared to an integration time of 1 second and rendered useless the continuum detector. The initialization time of the device was also very high and could ammount up to 12 seconds.

After some investigation we found a setup and initialization sequence which minimized both times. The current initialization is included below. Each instruction has a comment that preceeds it and explains its aim.

```
   // Reset the device
:*RST
   //
:SYST:LSYN:STAT ON
  // Set data string to get the value only
:FORM:ELEM READ
```

```
  // Select measurement function: DC voltage
:FUNC 'VOLT:DC'
  // Disable filter
:VOLT:AVER:STAT OFF
  // Fix range
:VOLT:DC:RANG 10
  // Disable display
:DISP:ENAB OFF
  // Trigger delay 0
:TRIG:DEL 0
  // Clear the buffer/
:TRAC:CLE
  // Disable autozero
:SYST:AZER:STAT OFF
  // Set integration time to 1 second
:VOLT:DC:APER 1
  // Next 3 instructions: single shot mode
:INIT:CONT OFF
:TRIG:COUN 1
:SAMP:COUN 1
```

In order to speed up the measurements the front panel LED display is disabled, the trigger delay is set to 0 and the autozero is disabled.

Currently, it is possible to switch between single shot mode:

```
:INIT:CONT OFF
:TRIG:COUN 1
:SAMP:COUN 1
```

or continuous mode:

```
:TRIG:COUN INF
:SAMP:COUN 1
:INIT:CONT ON
```

However the latter mode has not been fully tested and it has never been used with the OAY-14.

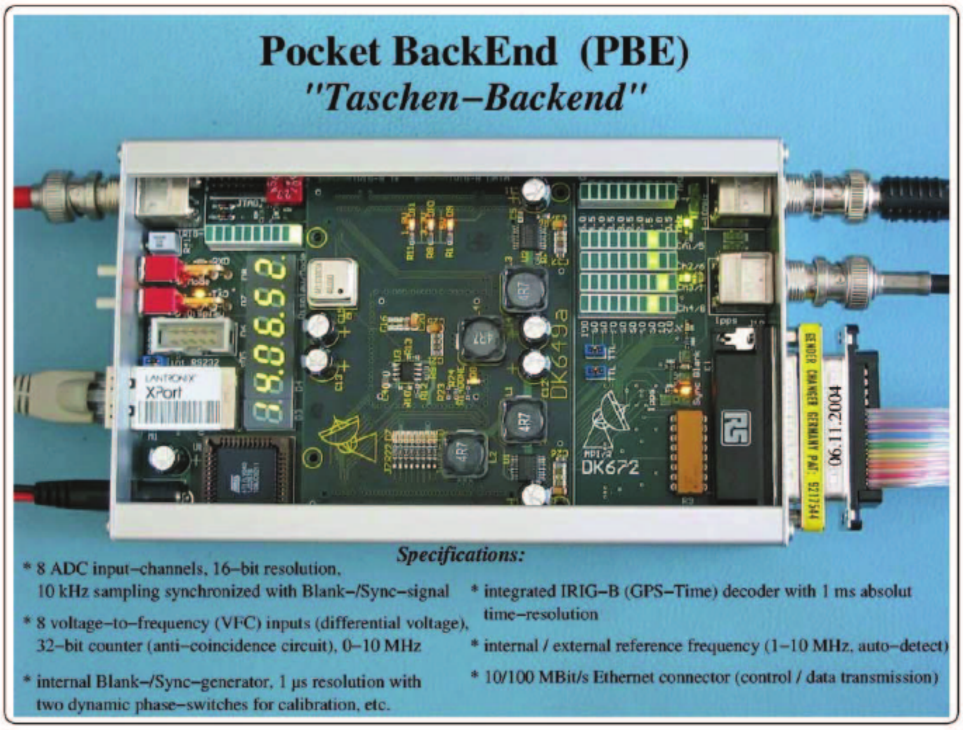
Every readout in single shot mode is achieved by sending the following instruction:

```
:READ?
```

Currently the time elapsed between individual measurements is 20 mseconds when the integration time is 1 s. The initialization interval is 0.4 seconds after setting the device to single shot mode. Reading a value after a single shot instruction has been commanded is the main cause for delaying the initialization of the device. This interval also depends on the commanded integration time.

3 The Pocket Backend

The PBE, Pocket Backend, is an 8 channel continuum backend with 16 bit resolution manufactured at MPI für Radioastronomie in Bonn by B. Klein's group. It is on free loan in the Observatory of Yebes since summer 2008. Fig. 1 shows a picture of the device provided by B. Klein.



Pocket BackEnd (PBE)

"Taschen–Backend"

Specifications:

- 8 ADC input–channels, 16–bit resolution, 10 kHz sampling synchronized with Blank–/Sync–signal
- 8 voltage–to–frequency (VFC) inputs (differential voltage), 32–bit counter (anti–coincidence circuit), 0–10 MHz
- internal Blank–/Sync–generator, 1 µs resolution with two dynamic phase–switches for calibration, etc.
- integrated IRIG–B (GPS–Time) decoder with 1 ms absolut time–resolution
- internal / external reference frequency (1–10 MHz, auto–detect)
- 10/100 MBit/s Ethernet connector (control / data transmission)

Figure 1: *Top view of the Pocket Backend, with summarized information on its characteristics. Author: B. Klein*

The PBE accepts either a group of 8 continuum analog signals or 8 frequency to voltage inputs (using differential signals). For that purpose it has got two 25 D female connectors on the front of the device. The pinout and function of each pin is summarized in table 1 and comes from the specification notes of the equipment. There are also two inputs for digital signals and input/output connectors for a blank and a sync signal, which allow to synchronize the data acquisition with an external signal.

The front face has also got two BNC connectors, 1 PPS, which is not used if the time is provided using an IRIG-B signal and 1-10 MHz, used as an external reference. This signal is automatically used if the level is high enough (TTL nominal signal level) and the frequency is a multiple of 1 MHz.

The rear face has got 1 IRIG-B (1 KHz) input connector (8 Vpp maximum and 100 mVpp minimum). This signal is used for time keeping inside the device. There is also a 10/100 ethernet connector and a +5 V continuum voltage input (maximum intensity 500 mA). Two

ADC connector		VFC connector		
Pin number	Function	Pin number	Direction	(Function)
1	ADC 1	1	IN	-VFC1
2	ADC 2	2	IN	-VFC2
3	ADC 3	3	IN	-VFC3
4	ADC 4	4	IN	-VFC4
5	ADC 5	5	IN	-VFC5
6	ADC 6	6	IN	-VFC6
7	ADC 7	7	IN	-VFC7
8	ADC 8	8	IN	-VFC8
9	DAC 1	9	IN/OUT	-Sync
10	DAC 2	10	IN/OUT	-Blank
11	-	11	OUT	-S1
12	-	12	OUT	-S2
13	GND	13		GND
14	GND	14	IN	+VFC1
15	GND	15	IN	+VFC2
16	GND	16	IN	+VFC3
17	GND	17	IN	+VFC4
18	GND	18	IN	+VFC5
19	GND	19	IN	+VFC6
20	GND	20	IN	+VFC7
21	GND	21	IN	+VFC8
22	GND	22	IN/OUT	+Sync
23	GND	23	IN/OUT	+Blank
24	-	24	OUT	S1
25	-	25	OUT	S2

Table 1: *Pinout for the two 25 sub-D female connectors on the front of the PBE. ADC: analog to digital input,*

white push buttons labelled: ”set” and ”mode” allow to select the content to be shown in the LED display on the top of the box.

The top side has got a plastic cover that allows to see the different LEDs inside the device. The most important information comes from a group of green LED digits that compose a rudimentary display. This display may show 10 different informative channels/lines. The ”mode” push button allows to move from one line to another cycling around, and the ”set” button allows to choose different options within one informative line. This latter button only works for informative lines 4 and 5. For example, informative line number 5 shows the detected voltage on the selected analog input channel. By pushing the ”set” button, the next analog input channel may be viewed. The position of the informative channel/line is displayed on a green LED matrix perpendicular and besides the green digit LED display. Other LEDs on the board indicate the status of the device.

Table 2 summarizes the 10 available informative lines. We also provide examples to see the formatting of data in each case.

Informative line	Content	Example
Line 1	Time (IRIG-B)*	08.05.59
Line 2	?*	00001
Line 3	Day of Year*	0033
Line 4	Channels to show on a separate LED matrix	Ch 1-4
Line 5	Detected voltage on specified channel	A1 2.78
Line 6	Last command sent	A.00.d14
Line 7	Blank time (ms)	b.00.010
Line 8	?	5.——
Line 9	Phases in use	P. 001
Line 10	Date? (not current date)	02.12.06

Table 2: *Description and example of the information provided on the LED display on top of the PBE. Due to the lack of PBE documentation, the information has been obtained by trial and error and is unknown for some lines (those with a question mark). Lines marked with *, indicate that a green dot at the right bottom of last LED digit lights each second. This may indicate that these lines are related to a date time field.*

Figures 2a and 2b show a picture of the front and the rear face of the PBE.

3.1 Installation

The PBE was installed in a rack in the backends room of the 40 m telescope. It stands on one of its side faces which is attached to a horizontal plate in the rack so that the top side is visible and the LED displays can easily be seen. The workshop at Yebes manufactured a plate that interfaces the input DB-25 pin connectors on the front side so that users can easily plug and unplug BNC RG58 cables with input signals. An IRIG-B signal is being injected from the Meinberg IRIG-B distributor module. No 1 PPS signal and no reference signal are used for the time being. The device was connected to the private LAN at Yebes. The IP address

Figure 2: *Left: Picture of the front face of the PBE, Right: Picture of the rear face of the PBE.*

is not handled via DHCP, and was set at MPI previous to coming to Yebes. The current IP is 192.168.0.114. Figure 3 shows the final disposition of the backend in the rack.

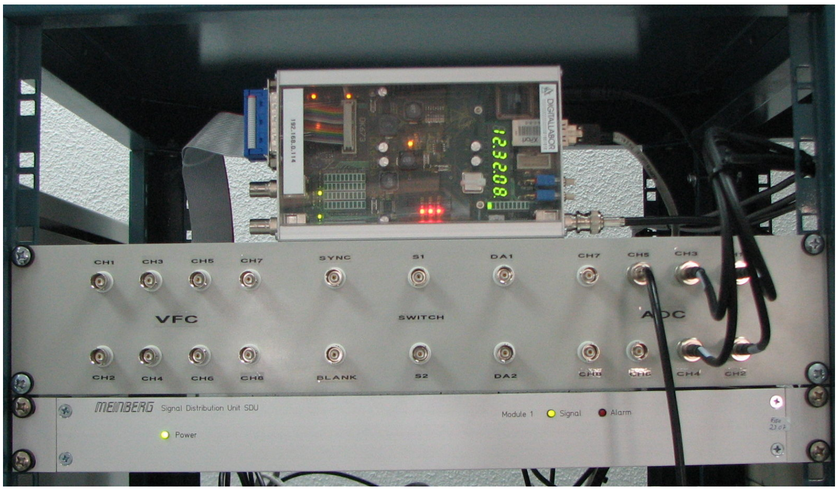


Figure 3: *Current installation of the PBE in a rack in the Backends room. The PBE stands on one of its sides, so that the LEDs on top of the device area easily visible.*

Since the PBE requires an analog voltage proportional to the detected power we have used the continuum detectors of the VLBA backend for that purpose. The VLBA has got 4 IF modules 512 MHz bandwidth with a square law detector each. The detected power is available as a continuum voltage output signal on the front connectors labelled as ”Total Power Monitor”. Currently the four IF total power connectors are connected to the first 4 input connectors of the PBE. Figure 4 shows a sketch of the current connections.

The usage of the VLBA IF modules as an intermediate stage between the receiver IFs and the

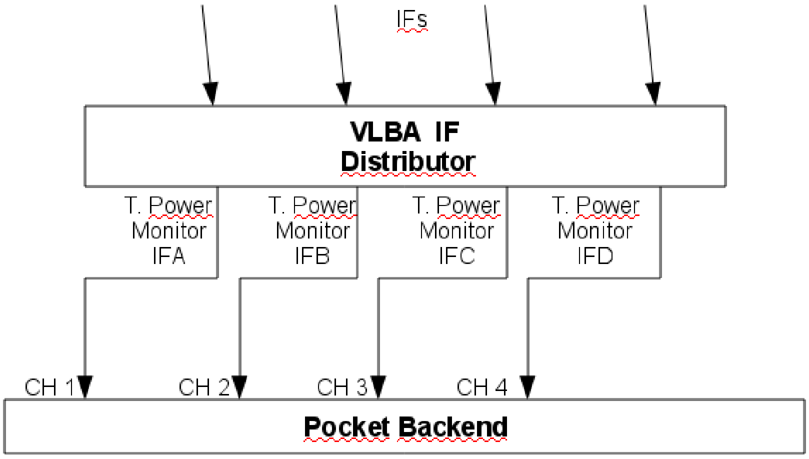


Figure 4: *Current connections between the IFs and the PBE. The VLBA terminal is used as an intermediate device. Currently only 4 IFs are connected (usually two polarizations from two different receivers).*

PBE, apart from being necessary due to the lack of independent continuum square law detectors, has an additional advantage: the zero of the continuum detectors can be easily measured by commanding remotely the VLBA IFs to attenuate 20 dB the input signal and switching the input to the external connector where there is no signal.

3.2 Optimum power regime

The optimum input signal for the VLBA IF continuum detectors has to be within the interval where they work in a linear regime. According to Lopez (2010) the interval is between -32 dBm and -23 dBm which corresponds to 1 V and 5.5 Volts respectively. In order to check the linearity we have injected power from the X band receiver, RCP polarization, while selecting different values of the IF attenuator from 31 dB to 3 dB. We have measured the total power voltage at the Total Power Monitor output in the VLBA IF distributor module A with a voltimeter. Simmultaneously we have read the power using the Field System and the total power detectors of the VLBA terminal. The values read by the VLBA are in arbitrary units and the maximum allowed value is around 65536 (2^{16}), possibly because digitation is done with 16 bits. We have also read the Pocket Backend using analog channel 1 and the values are also in arbitrary units. Figure 7 summarizes the results.

The main conclusion is that the Pocket Backend works in a linear regime between 1 and 5 Volts. Taking into account this fact, the total output power from the IFs of the different receivers is adjusted using attenuators so that the input total power reads between 15000 and 65000 VLBA arbitray counts. This is easy to acomplish for frequencies below 22 GHz, but requires careful tuning at 22 GHz and upper frequencies where the atmosphere is an important emitter. Figure 6 displays the total power detected in the IF detectors at 3 different elevations and for 3 different frequency receivers for good atmospheric conditions.

We have investigated the best IF attenuation value for the 3 mm receiver using the Pocket

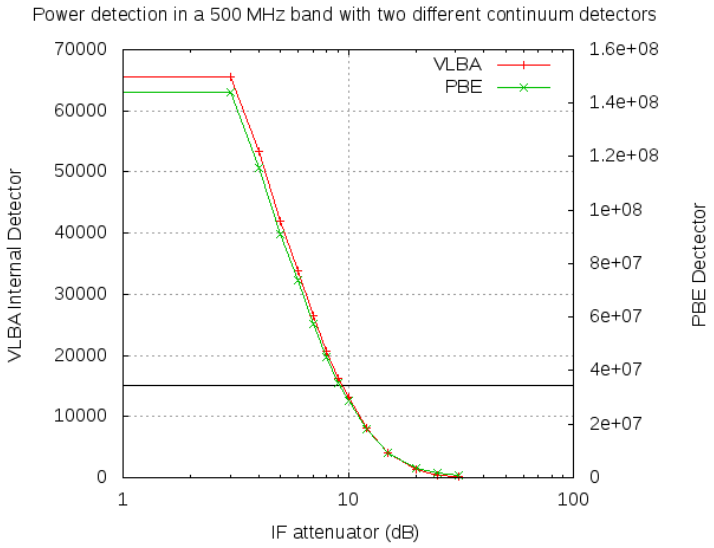


Figure 5: *Voltage detected from the continuum IF 500 MHz bandwidth band of the X band receiver. Integration time was 1 second. The receiver was looking at a hot load. The IF attenuator of the receiver was tuned at several values: 3, 4, 5, 6, 7, 8, 9, 12, 15, 20, 25 and 30 dB. The conversion factor between voltage and arbitrary units is different for the VLBA and PBE, but both seem to be linear*

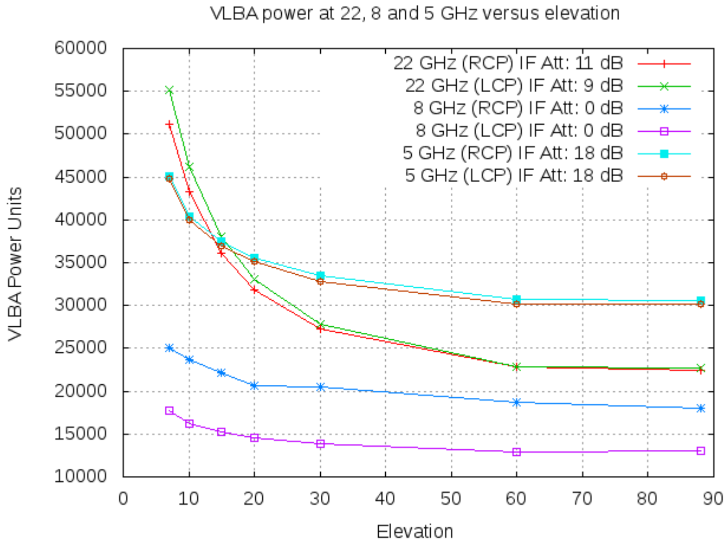


Figure 6: *Power (in VLBA arbitrary units) as a function of elevation at 22, 8 and 5 GHz. X Band LCP is below and close to the limit of non-linearity (15000). Both polarizations use 0 dB attenuation at the IF the attain the maximum power.*

Backend and the continuum detectors of the VLBI terminal. The linearity is determined by the voltage range covered when doing a calibration scan. A millimeter calibration scan observes the sky, a hot load at ambient temperature, a cold load and no signal. In order to have linear measurements we need that the three first subscans give voltages between 1 V and 5 V. Table 3 summarizes the results for 2 attenuation values. 2 dB attenuation seems to be the most adequate one.

Subscan	Voltage (0 dB)	Voltage (2 dB)
Hot load	5.53	4.18
Cold load	1.58	1.09
Sky	2.82	1.78
Zero offset	0.02	0.02

Table 3: *Voltages detected with the PBE during a calibration scan at 3 mm. The voltage in the sky phase depends on weather conditions but should never surpass the hot load one. The offset voltage is obviously out of the linear regime interval. An attenuation of 2 dB in the IF seems to be the best option.*

Table 4 summarize the best IF attenuator values to work in the linear regime at different frequencies both for single dish and VLBI observations.

Receiver	RCP IF att. (dB)	LCP IF att. (dB)
87 GHZ	2	2
23 GHz	5	7
22 GHz	9	11
8 GHz	0	0
5 GHz	18	18

Table 4: *Optimum IF attenuator values for different receivers so that the PBE works in a linear regime. Voltages are always between 1 and 5 V.*

The interval between 1 V and 5 V may be too small for frequencies larger than 22 GHz. In the mid-term future we should avoid using the VLBA continuum detectors and use, instead, square law detectors with a wider linear regime, like the ones in the OAY-14. On the other hand the IF power from the X band receiver (specially LCP polarization) is a too close to the limit and should be 3 dB higher.

3.3 Modes and Phases

The PBE has the possibility to be used either in continuum or single shot mode. It also allows to be triggered with an internal signal or with an external synchronization signal. In single shot mode the PBE is triggered and starts a single measurement. After the integration time has ellapsed, the result is available in the output register which is read by a socket client.

The continous mode is a more versatile one. The PBE is triggered by a periodic signal, either internal or external. After the integration time has ellapsed the result is, like in the previous case, available in the output register via sockets. Our remote client reads the socket and sends the data to a notificacion channel. Immediately after, a new integration cycle is started by the triggering signal.

It is possible to define several phases on a single cycle. Each phase is composed of a blank period, and a sync period. Both periods are defined by a square signal injected in the PBE (or generated internally). When this square signal has a high level, the blank period is active and when it has a low level, the blank period is inactive. The blank period is a time interval in which the integrator does not work and hence the signal is discarded. The increasing ramp of the sync signal is used to determine when a new cycle starts. If the cycles are made of one phase the start of a cycle is the same as the start of a phase. Each phase is determined by the increasing ramp of the blank signal. The total integration time per phase is the time elapsed while the blank signal is low.

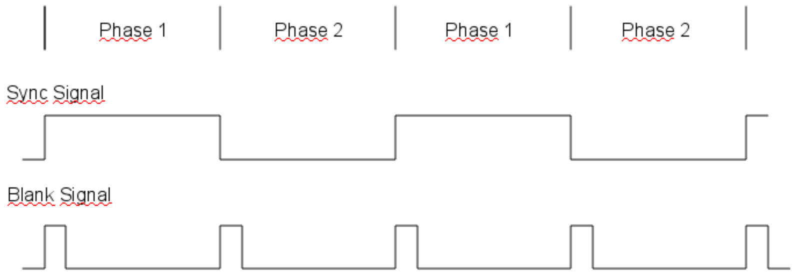


Figure 7: *Sync and Blank signals for a two phase cycle*

The blank signal is usually used for choppers (or mirrors) and switched noise diodes. For example, in order to correct for gain variations due to the atmosphere in continuum observations, a rotating mirror is placed in front of the horn. The beam is directed alternatively either towards the source or towards a reference position several times per second. Part of the time the horn sees the source and part of the time the horn sees the reference. However there is a small interval in which the horn is seeing both positions. This happens when the mirror enters into the field of view of the horn and it does not cover it completely. This period is the blank interval, and data should be discarded while this happens. Data are taken while the horn fully and only sees the sky or the mirror. This same scheme is also valid for switched noise diodes. These are used to calibrate in amplitude and avoid drifts in the receiver-backend chain. For example, a diode is switched on and off with a periodicity of 80 Hz. The blank period should be the interval required by the noise diode to produce a stable signal.

In the previous two examples, in order to distinguish, between the time the horn is seeing the reference or the source, or the noise diode on or off, the PBE uses the phases; one phase may be the one for the reference and the other one for the source. Or in the noise diode sheme, one phase happens when the noise diode is on and the other phase happens when the noise diode is off. The PBE allows to define several phases per cycle. The blanking and synchronization time may be defined with a resolution of 1 μs. The PBE allows a maximum of 2 phases.

Currently, at the 40 m radiotelescope, the PBE is not used with external signals, but in the mid term future we will use it with switched noise diodes for low frequency receivers. For high frequency receivers there are no plans for a rotating chopper wheel. Tests in the future with an external sync signal and several phases will be documented.

3.4 Remote operation

The Pocket Backend is controlled remotely through a TCP socket at a given IP address and port. When the PBE reads the socket (a command is sent), it writes on a given address memory the value sent. When the PBE is read by a socket (data acquisition) it returns the content at a given address memory. Therefore each command sent and read through the socket is composed of a pair of bytes: the memory address and the content of that address. There is no acknowledgment and no error checking in this philosophy. The memory address has a range of 32 positions and ranges from 0x00 to 0x1E. The first memory address is reserved for the control byte and it allows to set the main properties of the device.

The control byte may enable/disable the following properties via the memory register 0x00. The meaning of 1 and 0 for each bit is included below:

- Bit 1: Enable (1) /Disable (0) single shot mode
- Bit 2: Enable (1) /Disable (0) the Blank/Sync signal output if using the internal triggering.
- Bit 3: Enable (1) /Disable (0) the ADC integration flag which allows the integration of data to take place.
- Bit 4: If one external PPS is used, it allows to determine if trigering is done when slope is raising (1) or decreasing (0)
- Bit 5: Choose between keeping the internal time with an IRG-B signal (1) or 1 PPS signal (0).
- Bit 6: Enable (1) /disable 1 PPS for internal generation of 1 μs ticks. It allows to tag the results with a resolution of microseconds.
- Bit 7: Flag to use internal (1) or external (0) signals for blank and synchronization signals.
- Bit 8: Flag which determines if data transmission continues (1) or not. Data are continuously updated in the memory address to be read

During the initialization of the device all these properties are set to a given value using private variables in the C++ class. Some of them can be modified via the software component, but others are kep immutable for the whole operation, since we do not foresee to be used in the future. The default control byte is: 0x00101001. The default control byte is sent with each *start()* and *stop()* command. All properties are immutable for the time being except the flag that determines if the data are transmited or not, and the flag that allows to switch between an internal or an external signal. These two values may be changed from two methods of the C++ class, but are not taken into account until a *start()* or a *stop()* command are sent. Every time a *start()* command is sent the continuum data transmission flag is turned on, and it is turned off after every *stop()* command.

Other properties are set by writting in the appropiate memory registers. These are the blank time, the sync time, the number of phases, the switches and the DACs (Analog to Digital converters) to be used, and the read registers that will be activated to get the data. The blank time corresponds to a time interval in which the data are discarded and the sync time is the integration time per sample. There are two DACs and two switches available and they can copy two signals from the ADC inputs and two signals from the VFC input into the output connectors respectively. Below we show the commands for an example we wrote to test the device:

```
c.setBlankSyncMode(PBEBackend.PocketBackend.INTERNAL)
# usecs
c.setBlankTime(10)
# usecs
c.setSyncTime(1000000)
c.setNumPhases(1)
c.setDAC(PBEBackend.PocketBackend.ALLDAC)
c.setSwitch(PBEBackend.PocketBackend.ALLSWITCH)
c.start()
```

The previous example shows a typical setting for the Pocket Backend. Sync time is 1 second, only one phase is used and both swithes copy the input from channel 1 (disconnected now) and the two DACs copy the input from ADC channel 1. The two latter commands are not required and can be avoided. During the initializacion of the device all read registers are enabled so that the results from integrating the signal from the ADC channels are available.

Appendix 1, includes the hexadecimal addresses to be used, and its content in order to write and read the Pocket Backend memory.

After each integration period the Pocket Backend sends to the socket a new result from each channel. The Pocket Backend ACS component reads this value and delivers it in a notification channel. An independent thread reads the output register (even if no values are available at the register) for all the life time of the component since it is started. A variable which counts the number of events is updated after a new result is available.

We have tested the time it takes to initialize the PBE and the time ellapsed between measurements. The initialization time is around 0.8 ms and the time required to start the measurement 0.5 ms. The internal sync signal is therefore started 0.5 ms after issuing a start command. The time ellapsed between two consecutive measurements is less than 10 μs, and is determined by the blank time. These values highly contrast with the equivalent ones from the Keithley multimeter.

4 Allan variance for the continuum backends

We have investigated the Allan variance of the system using three combinations of the backends with the 22 GHz receiver covered with an absorber. The three combinations were: the OAY-14+Keithley, VLBA+PBE, OAY-14+PBE. In order to use the same signal simmultaneously the setup was as follows: The IF from the RCP of the 22 GHz was injected in the VLBA terminal, IF module A. The output monitor output from module A was connected to the OAY-14 continuum detector. The total detected power from the OAY-14 can be monitored from two different output connectors in its rear side. One of the connectors was used to inject a signal to the Keithley multimeter and the other one to feed one of the PBE channels. The total power monitor from IFA A module at the VLBA terminal was used to feed another channel from the PBE. Figure 8 shows a simple scheme of the setup.

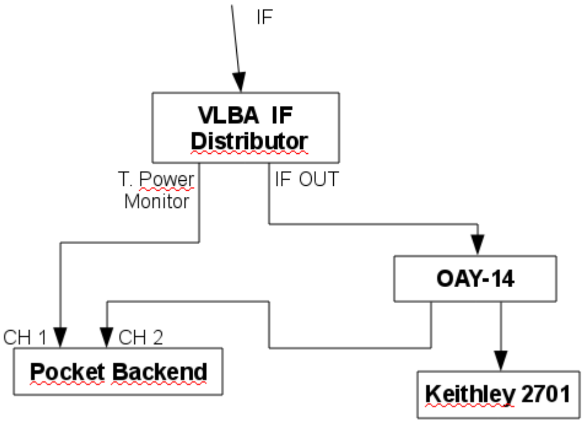


Figure 8: *Setup to measure simmultaneously the Allan variance of the IF signal using three different continuum backend combinations: VLBA+PBE, OAY-14+PBE and OAY-14+Keithley 2701.*

Figure 9 shows a plot of the Allan variance as function of integration time. The detected signal was squared and normalized. Maximum integration time was 8192 seconds. This figure shows that the best combination is the OAY14-PBE one. The combination OAY14-Keithley and VLBA-PBE show the same performance. It seems that the continuum detector at the OAY14 is better than the ones at the VLBA terminal. The best integration time for the three combinations can be obtained from the minimum of the curves: 8 seconds for the VLBA-PBE and OAY14-Keithley and 25 seconds for the OAY14-PBE combination. These numbers place a limit to the integration time taking into account the instabilities of the receiver chain. However at frequencies higher than 22 GHz, where the atmosphere plays an important role such integration times may be too high.

According to the Allan variance plot, the best option should be to use the OAY14-PBE combination for continuum detection, but unfortunately there is only one OAY14 continuum detector, and the receiver has got two polarizations. In order to detect two polarizations simmultaneously two continuum detectors are required and these are only provided by the IF modules of the VLBA terminal. It is the only possible and available combination for the time being.

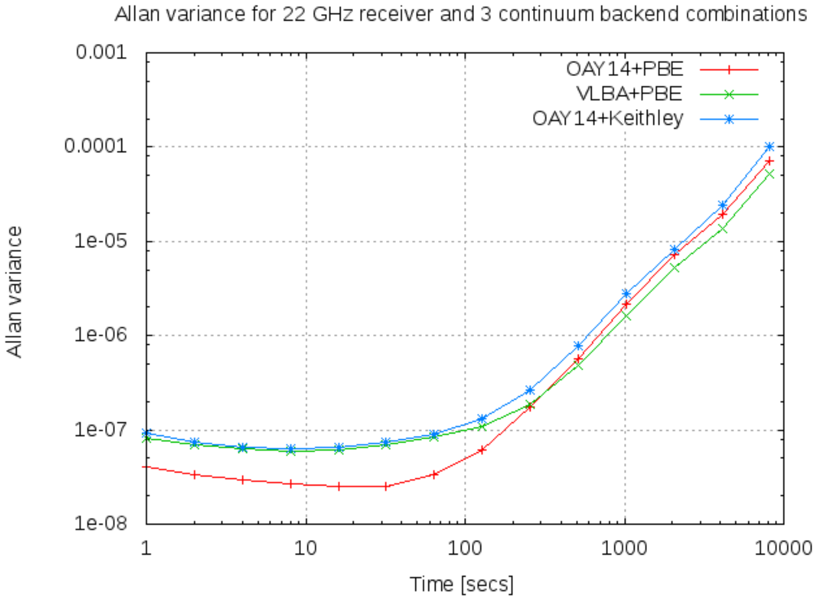


Figure 9: *Allan variance for 3 different IF continuum detectors connected to the 22 GHz frontend. The best performance is achieved by the OAY14-PBE combination.*

5 Conclusion

The total power continuum detectors from the VLBA should be replaced by at least 4 new ones, with the characteristics of the OAY-14, with a better Allan variance performance and a larger linearity regime. It should also be possible to attenuate the signal to measure the zero of the detectors and a switch matrix should allow to choose between different IFs from the receiver cabin.

References

[Gallego 1996] J.D. Gallego, I. López, J.E. Garrido, A. Barcia, C. Almendros, J.L. Aguado. ”Wideband Continuum Detector (50-1500 MHz) OAY-14”. Informe Técnico OAN 1996-7.

[Lopez 2010] J.A. López-Pérez ”Linearity Measurements of Mark-4 rack IF Total Power Detectors”. Informe Técnico OAN 2010-6.

6 Appendix 1: Memory address map

Pocket-Backend-ADC Address Map (24.03.05)

Inputs: x"00" -> Controll Byte(bin "t e p i r a b s")
(msb lsb)
(s = single shot of all Data (rising Edge) = 116 Bytes)
(b = enables Blank/Sync-Output(1))
(a = ADC integration Flag(1))
(r = rising (1) or falling (0) edge of 1pps)
(i = IRIG-B (1) or 1pps - Counter)
(p = 1pps for µs geeration(1))
(e = int(0)/ext(1) Flag for Blank/Sync)
(t = Flag to transmit data continues(1))

x"01" - x"04" -> Blank-Time (internal Generator high Byte first)

x"05" - x"08" -> Sync-Time (internal Generator high Byte first)

x"09" -> # Phases (internal Generator Number of Phases)

x"0A" - x"0B"-> Switches (S1 -> x"0A")
(S2 -> x"0B")

x"0C" - x"0F"-> DAC 0 - 1 (high Byte first)
(DAC0 -> x"0C" - x"OD")
(DAC1 -> x"OE" - x"0F")

x"10" - x"1E" -> Data to wr in continues Mode
(each Output Byte is represented by one Bit)

Outputs:x"00" - x"07"-> Header (all x"ff")

x"08" - x"0B" -> Blank-Time (measured high Byte first)

x"0C" - x"0F"-> Sync-Time (measured high Byte first)

x"10" -> # Phases (measured Number of Phases)

x"11" -> actual Phase (measured Phase)

x"12" - x"1B" -> time (µs, sec, days)
if irig (x"12" -> "00" + days_bcd(9 - 4))
if irig (x"13" -> days_bcd(3 - 0) +"000"+ sec_bin(16))
if irig (x"14" -> sec_bin(15 - 8))
if irig (x"15" -> sec_bin(7 - 0))
if irig (x"16" -> houre_bcd)
if irig (x"17" -> minute_bcd)
if irig (x"18" -> second_bcd)
if pps (x"12" - x"14" -> x"00")
if pps (x"15" -> relative_second_bin(31 - 24))
if pps (x"16" -> relative_second_bin(23 - 16))
if pps (x"17" -> relative_second_bin(15 - 8))
if pps (x"18" -> relative_second_bin(7 - 0))

(x"19" -> 1pps + "000" + µs(19 - 16))
(x"1A" -> µs(15 - 8))
(x"1B" -> µs(7 - 0))

x"1C" – x"1F"-> Event Count (high Byte first)

x"20" - x"3F" -> ADC 0 - 7 (high Byte first)
(ADC0 -> x"20" - x"23")
(ADC1 -> x"24" - x"27")
.
.
(ADC7 -> x"3C" - x"3F")

x"40" - x"4F" -> ADC integ (high Byte first)
(ADC0 integ -> x"40" - x"41")
(ADC1 integ -> x"42" - x"43")
.
.
(ADC7 integ -> x"4E" - x"4F")

x"50" - x"6F" -> Counter 0-7 (high Byte first)
(Counter0 -> x"50" - x"53")
(Counter1 -> x"54" - x"57")
.
.
(Counter7 -> x"6B" - x"6F")

x"70" -> Tail (x"00")

Write Register:

<table>
<tr><th><i>Address (Hex)</i></th><th><i>MSB 7</i></th><th><i>6</i></th><th><i>5</i></th><th><i>4</i></th><th><i>3</i></th><th><i>2</i></th><th><i>1</i></th><th><i>LSB 0</i></th></tr>
<tr><td>00</td><td>Transmitt</td><td>Int/Ext-BS</td><td>Enabl.pps</td><td>Irig/1pps</td><td>Edge 1pps</td><td>ADC integ</td><td>BS enable</td><td>Single</td></tr>
<tr><td>01</td><td colspan="8">U32 Generator Blank-Time (31 : 24)</td></tr>
<tr><td>02</td><td colspan="8">U32 Generator Blank-Time (23 : 16)</td></tr>
<tr><td>03</td><td colspan="8">U32 Generator Blank-Time (15 : 8)</td></tr>
<tr><td>04</td><td colspan="8">U32 Generator Blank-Time (7 : 0)</td></tr>
<tr><td>05</td><td colspan="8">U32 Generator Sync-Time (31 : 24)</td></tr>
<tr><td>06</td><td colspan="8">U32 Generator Sync-Time (23 : 16)</td></tr>
<tr><td>07</td><td colspan="8">U32 Generator Sync-Time (15 : 8)</td></tr>
<tr><td>08</td><td colspan="8">U32 Generator Sync-Time (7 : 0)</td></tr>
<tr><td>09</td><td colspan="8">U8 Generator Number of Phases (7 : 0)</td></tr>
<tr><td>0A</td><td colspan="8">U8 Generator Pattern of Switch 1 (7 : 0)</td></tr>
<tr><td>0B</td><td colspan="8">U8 Generator Pattern of Switch 2 (7 : 0)</td></tr>
<tr><td>10</td><td colspan="8">Enables Read-Register-Address x“ 07 – 00 “</td></tr>
<tr><td>11</td><td colspan="8">Enables Read-Register-Address x“ 0F – 08 “</td></tr>
<tr><td>12</td><td colspan="8">Enables Read-Register-Address x“ 17 – 10 “</td></tr>
</table>

Address (Hex)	*MSB 7*	*6*	*5*	*4*	*3*	*2*	*1*	*LSB 0*
13	Enables Read-Register-Address x“ 1F – 18 “							
14	Enables Read-Register-Address x“ 27 – 20 “							
15	Enables Read-Register-Address x“ 2F – 28 “							
16	Enables Read-Register-Address x“ 37 – 30 “							
17	Enables Read-Register-Address x“ 3F – 38 “							
18	Enables Read-Register-Address x“ 47 – 40 “							
19	Enables Read-Register-Address x“ 4F – 48 “							
1A	Enables Read-Register-Address x“ 57 – 50 “							
1B	Enables Read-Register-Address x“ 5F – 58 “							
1C	Enables Read-Register-Address x“ 67 – 60 “							
1D	Enables Read-Register-Address x“ 6F – 68 “							
1E	Enables Read-Register-Address x“ 77 – 70 “							

Read Register: (x = unused)

Address (Hex)	*MSB 7*	*6*	*5*	*4*	*3*	*2*	*1*	*LSB 0*
00 - 07	4 x Header = U32 x“FFFFFFFF“							
08 - 0B	4 x Measured Blank-Time = U32 (high Byte first)							
0C - 0F	4 x Measured Sync-Time = U32 (high Byte first)							
10	Measured Number of Phases = U8							
11	Actual Phases = U8							
12	x	x	BCD days (9 - 4)					
13	BCD days (3 - 0)				x	x	x	sec(16)
14	Sec (15 – 8)							
15	Sec (7 – 0)							
16	BCD hour (7 – 0)							
17	BCD minute (7 – 0)							
18	BCD second (7 – 0)							
19	1 PPS	x	x	x	U20 µs (19 – 16)			
1A	U20 µs (15 – 8)							
1B	U20 µs (7 – 0)							
1C - 1F	4 x Event Counter = U32 (high Byte first)							
20 - 23	4 x ADC 0 = I32 (high Byte first)							
24 - 27	4 x ADC 1 = I32 (high Byte first)							
28 - 2B	4 x ADC 2 = I32 (high Byte first)							
2C - 2F	4 x ADC 3 = I32 (high Byte first)							

Address (Hex)	***MSB 7***	***6***	***5***	***4***	***3***	***2***	***1***	***LSB 0***
30 - 33	4 x ADC 4 = I32 (high Byte first)							
34 - 37	4 x ADC 5 = I32 (high Byte first)							
38 - 3B	4 x ADC 6 = I32 (high Byte first)							
3C - 3F	4 x ADC 7 = I32 (high Byte first)							
40 - 41	2 x ADC 0 integrations = U16 (high Byte first)							
42- 43	2 x ADC 1 integrations = U16 (high Byte first)							
44 - 45	2 x ADC 2 integrations = U16 (high Byte first)							
46- 47	2 x ADC 3 integrations = U16 (high Byte first)							
48- 49	2 x ADC 4 integrations = U16 (high Byte first)							
4A- 4B	2 x ADC 5 integrations = U16 (high Byte first)							
4C- 4D	2 x ADC 6 integrations = U16 (high Byte first)							
4E - 4F	2 x ADC 7 integrations = U16 (high Byte first)							
50 - 53	4 x Counter 0 = U32 (high Byte first)							
54 - 57	4 x Counter 0 = U32 (high Byte first)							
58 - 5B	4 x Counter 0 = U32 (high Byte first)							
5C - 5F	4 x Counter 0 = U32 (high Byte first)							
60 - 63	4 x Counter 0 = U32 (high Byte first)							
64 - 67	4 x Counter 0 = U32 (high Byte first)							
68 - 6B	4 x Counter 0 = U32 (high Byte first)							
6C - 6D	4 x Counter 0 = U32 (high Byte first)							
70	Tail = U8 x“00“							

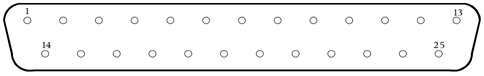
7 Appendix 2: Connections

2.Anschlüsse

2.1. Vordersdeite

ADC 1- 8 + DAC 1- 2

(25pol. Sub-D female)

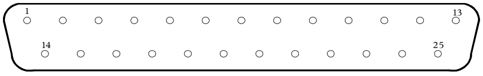


PIN Nr.	Funktion
1	ADC 1
2	ADC 2
3	ADC 3
4	ADC 4
5	ADC 5
6	ADC 6
7	ADC 7
8	ADC 8
9	DAC1
10	DAC2
11- 13	* NC
14- 23	GND
24 -25	* NC

* NC = No Conection

VFC 1- 8 + B/S

(25pol. Sub-D female)



PIN Nr.	Richtung	Funktion
1	IN	-VFC1
2	IN	-VFC2
3	IN	-VFC3
4	IN	-VFC4
5	IN	-VFC5
6	IN	-VFC6
7	IN	-VFC7
8	IN	-VFC8
9	IN/OUT	-Sync
10	IN/OUT	-Blank
11	OUT	-S1
12	OUT	-S2
13		GND
14	IN	+VFC1
15	IN	+VFC2
16	IN	+VFC3
17	IN	+VFC4
18	IN	+VFC5
19	IN	+VFC6
20	IN	+VFC7
21	IN	+VFC8
22	IN/OUT	+Sync
23	IN/OUT	+Blank
24	OUT	+S1
25	OUT	+S2

1PPS (BNC)

zur Zeit nicht benutzt

1-10 MHz (BNC)

Referenztakteingang wahlweise TTL /CMOS -Pegel oder Symmetrischer Sinus (durch rechten Jumper „TTL“ einstellbar). Mit 50 Ω Abschliesbar (rechter Jumper „50 Ω“). Das Backend schaltet automatisch auf externe Referenz um wenn ausreichender Pegel anliegt und die Frequenz hinreichend genau einen Ganzzahlige MHz Betrag hat. Andernfalls blinkt die Frequenzanzeige „f-ref“ .

2.2. Rückseite

IRIG-B (BNC)

1kHz Amplituden-Moduliertes Zeitsignal

Modulationsgrad	1:3
Maximalpegel	8Vpp
Minimalpegel	100mVpp

10/100B-T (Etherner RJ45)

Ethernet-Anschluss für 10MBit/s und 100MBit/s

5V/DC (Netzteilstecker außen5,5mm innen 2,1mm)

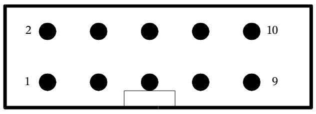
Stromversorgung 5V/500mA über Steckernetzteil

2.3 Geräteinnenteil

RS232 (Stiftleiste 1/10 inch 10pol.)

RS232 Schnittstelle zur Konfiguration des XPort-Servers. Durch Schneidklemmen Verbindung der 10 Pol. Stiftleiste und einer 9pol. Sub-D-Buchse entsteht ein Adapter, mit dem man den Xport-Server unmittelbar mit einem PC verbinden kann.

Stiftleiste		Sub-D-Buchse
Pin Nr.	**Funktion**	**Pin Nr.**
1	DCD	1
2	*NC	6
3	RXD	2
4	RTS	7
5	TXD	3
6	CTS	8
7	*NC	4
8	*NC	9
9	GND	5
10	*NC	

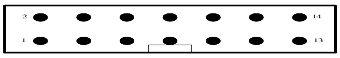


* NC = No Conection

JTAG (Stiftleiste 2mm 14pol.)

JTAG Schnittstelle zum Debuggen des FPGA-Bausteins

Pin Nr.	Funktion	Pin Nr.	Funktion
1	GND	2	Vref
3	GND	4	TMS
5	GND	6	TCK
7	GND	8	TDO
9	GND	10	TDI
11	GND	12	*NC
13	GND	14	*NC



* NC = No Conection