About an Impedance Database for the Machines in the PS Complex

A. Mostacci

ABSTRACT

In the coming years, the machines in the PS complex will manipulate high intensity beams (e.g. LHC beam or TOF beam). Therefore it is mandatory to keep under control the coupling impedance of all the elements installed in the rings. Activities have been launched to evaluate/measure the coupling impedances of all the elements (whenever possible) and to store those data in a database. Here we present a collection of slides discussing goals and characteristics of such a database and a possible application of the impedance database foreseen for LHC and SPS (ZBASE) to the PS ring.
1 Introduction and motivation
A constant and persistent effort is required to monitor (and improve whenever possible) the beam coupling impedance of all PS machine elements. The PS machine has undergone many upgrades during its evolution over the past decades; as a consequence the beam intensity has been augmented by several orders of magnitude and bunch lengths became shorter. A rigorous control of the PS impedance budget is mandatory in the near future, to allow high intensity beams (e.g. LHC beam or TOF beam) to be manipulated in the machine.

Such an effort is logically divided into two main parts: acquiring the coupling impedance data (both longitudinal and transverse) and storing them in an appropriate database system.

Coupling impedance data of a given element are usually obtained or by analytical estimates or by numerical simulations or even bench measurements. For a great part of the devices installed in the PS, impedance related informations are not available, since they were designed.installed in times where such a parameter was considered not to be critical. On the contrary, in newly designed components (e.g. [1]) the coupling impedance is calculated and minimised at the design stage. That is also the case of LHC, where every element which will enter in the ring, is checked impedance-wise and the impedance data are properly recorded for future use. Concerning the PS complex machines, the lack of available data for the installed items is the main difficulty. Impedance data have been found only for high order modes in the cavities (40 MHz and 80 MHz) [2]. Thus bench measurement campaigns have been started to measure the (longitudinal) coupling impedance of elements taken out from the ring for repair or upgrade; for the moment, the only available items have been two electrostatic septa under the responsibility of the PS/PO group (see [3, 4]).

Once that the impedance data for each element (or the most critical ones) will be available, they will have to be stored (electronically) in a suitable location and to be manipulated in order to provide meaningful informations to accelerator physicists. The following collection of slides discusses possible features of such a storage system, beginning with the tool “officially” decided for the LHC, that is the ZBASE [5].

ZBASE stores the impedance data of all the elements (primary data) in a protected place where all the changes can be tracked and documented. Then it assigns to every element other (user-defined) informations such as optic functions, position in the machine and it stores also the beam parameters. Afterwards, the user is able to “build” his own machine by selecting the elements he need and then compute interesting quantities as machine impedance, Multi-Bunch Instability rise times, Transverse Mode Coupling thresholds. Such a tool might be very useful to study the machine behaviour with respect to layout changes or element upgrades.

Such a tool will be used both for LHC and SPS and thus it will be maintained accordingly. A possible implementation to PS complex is briefly discussed, the main problem being the lack of data. Possible improvement directions of the ZBASE to better fit the needs of the PS machines and even other solutions have been shortly discussed in the slides.

2 Acknowledgements
This work profited of many suggestions by F. Caspers, who always followed very closely my work. Many discussions have also been very useful: O. Brüning helped me a lot with ZBASE while D. Brandt and E. Wildner gave interesting suggestions. J. Belleman,
J. Borburgh, R. Brown, S. Hancock and J. Schinzel explained me a lot about the PS machines and the facilities available in the division. Thanks are also to R. Garoby and A. Blas for support.

References
**PS impedance database**

Impedance database goal (the dream …).

Zbase tool: features.

PS case: sorting the impedance sources.

Zbase tool: limits and developments plans.

Is there any other approach?

Future directions *(your ideas …).*
General view: a tool for accel. design

1. Storing Unit

2. "Selection" Unit

3. Processing Unit

... Primary data (protected)

Secondary data (user accessible)

Beam data

Layout

Optics

Impedance

TMCI thresholds

MBI rise times

...
Zbase approach: directory structure

data/machine/group/Oracle-Name/mode

data/lep/cavities-sc/ascl/long/trans

Compatibility with Oracle based systems !!!

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PS impedance database 22-Mar-02
Zbase: GUI

Database File: /afs/cern.ch/user/z/zdata/public/zbase/archive/.../data

Groups in the Database:
- PTest/cavities
- PTest/septum
- lep/hollows-hi
- lep/hollows-cav
- lep/hollows-ex
- lep/hollows-sh
- lep/hollows-us
- lep/cavities-cu
- lep/cavities-fb
- lep/cavities-sc

Selected Items:
- No-Selection

Tcl-Tk language.

PS impedance database
Zbase: view data

![Diagram of Zbase interface]

PS impedance database

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22-Mar-02
**Zbase: element entries**

Please Select One Option:
- If you want to add a file click on 'AddFile'.
- If you want to remove a file click on 'RemoveFile'.
- If you want to change the item attributes click on 'Attributes'.
- If you want to change the higher order mode entries click on 'HOM'.
- If you want to change the location entries click on 'Location'.
- If you want to add a loss factors click on 'LossFactor'.
- If you want to add a wake potential click on 'Wakepot'.
- If you want to add impedance data click on 'Impedance'.

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**Element label (attributes)**

<table>
<thead>
<tr>
<th>Command Line</th>
<th>Zbase (RF cavity, 80 MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of installed items:</td>
<td>1</td>
</tr>
<tr>
<td>Position of items:</td>
<td></td>
</tr>
<tr>
<td>Horizontal Data Function [m]:</td>
<td></td>
</tr>
<tr>
<td>Vertical Data Function [m]:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$z$</th>
<th>$z_x$</th>
<th>$z_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$i$</td>
<td>$i$</td>
<td>$i$</td>
</tr>
</tbody>
</table>

**Adding a new Impedance file**

Please enter the 'machine', 'group', 'item' labels for the item you want to modify and select the appropriate specifics and click on OK.
Zbase: processing data

Philosophy:
1. select the items.
2. use available information.
3. list non used items.

Warning: numerical values are not meaningful (it is only an example)
**Zbase: comments ...**

Very safe data inserting system to trace all kind of changes (e.g. the data changing is completed only after updating a log file).

Selection of different elements of the machine is possible.

Handling many machines.

PS case: one machine for each cycle (suggestion by D. Brandt).

The beam parameters are additional **input variables**.

Calls to external programs (ABCI, URMEL, MAFIA, MAD, …) possible.

Good help and easy use. Mouse oriented GUI (working correctly!!).
## PS elements naming scheme

<table>
<thead>
<tr>
<th>Group</th>
<th>Element Name</th>
<th>Description</th>
<th>Responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavity</td>
<td>C02</td>
<td>rf cavity, 200 MHz</td>
<td>M. Morvillo</td>
</tr>
<tr>
<td></td>
<td>C10</td>
<td>rf cavity, 10 MHz</td>
<td>D. Grier</td>
</tr>
<tr>
<td></td>
<td>C40</td>
<td>rf cavity, 40 MHz</td>
<td>E. Jensen / P. Maesen</td>
</tr>
<tr>
<td></td>
<td>C80</td>
<td>rf cavity, 80 MHz</td>
<td>E. Jensen</td>
</tr>
<tr>
<td></td>
<td>C20</td>
<td>rf cavity, 20 MHz</td>
<td>M. Morvillo</td>
</tr>
<tr>
<td>Transition</td>
<td>TSN</td>
<td>special-normal</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td></td>
<td>TNS</td>
<td>normal-special</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td>Pick-Ups</td>
<td>UDP/USP</td>
<td>Low intensity pick-up</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td></td>
<td>UCS</td>
<td>Compact pick-up standard</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td></td>
<td>UCL</td>
<td>Compact pick-up large</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td></td>
<td>UCS</td>
<td>Compact pick-up large (in straight sections)</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td></td>
<td>UEP</td>
<td>Empty pick-up pot</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td></td>
<td>URP</td>
<td>Resistive position. (wall current monitor)</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td></td>
<td>URS</td>
<td>Wide band, resistive (wall current monitor)</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td></td>
<td>UWB</td>
<td>Electrostatic pick-up</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td></td>
<td>UQU</td>
<td>Quadrupolar pick-up</td>
<td>A. Jansson</td>
</tr>
<tr>
<td>Vacuum pumps/valves</td>
<td>VPI</td>
<td>ion pump 200l/s.</td>
<td>E. Mahner / J. Hansen</td>
</tr>
<tr>
<td></td>
<td>VPI</td>
<td>ion pump 400l/s.</td>
<td>E. Mahner / J. Hansen</td>
</tr>
<tr>
<td></td>
<td>VPT</td>
<td>turbomolecular pump</td>
<td>E. Mahner / J. Hansen</td>
</tr>
<tr>
<td></td>
<td>VS</td>
<td>vacuum sector valve</td>
<td>E. Mahner / J. Hansen</td>
</tr>
<tr>
<td>Vacuum chamber</td>
<td>VCC</td>
<td>ceramic vacuum chamber</td>
<td>E. Mahner / J. Hansen</td>
</tr>
<tr>
<td></td>
<td>VCI</td>
<td>corrugated Inconel vacuum chamber</td>
<td>E. Mahner / J. Hansen</td>
</tr>
<tr>
<td>Septum magnets (only under vaccum)</td>
<td>SEH</td>
<td>electrostatic septum (sec. 23-31)</td>
<td>J. Borburgh</td>
</tr>
<tr>
<td></td>
<td>SMH</td>
<td>magnetic septum (sec.16-26-42-57-74-92)</td>
<td>J. Borburgh</td>
</tr>
<tr>
<td></td>
<td>SH</td>
<td>Shims</td>
<td>T. Zickler, D. Cornuet</td>
</tr>
<tr>
<td>Kickers</td>
<td>KDP</td>
<td>kicker, damper.</td>
<td>T. Fowler</td>
</tr>
<tr>
<td></td>
<td>kFA</td>
<td>fast injection kicker (monoturn).</td>
<td>T. Fowler</td>
</tr>
<tr>
<td></td>
<td>kSW</td>
<td>slow injection kicker (multiturn).</td>
<td>T. Fowler</td>
</tr>
<tr>
<td></td>
<td>KFA</td>
<td>fast ejection kicker.</td>
<td>T. Fowler</td>
</tr>
<tr>
<td></td>
<td>KFB</td>
<td>kicker, transverse feedback.</td>
<td>J. Gonzalez / G. Lobeau</td>
</tr>
<tr>
<td></td>
<td>KOM</td>
<td>kicker, Q-measurement.</td>
<td>J. Belleman / J. Gonzalez</td>
</tr>
<tr>
<td>Monitors</td>
<td>MBP</td>
<td>beam profile monitor</td>
<td>G. Martini</td>
</tr>
<tr>
<td></td>
<td>MSG</td>
<td>SEM grid</td>
<td>G. Martini</td>
</tr>
<tr>
<td></td>
<td>MSR</td>
<td>miniscanner</td>
<td>J. Borburgh</td>
</tr>
<tr>
<td></td>
<td>MTO</td>
<td>minitoposcope</td>
<td>G. Martini</td>
</tr>
<tr>
<td></td>
<td>MTV</td>
<td>TV screen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MGP</td>
<td>Gas profile monitor prototype</td>
<td>R. Maccaferri</td>
</tr>
<tr>
<td></td>
<td>MIP</td>
<td>Ionisation Profile Monitor</td>
<td>R. Maccaferri</td>
</tr>
<tr>
<td>Coupling Circuits</td>
<td>Z</td>
<td>standard impedance: $R = 0.8 , \text{Ohm}$, $C = 0.415 , \text{uF}$.</td>
<td>J. P. Terrier</td>
</tr>
<tr>
<td></td>
<td>Zp</td>
<td>standard impedance sur pince.</td>
<td>J. P. Terrier</td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>Port court-circuit.</td>
<td>J. P. Terrier</td>
</tr>
<tr>
<td>Transformers</td>
<td>TRA</td>
<td>beam current transformer (SS38 &amp; 44)</td>
<td>C. Carter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>beam current transformer (SS34)</td>
<td>P. Odier</td>
</tr>
</tbody>
</table>

Discussions with J. Belleman, J. Borburgh, R. Brown, S. Hancock.
The Zbase is the official tool for SPS/LHC impedance data storing.

Program writer: O. Burning (SL/AP)
Responsible (LHC and SPS): D. Brandt (SL/AP)

The impedance data (LHC) are collected for each element with a definitive design and they are going to be stored in the database.

The link with the optical functions and the machine layout will be reviewed (in connection with E. Wildner, “responsible” of LHC sequence).
Present limits … (my point of view)

Platform compatibility (after 12 Nov. 2001): HP-UX (SLAP) → LINUX

Some modules suffered from machine dismantling (cernsp → rsplus → lxplus).

The distinction between Unit 1 (storing) and Unit 2 (selection) should be deeper.

Unit 2 (“selection”) need to be designed (plans for this in the SL/AP): this unit might be accelerator dependent.

Few small bugs
Other approaches? (I)

Discussion with J. Schinzel (suggested by E. Wildner and S. Hanckock).

Inserting information in the ACCIS (storing only the imped. related data).

A system analogous to the Zbase is possible to make (starting from scratch): support by J. Schinzel.

Once the data are stored in a Zbase like structure can be converted in an ACCIS compatible format and vice versa (to be more carefully checked).

My comment: Building the unit 2 is not much more difficult than starting from scratch.

Warning: There are different databases used in LHC and PS worlds (why??).
Other approaches? (II)

Discussion with J. Schinzel.

Processing unit (as in Zbase) → Rise times
Optics, layout Beam info → Thresholds
Impedance data

Not a difficult problem (J. Schinzel)
Possible future directions (I)

Minimal solution:
collecting impedance data “copying the directory structure”.

Checking the list of PS elements, filling the database with the available data.
Simulations of installed structure (from CAD drawings??).
Data about transverse problem maybe more difficult to get.
The data can be inserted in a reasonably simple system (J. Schinzel).
Booster???

Comments:
time (not many available data).
No straight-forward usage of the data.
Data format and future compatibility/usage (problem reduced if using ACCIS).
Possible future directions (II)

Maximal solution:
An impedance database makes sense only in a long time scale … contribute in order to have a fully operational/transparent tool.

Set up a to-do list to improve the Zbase (80% done).

Collaboration in upgrading the Zbase code and defining the unit 2 (considering PS necessities).

Building a new tool in the ACCIS environment??

Comments:

time (maybe).
synchronization with SL/AP.

one maintained (and useful) toll for every CERN machine.
Pick-Ups (discussion with J. Belleman)

New classification of pick-ups (the others are identical to the R.B. naming):

Compact pick-Up (large) mounted in pumping manifolds
Compact pick-Up (standard) mounted in pumping manifolds
Compact pick-Up (large) mounted on the straight section (sec17, 33, 63)
Empty pick-up pot (sec 30)

Tof beam: 200 W on the wall current monitor URS.

Estimated impedances (to be checked and understood):

URS 6 Ohm (100 Hz – 3 GHz)  URP 1 Ohm (100 Hz – 3 GHz)

The electrostatic pick-up UWB is similar to a cube with 120 mm side)