| | EDMS No.<br>**EDMS 503582** |
|---|---|
| | ST or Div./Group or Supplier/Contractor Document No.<br>**TS-EL** |
| | File name:<br>**second_meas_report_rackmounted_PC_final1.doc** |

| **Report** |
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# SUMMARY OF MEASUREMENTS OF THE RACK MOUNTED PC'S FOR LHC EXPERIMENTS

*Abstract*

The following document is an addition to the existing report 'Measurements of the rack mounted PC's for LHC experiments' (EDMS 442180) [1].

With reference to previous measurements, some of the measurements have been repeated in more detail to better understand the behavior of a whole rack of PC's.

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| *History of Changes* | | | |
|---|---|---|---|
| *Rev. No.* | *Date* | *Pages* | *Description of Changes* |
| | | | |

Template Version: 2000-08-22

## CONTENTS

# 1. INTRODUCTION

The following document is an addition to the existing report 'Measurements of the rack mounted PC's for LHC experiments' (EDMS 442180) [1].

With reference to previous measurements [1], some of the measurements have been repeated in more detail to better understand the behavior of a whole rack of PC's.

Measurement setup and measurement error are the same as during the previous measurement, see [1].

At the time of test, the rack contained the following 46 PC's:

LBFARM001 -> LBFARM005:  5 x ELONEX single CPU 2.4GHz
LBFARM006 -> LBFARM030:  25 x MELROW single CPU 2.4GHz
LBFARM031 -> LBFARM044:  14 x MELROW dual CPU 2.8GHz
LBFARM045:   1 x MELROW dual CPU 2.8GHz (other chassis)
LBFARM046:   1 x MELROW dual CPU 3.06GHz (other chassis)

The type and make of the power supplies are listed on the last page of this report.

## 2.  HARMONIC CURRENT DISTORTION

The harmonic current distortion of the individual types of PC's at full power was measured as follows:

| Type | THD(I) [%] | Recording |
|------|-----------|-----------|
| LBFARM0044 MELROW dual CPU 2.8GHz | 23.5 | Fig. 1 |
| LBFARM0045 MELROW dual CPU 2.8GHz | 30.7 | Fig. 2 |
| LBFARM0046 MELROW dual CPU 3.06GHz | 25.5 | Fig. 3 |
| DELL3250 Dual Titalium | 17.9 | Fig. 4 |
| AMD 2GHZ dual CPU | 19.6 | Fig. 5 |
| Entire rack | 15.8 | Fig. 6 |

It should be noted that a THD(I) below 30% usually results in Neutral currents below 100% of nominal current (if the load is balanced between the three phases). The entire rack had a THD(I) of 15.8%, which is no problem for the power distribution system.

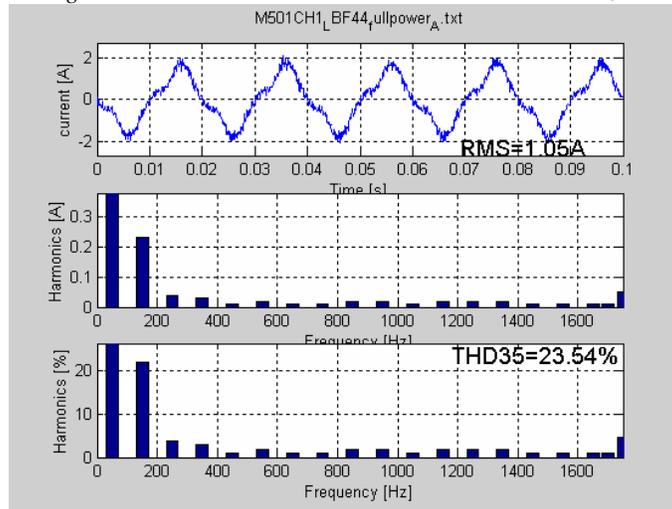*Fig. 1 : LBFARM0044 MELROW dual CPU 2.8GHz*
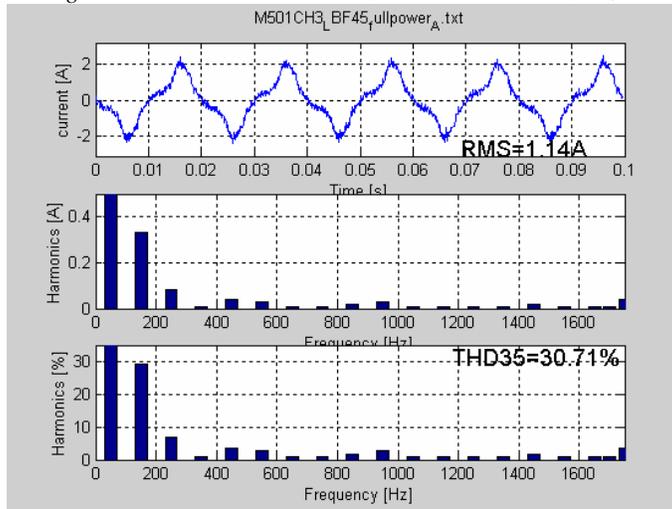


*Fig. 2 : LBFARM0045 MELROW dual CPU 2.8GHz*
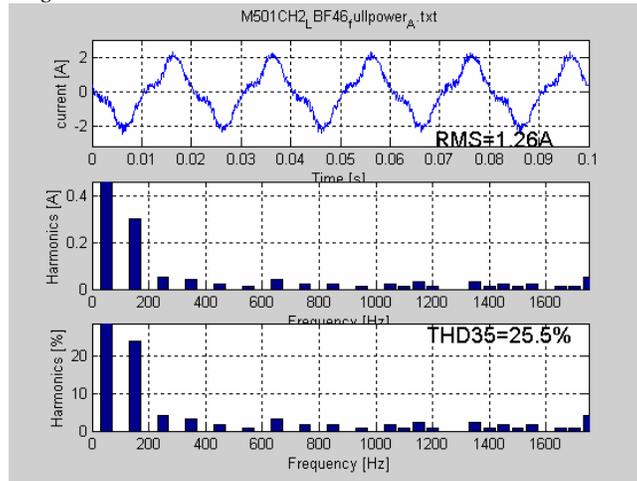
*Fig. 3 : LBFARM0046 MELROW dual CPU 3.06GHz*



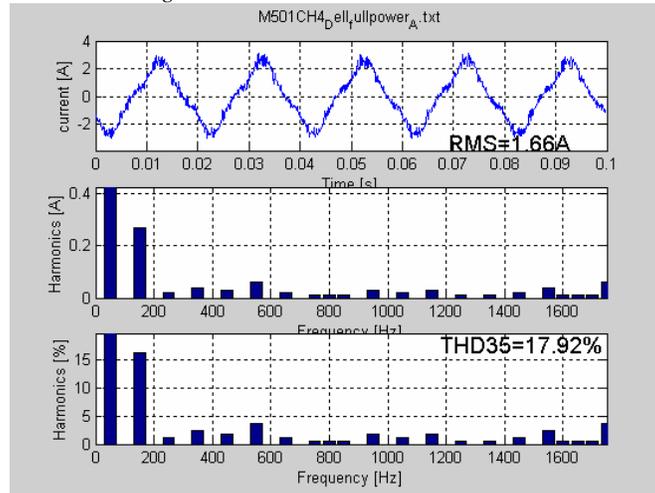*Fig. 4 : DELL3250 Dual Titalium*



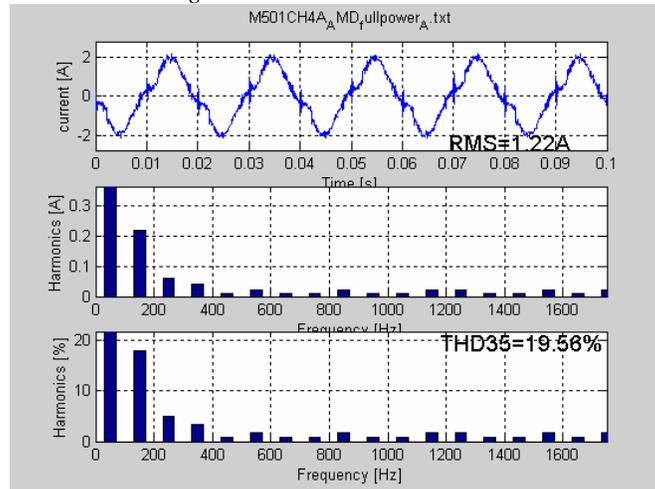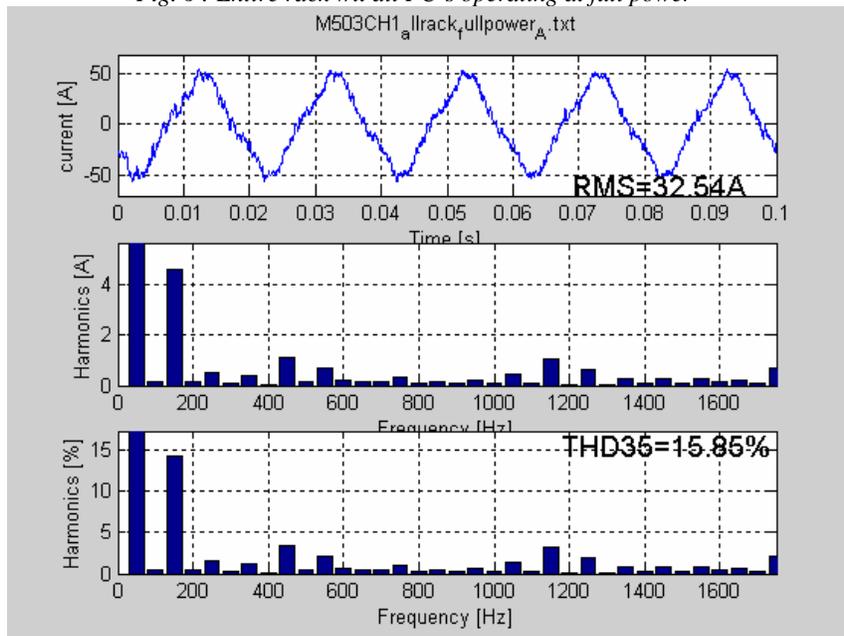*Fig. 5 : AMD 2GHZ dual CPU*

*Fig. 6 : Entire rack wit all PC's operating at full power*

## 3. INRUSH CURRENT DURING ENERGIZATION

*Fig. 7 : LBFARM0023 MELROW single-CPU 2.4 GHz, 100mV/A, corresponding to 10 A per div*
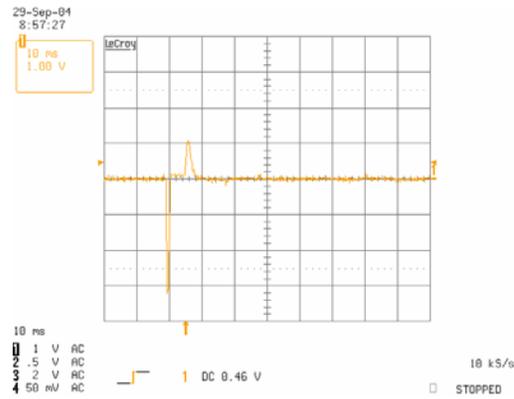*I peak = 32 A*



*Fig. 8 : LBFARM43 MELROW dual CPU 2.8 GHz, 100mV/A, corresponding to 10 A per div*
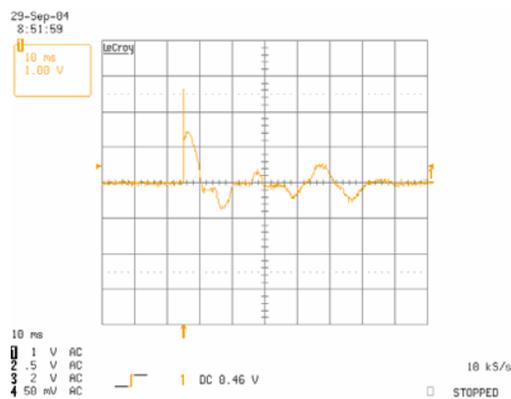*I peak = 27 A*



*Fig. 9 : LBFARM0044 MELROW dual CPU 2.8GHz [M502-CH1],*
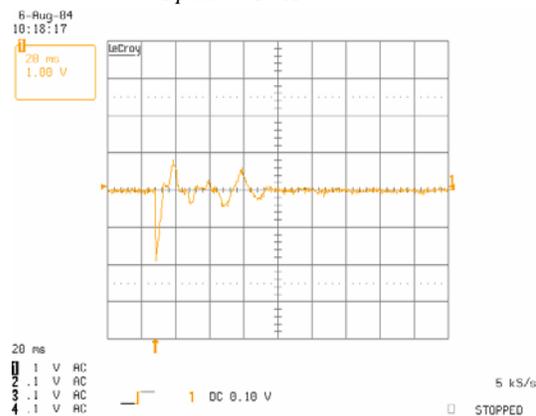*100mV/A, corresponding to 10 A per div*
*I peak = 19 A*

*Fig. 10 : LBFARM0045 MELROW dual CPU 2.8GHz (other type of power supply) [M502-CH3],*
*100mV/A, corresponding to 10 A per div*
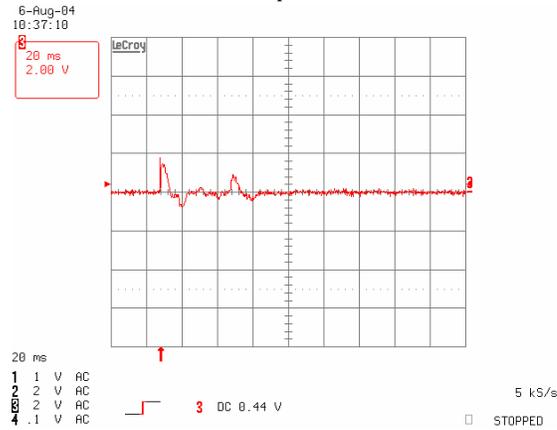*I peak = 9 A*



*Fig. 11 : LBFARM0046 MELROW dual CPU 3.06GHz [M502-CH2],*
*100mV/A, corresponding to 10 A per div*
*I peak = 15 A*



*Fig. 12 : DELL3250 Dual Titalium,  inrush of one power supply (PC has double power supply) [M502-CH4],*
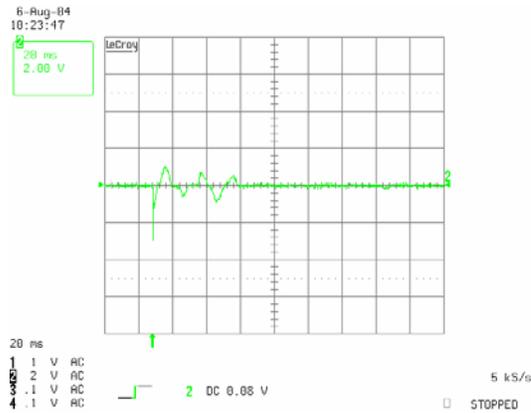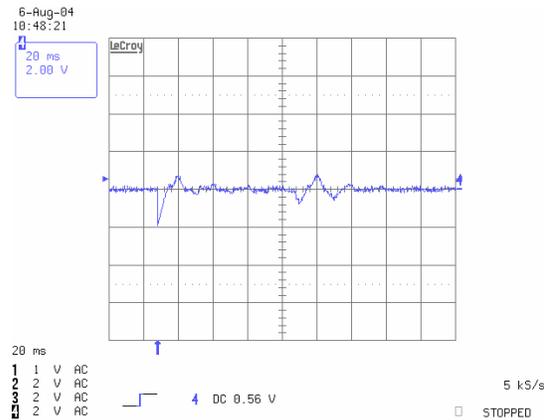*100mV/A, corresponding to 10 A per div*
*I peak = 10 A*

*Fig. 13 : DELL3250 Dual Titalium, inrush of two power suppies (PC has double power supply) [M502-CH4],*
*100mV/A, corresponding to 10 A per div*
*I peak = 20 A*
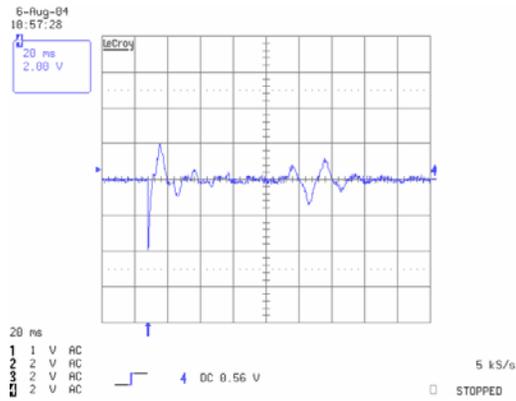


*Fig. 14 : AMD 2 GHz dual CPU., 100mV/A, corresponding to 10 A per div*
*I peak = 13 A*

*Fig. 15 : Inrush of entire rack [M504], 10mV/A, corresponding to 100 A per div*
*I peak = 300 A*



*Fig. 16 : Simultaneous energization of 14 PC's LBFARM43 MELROW dual CPU 2.8 GHz,*
*10mV/A, corresponding to 100 A per div*
*I peak = 160 A*



*Fig. 17 : Simultaneous energization of 25 PC's LBFARM0023 MELROW single-CPU 2.4 GHz*
*10mV/A, corresponding to 100 A per div*
*I peak = 180 A*

## 4. CONCLUSIONS

### 4.1 Harmonic current distortion

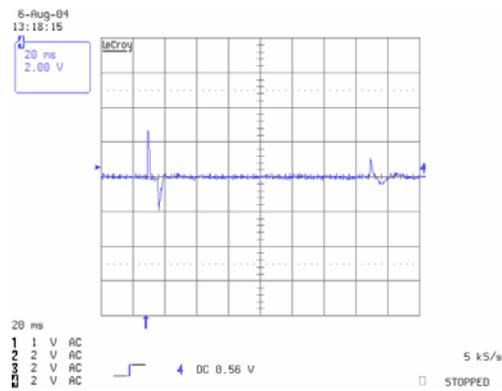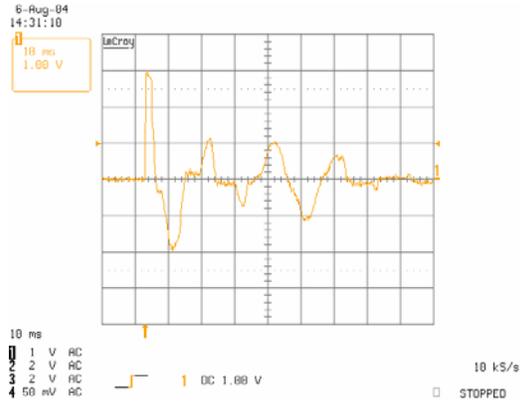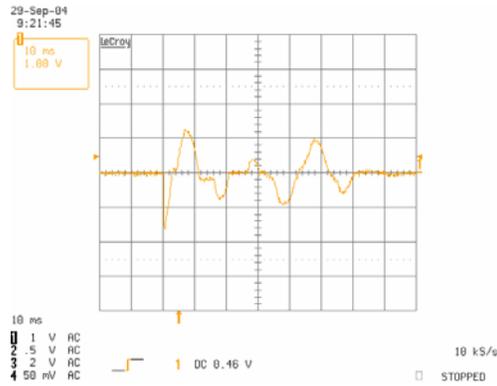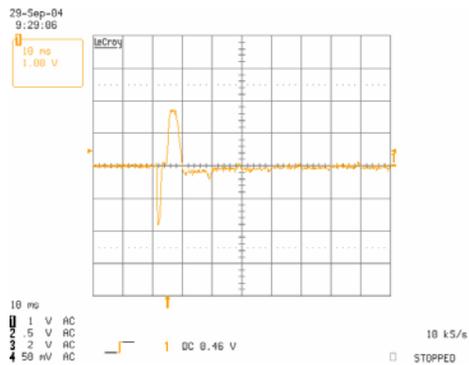The Total Harmonic Current Distortion THD(I) of all PC's was acceptable. The highest value measured was THD(I) = 31%, which will result in Neutral currents below 100% of nominal current (if the load is balanced between the three phases). The entire rack had a THD(I) of 15.8%, which is no problem for the power distribution system.

**Harmonic current emission of the individual PC's shall be in conformity with norm IEC61000-3-2 (class D). [5]**

### 4.2 Inrush current

The feeding circuit breakers 63A (curve D) will trip at 10…14 x In (630…880A). To avoid unwanted trips during energization, the inrush current must remain below 630A. The rack cooling system is rated for 11kW (In=48A). Thus, the rack as a whole must not exceed an inrush current of 630A/48A=13 x In. *Please note that the nominal current In is the current of the PC with the CPU operating at full load.*

| Type | Inrush (peak) in A | Recording |
|---|---|---|
| LBFARM005 ELONEX single CPU 2.4GHz | 46 | see [1] |
| LBFARM0023 MELROW single CPU 2.4GHz | 32 | Fig. 7 |
| LBFARM040 MELROW dual CPU 2.8GHz | 35 | see [1] |
| LBFARM0043 MELROW dual CPU 2.8GHz | 27 | Fig. 8 |
| LBFARM0044 MELROW dual CPU 2.8GHz | 19 | Fig. 9 |
| LBFARM0045 MELROW dual CPU 2.8GHz | 9 | Fig. 10 |
| LBFARM0046 MELROW dual CPU 3.06GHz | 15 | Fig. 11 |
| DELL3250 Dual Titalium with double power supply, 1 power supply switched on | 10 | Fig. 12 |
| DELL3250 Dual Titalium with double power supply, Both power supplies switched on simulataneously | 20 | Fig. 13 |
| AMD 2GHZ dual CPU | 13 | Fig. 14 |
| Entire rack, consisting of 46 PC's of mixed types, as measured in previous report [1] | 300 | Fig. 15 |
| 14 PC's simultaneously like LBFARM0043 and LBFARM0044, MELROW dual CPU 2.8GHz | 160 | Fig. 16 |
| 25 PC's simultaneously LBFARM0023 MELROW single CPU 2.4GHz | 180 | Fig. 17 |

It is impossible to precisely predict the total inrush current of large quantities of PC's, even if the inrush current of a single PC is known. The rack which has been investigated during the measurement campaign is equipped with large numbers of MELROW PC's (=the dominating type), each of them having an inrush current around of 27…32 A. It was observed that the total inrush current of large quantities of identical PC's was by far not the arithmetical sum of the individual inrush currents. During the measurements, an overall reduction factor of 0.2…0.4 was found. This would lead to inrush currents up to 400…700A per rack (all PC's connected to the same phase).

In the future, increasing CPU speed will require larger PC power supplies, potentially leading to higher inrush currents. In addition, the low voltage installation of the LHC experiments will have a much lower short-circuit impedance than the LV system in the test lab, potentially also contributing to higher inrush currents.

It is recommended to connect 3 racks to one outgoing circuit breaker 63A, each rack containing only one single phase. The expected inrush currents for an entire rack 11kW (connected to one single phase) might, under certain conditions, exceed the threshold of 630 A. To avoid potential problems, it is recommended to use a programmed energization sequence via time relay. One time relay (delay 1s) would be required for each 3 racks. In the first phase of energization, the circuit breaker energizes about 40…60% of the PC's, while 1s later a time relay switches on the remaining 60…40% of PC's.

Racks which are designed for less than 8.5kW can be switched on directly via a 63A (curve D) circuit breaker, without time relay energization sequence.

**Power supplies:**

LBFARM0044 MELROW dual CPU 2.8GHz:
Delta Electronic, DPS-350PB-1C (Rev. 02), output 2.55A / 350W max., P/N C32192-003,
S/N DLD0418005248

LBFARM0045 MELROW dual CPU 2.8GHz:
Delta Electronic, DPS-350PB A (Rev. 04), output 2.48A / 350W max., DND0346042863, PNA72233

DELL3250 Dual Titalium
Delta Electronic, DPS-350MBN (Rev. 02), output 350W max., P/N C35096-003, S/N ZID03500 19194
Delta Electronic, DPS-350MBN (Rev. 02), output 350W max., P/N C35096-003, S/N ZID03500 19162

**References:**

[1]     CERN Report "Measurements of the rack mounted PC's for LHC experiments", K. Kahle,
        A. Funken, January 2004, (EDMS 442180)

[2]     CERN Report "Expected harmonic distortion in the LV distribution systems of the
        LHC experiments", K. Kahle, R. Sternberger (FHTW), May 2004, (EDMS 474927)

[3]     CERN Report "Measurements of the electronic crates for LHC experiments", K. Kahle,
        A. Funken, Nov. 2003, (EDMS 442186)

[4]     CERN Report "Measurements for the new LHC Computer Centre 513", K. Kahle, June 2003,
        (EDMS 413142)

[5]     IEC61000-3-2, EMC: Limits for harmonic current emissions (equipment input current < 16A, Oct.
        2001