TBL BPM Electronics: Amplifier Status and Future Work

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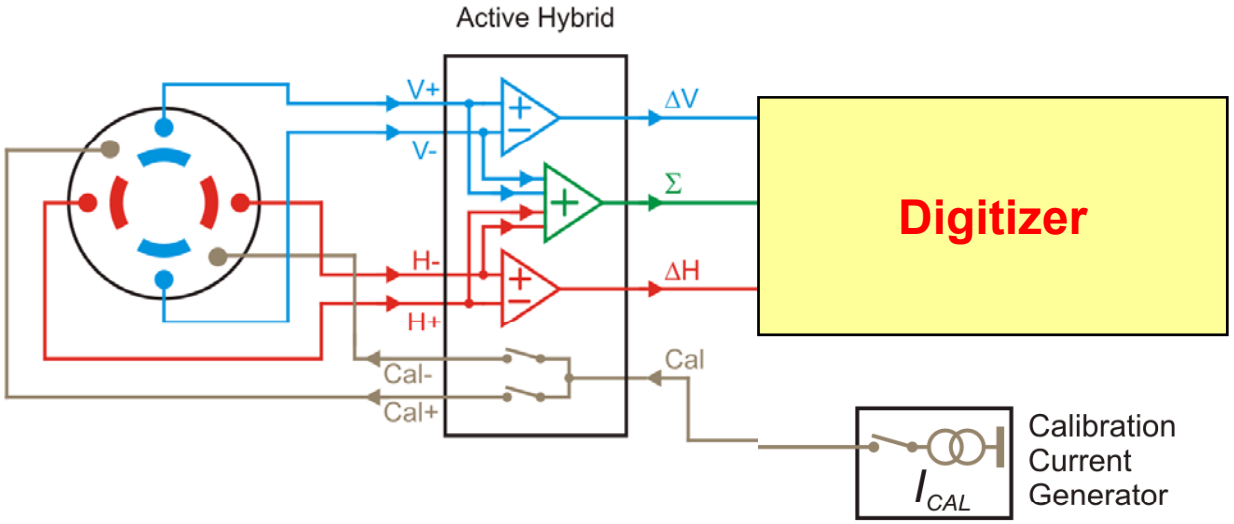
General scheme of the analog head electronics

- The signals (V+,V-, H+ and H-) sensed by the IPU must be processed in order to obtain the signals difference and sum before being digitized.

- It must work as a digitizer front-end.



Previous design did by M. Gasior

Tentative parameters of the BPMs for the TBL	
BPM analog bandwidth (BPM with associated electronics)	**10 kHz -100 MHz (200 MHz is highly desirable)**
Beam position range of interest	+/-5 mm horizontal and vertical
Beam aperture diameter	22.5 mm
Overall mechanical length	< 100 mm
Number of BPM's in TBL	16
Resolution at maximum current	<5 μm
Overall precision	<50 μm
Typical radiation levels	**<1000 Gray/year (or 100 Krads)**

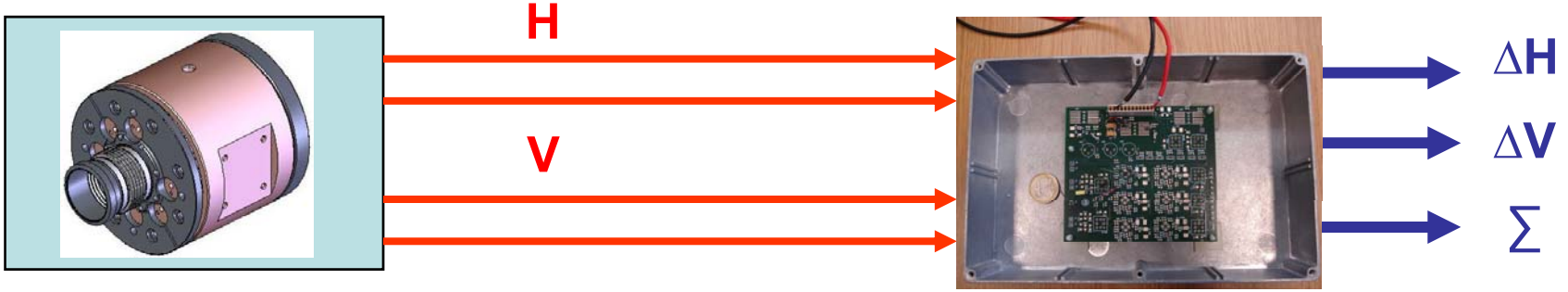
The BPM design for the DBL by M. Gasior cannot be applied directly. Modifications are required:

a) **The dimensions of the IPU should be reduced**

b) **The amplifier bandwidth should be increased (desired up to 200 MHz)**

Inductive pick-up

Analog front-end electronics



- Mechanics
- IPU electronics

- Amplifier

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BPM Analog amplifier for the TBL

Work done:

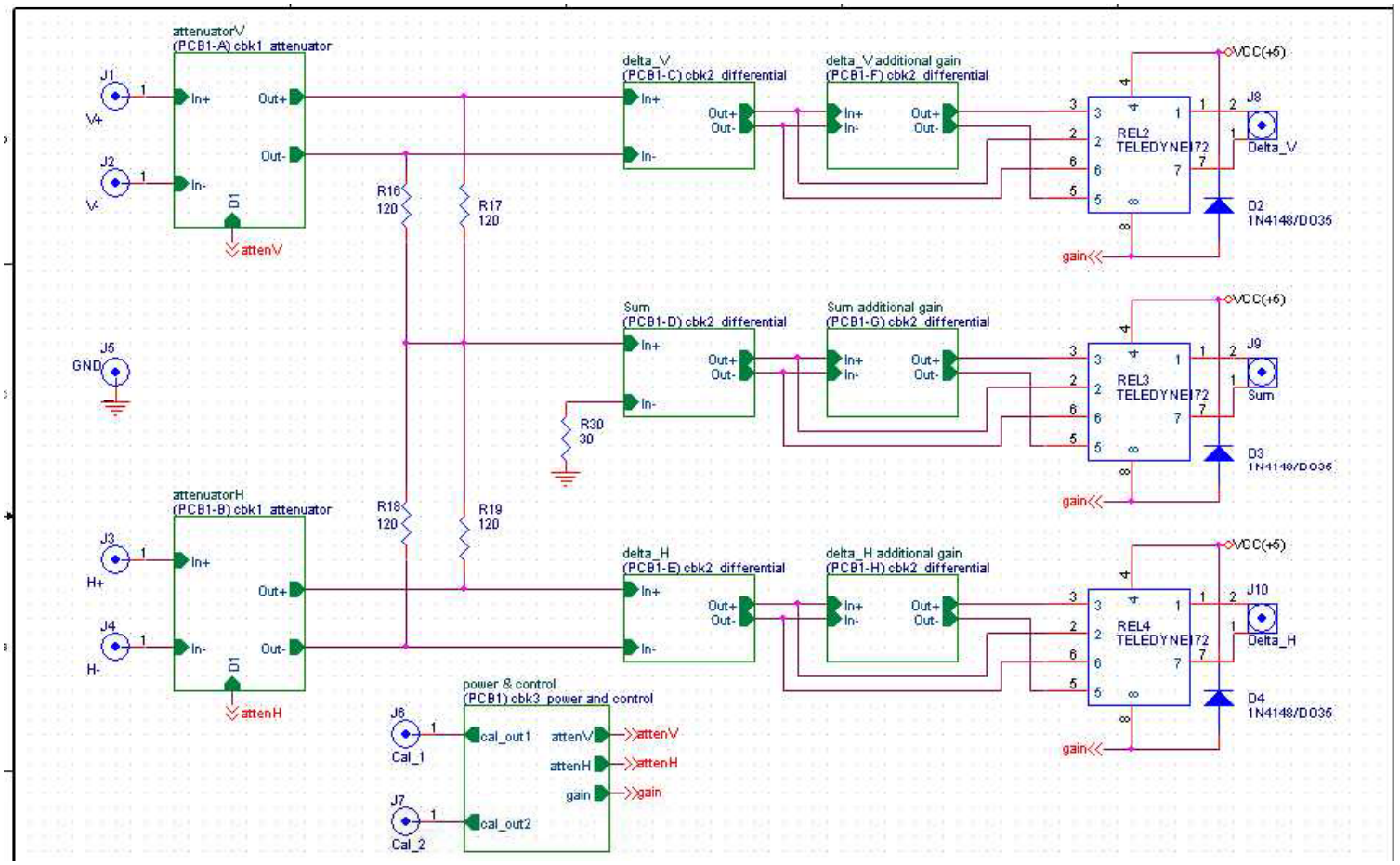
1. Specifications of the interface between the analog amplifier and the digitizer (developed by LAPP researchers) have been defined.
2. Design and schematics of the amplifier.
3. CAD design of the PCB and manufacturing.
4. Building and some tests in the UPC lab.
5. First tests in CERN.

Specifications of the interface between the analog amplifier and the digitizer

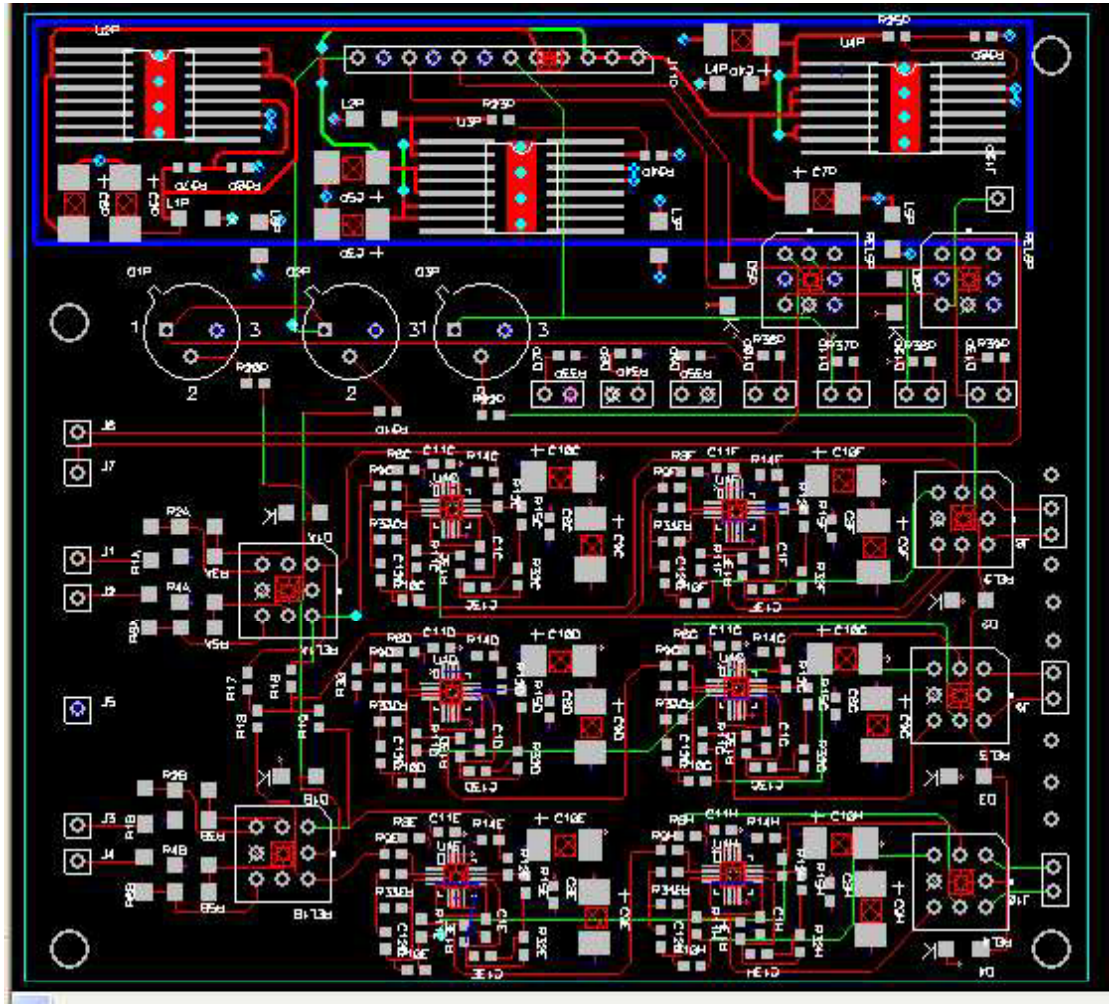
The following information was obtained from the LAPP group:

- The analog outputs must be bipolars.
- Levels: +-0,75V max.
- The power and control connector pinout has been determined.
- The signal output must consist in 3 double (balanced) signals: 1 sum and 2 differences.

Schematics done according to the previous specifications



The CAD design of the PCB has been also finished



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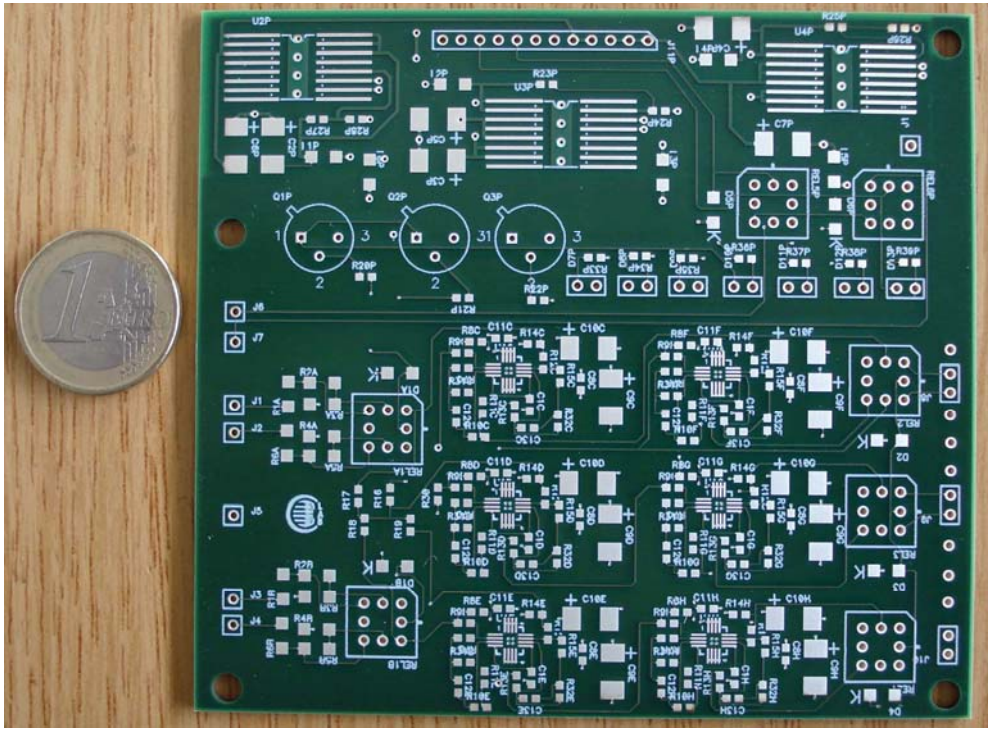
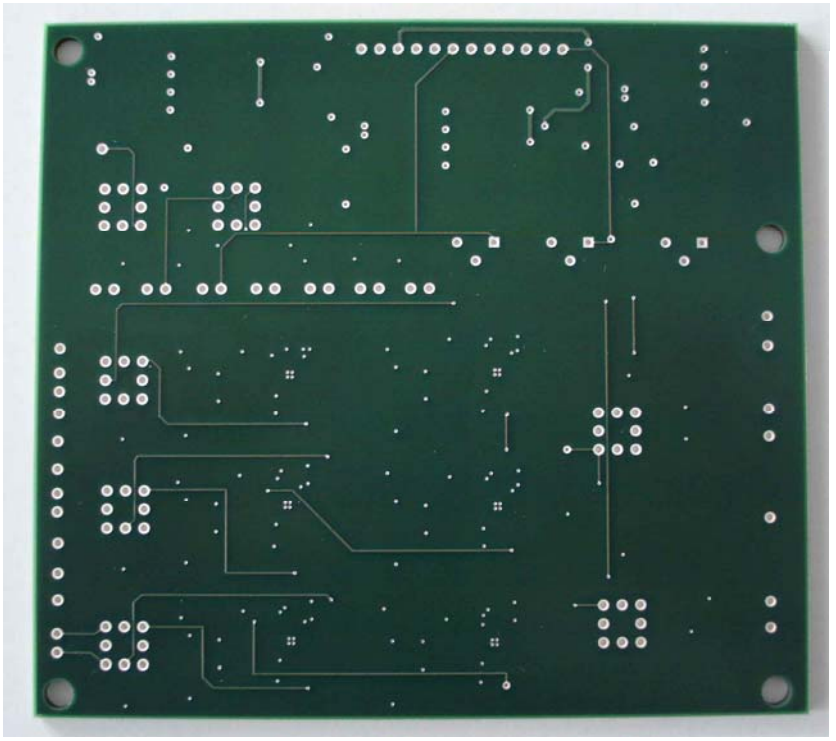
The Bill Of Materials (BOM)

Item	Quantity	Reference	Part	Footprint	Manufacturer	Distributor Price
1	18	C1H,C1G,C1F,C1E,C1D,C1C,C8H,C8G,C8F,C8E,C8D,C8C,C11H,C11G,C11F,C11E,C11D,C11C	100n	SMD0603		
2	6	C2P,C3P,C4P,C5P,C6P,C7P	22u	EIA-6032-28		
3	12	C9H,C9G,C9F,C9E,C9D,C9C,C10H,C10G,C10F,C10E,C10D,C10C	1u	EIA-6032-28		
4	12	C12H,C12G,C12F,C12E,C12D,C12C,C13H,C13G,C13F,C13E,C13D,C13C	CAP-NP/0603	SMD0603		
5	7	D1B,D1A,D2,D3,D4,D5P,D6P	1N4148/DO35	DO35		
6	7	D7P,D8P,D9P,D10P,D11P,D12P,D13P	LEDPCB2/PIN	2PIN		
7	1	J1	V+	1PIN		
8	1	J2	V-	1PIN		
9	1	J3	H+	1PIN		
10	1	J4	H-	1PIN		
11	1	J5	GND	1PIN		
12	1	J6	Cal_1	1PIN		
13	1	J7	Cal_2	1PIN		
14	1	J8	Delta_V	2PIN		
15	1	J9	Sum	2PIN		
16	1	J10	Delta_H	2PIN		
17	1	J11P	CONPCB12/PIN	12PIN_100MIL		
18	1	J12P	CALIN	1PIN		
19	6	L1P,L2P,L3P,L4P,L5P,L6P	EMI_IND	SMD1206		
20	3	Q1P,Q2P,Q3P	IRHLF770Z4/TO39	TO39		
21	7	REL1B,REL1A,REL2,REL3,REL4,REL5P,REL6P	TELEDYNE172	TELEDYNE172		
22	12	R1B,R1A,R2B,R2A,R3B,R3A,R4B,R4A,R5B,R5A,R6B,R6A	R/1206	SMD1206		
23	12	R7H,R7G,R7F,R7E,R7D,R7C,R15H,R15G,R15F,R15E,R15D,R15C	348	SMD0603		
24	12	R8H,R8G,R8F,R8E,R8D,R8C,R14H,R14G,R14F,R14E,R14D,R14C	287	SMD0603		
25	12	R9H,R9G,R9F,R9E,R9D,R9C,R12H,R12G,R12F,R12E,R12D,R12C	16.5	SMD0603		
26	12	R10H,R10G,R10F,R10E,R10D,R10C,R13H,R13G,R13F,R13E,R13D,R13C	50	SMD0603		
27	6	R11H,R11G,R11F,R11E,R11D,R11C	100	SMD0603		
28	4	R16,R17,R18,R19	120	SMD0603		
29	21	R20P,R21P,R22P,R23P,R24P,R25P,R26P,R27P,R28P,R31H,R31G,R31F,R31E,R31D,R31C,R32H,R32G,R32F,R32E,R32D,R32C				
30	1	R30	30	SMD0603		
31	7	R33P,R34P,R35P,R36P,R37P,R38P,R39P	1K	SMD0603		
32	6	U1H,U1G,U1F,U1E,U1D,U1C	THS4508	QFN16	TI	TI 6
33	1	U2P	RHFL7913A	FLAT16		
34	2	U3P,U4P	RHFL4913	FLAT16		

The 6-layers manufactured PCB



TOP



BOTTOM

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The most critical components: IC amplifier

- Rad-hard wideband IC amplifier: THS4508 (manufactured by TI and tested by up to 100 Krads).

  Status:

  We have received some samples from AVNET-SILICA (a TI distributor). It's possible to buy this IC online at Farnell distributor website.

TEXAS INSTRUMENTS
www.ti.com

SLAS469D – SEPTEMBER 2006 – REVISED MAY 2007

WIDEBAND, LOW NOISE, LOW DISTORTION FULLY DIFFERENTIAL AMPLIFIER

FEATURES

- Fully Differential Architecture
- Common-Mode Input Range Includes the Negative Rail
- Minimum Gain of 2 V/V (6 dB)
- Bandwidth: 2 GHz
- Slew Rate: 6400 V/µs
- 1% Settling Time: 2 ns
- HD_2: –72 dBc at 100 MHz
- HD_3: –79 dBc at 100 MHz
- OIP_2: 78 dBm at 70 MHz
- OIP_3: 42 dBm at 70 MHz
- Input Voltage Noise: 2.3 nV/√Hz (f > 10 MHz)
- Noise Figure: 19.2 dB (G = 10 dB)
- Output Common-Mode Control
- 5-V Power Supply Current: 39.2 mA
- Power-Down Capability: 0.65 mA

APPLICATIONS

- 5-V Data-Acquisition Systems
- High Linearity ADC Amplifier
- Wireless Communication
- Medical Imaging
- Test and Measurement

DESCRIPTION

The THS4508 is a wideband, fully-differential operational amplifier designed for single-supply 5-V data-acquisition systems. It has very low noise at 2.3 nV/√Hz, and extremely low harmonic distortion of –72 dBc HD_2 and –79 dBc HD_3 at 100 MHz with 2 V_{PP}, G = 10 dB, and 1-kΩ load. Slew rate is very high at 6400 V/µs and with settling time of 2 ns to 1% (2 V step) it is ideal for pulsed applications. It is designed for minimum gain of 6 dB, but is optimized for gain of 10 dB.

To allow for dc coupling to ADCs, its unique output common-mode control circuit maintains the output common-mode voltage within 5-mV offset (typical) from the set voltage, when set within 0.5 V of mid-supply. The common-mode set point is set to mid-supply by internal circuitry, which may be over-driven from an external source.

The THS4508 is a high-performance amplifier that has been optimized for use in high performance, 5-V single supply data acquisition systems. The output has been optimized for best performance with its common-mode voltages set to mid supply, and the input has been optimized for best performance with its common-mode voltage set to 0.7 V. High performance at a low power-supply voltage makes for high-performance single-supply 5-V data-acquisition systems with a minimum parts count. The combined performance of the THS4508 in a gain of 10-dB driving the ADS5500 ADC, sampling at 125 MSPS, is 82-dBc SFDR, and 68.3-dBc SNR with a –1-dBFS signal at 70 MHz.

The THS4508 is offered in a Quad 16-pin leadless QFN package (RGT), and is characterized for operation over the full industrial temperature range from –40°C to 85°C.

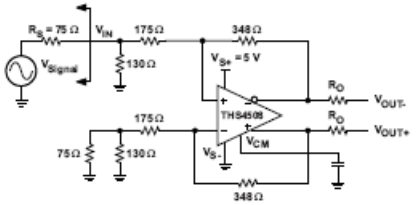
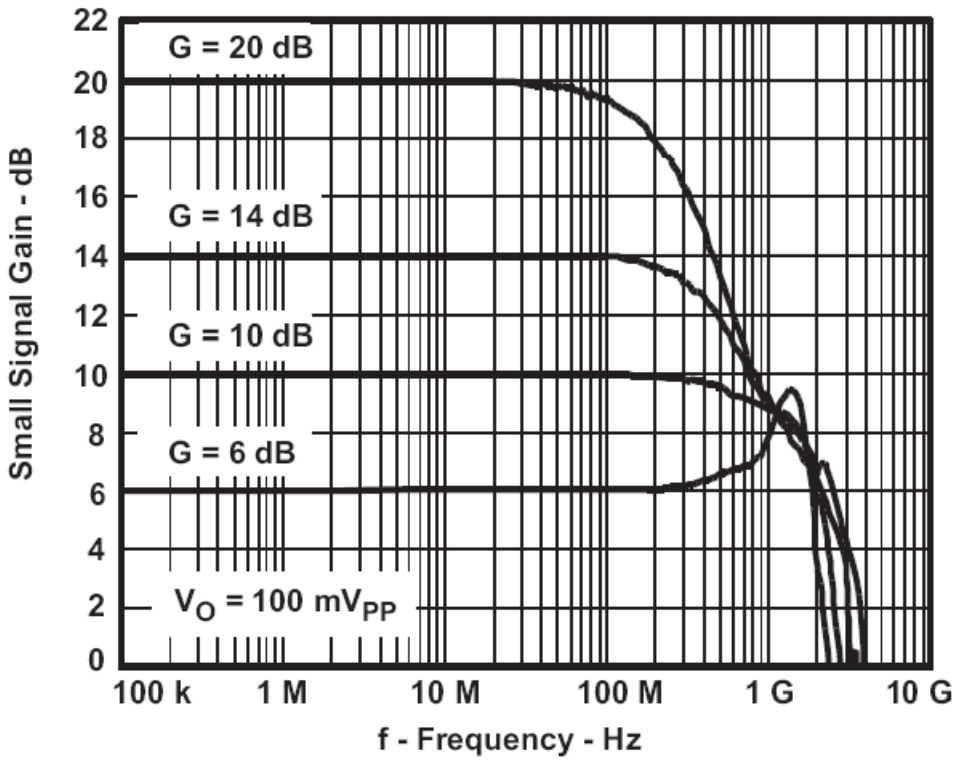


Figure 1. Video Buffer

SMALL-SIGNAL FREQUENCY RESPONSE



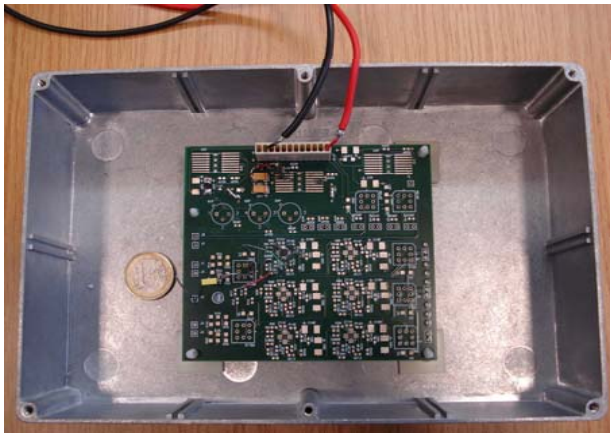
The most critical components: regulators

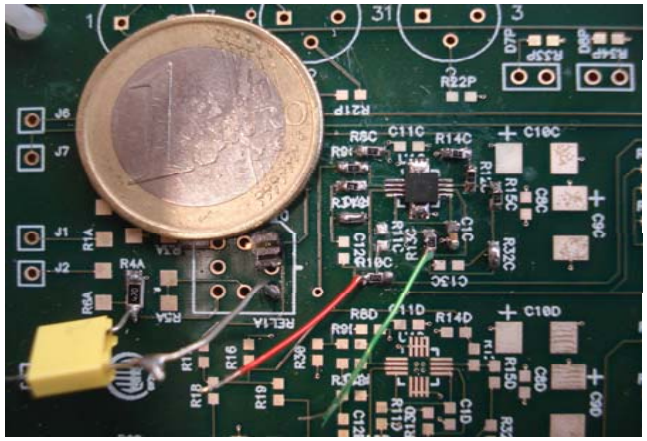
- RHFL4913 (positive regulator). Tested up to 100 Krads by the manufacturer, ST.
- RHFL7913A (negative regulator). Tested up to 100 Krads by the manufacturer, ST.

Status:

- These IC's are manufactured by ST.
- The RHFL4913 and the RHFL7913A can be obtained with the help of CERN (available at CERN store): these regulators are considered to be used in the ATLAS experiment.

BPM Amplifier: UPC Lab tests





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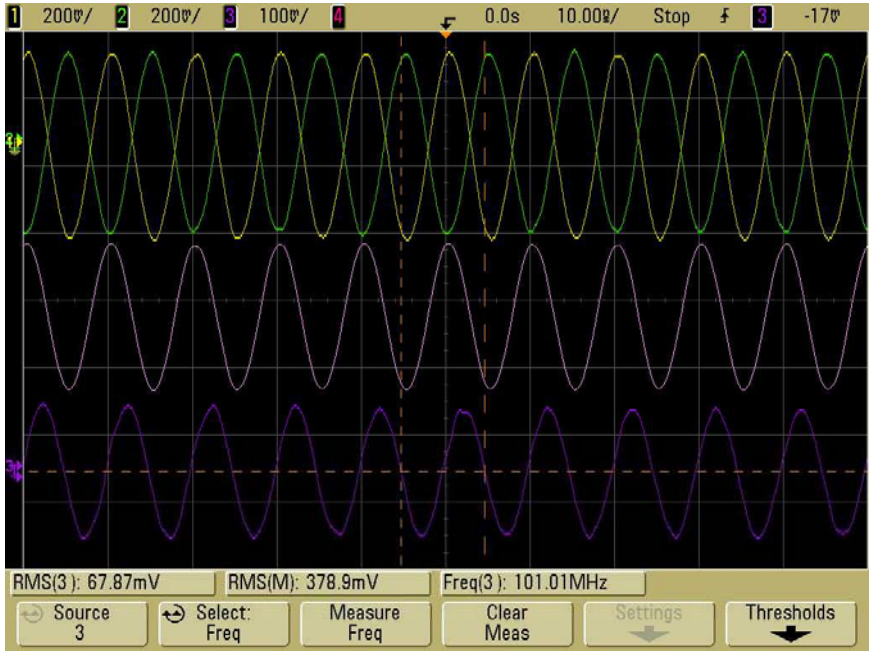
UPC Lab. tests: Testing one channel

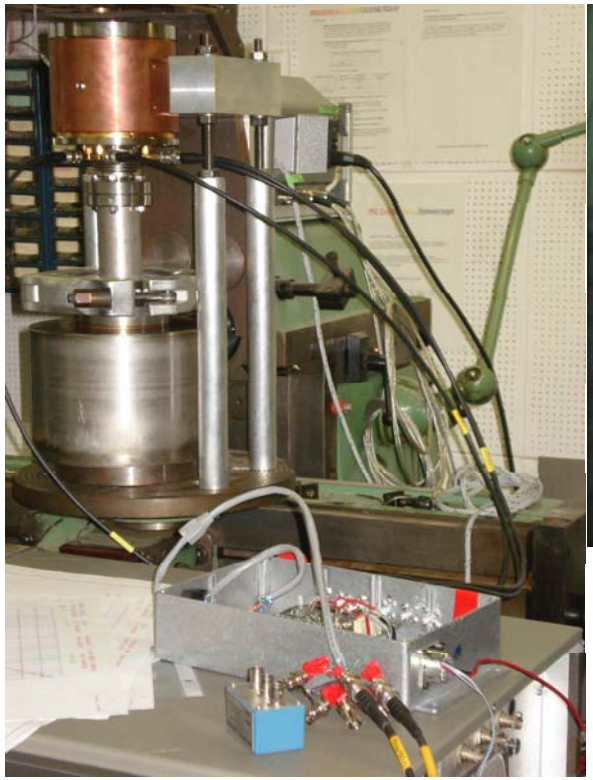
- Maximun gain of each stage: 10

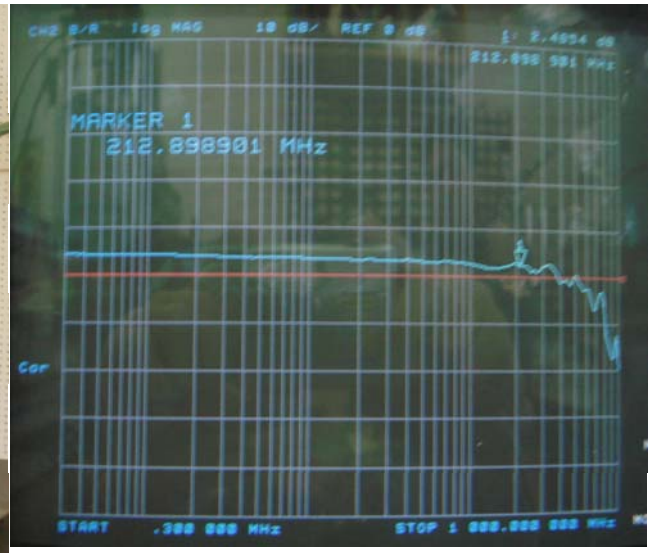
- Measured bandwidth: up to 200 MHz.

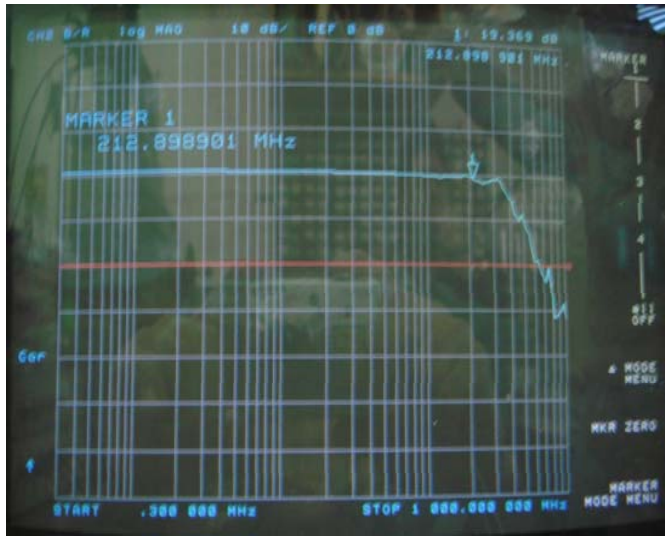
- Input impedance of: 50 ohms ? (It will require a fine measurement and tunning).



First CERN testings: 10th December 2007







Amplifier frequency response (left: low gain, right: high gain)

UPC Amplifier + CERN test-bench

Thanks to Lars Soby for his collaboration !!!

Results

- The results, afther the testings in CERN, show that the amplifier is accomplishing the main electronic requirements:
  - The gain (up to 10 or less) is OK.
  - The bandwidth (up to 200 MHz) is OK.
  - The output level can be accomplished: OK.

- … but there are some improvements to do:
  - Some input impedance decoupling was detected and must be adjusted to match 50 ohms.
  - Some delay diferencies between channels must be compensated.
  - The gain must be adjusted to meet the real IPU signal levels.

Future work-project

- We have presented (last december) a project to the Spanish Ministry to request a Grant for finishing the amplifiers: to build 16+2 (for replacement).

- Our first scheduled action is to build 2 amplifiers during the first half (March ?) of 2008 (now, we have 1 quasi-finished).

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