DESIGN AND DEVELOPMENT OF THE ECR ION SOURCE CONTROL SYSTEM*

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Abstract

The Rare Isotope Science Project at the Institute for Basic Science constructs a heavy ion accelerator (RAON) facility in South Korea. The stable ion beam for the RAON accelerator could be generated by ECR ion source system. Therefore, it is necessary to build an ECR ion source control system that could be integrated into an accelerator control system easily. The vacuum control system is divided several parts because of one vacuum chamber among three different voltage stages (ground, 50 kV, and 80 kV). In this report, we will present the preliminary design and implementation of vacuum control system for the ECR ion source. We plan to use a Programmable Logic Controller (PLC) in order to control the vacuum system through interlock logic program. The PLC system has two major components: a digital I/O module that provides power to each component and standard RS-232 modules to connect the gauge and pump controllers. In addition, we will discuss its extension plan to integrate the vacuum control system into the RAON accelerator control system based on the EPICS framework.

SYSTEM CONFIGURATION

The driver linac injector of the RAON consists of a 28-GHz superconducting Electron Cyclotron Radiation (ECR) ion source, the LEBT (low energy beam transport), the 500-keV/u RFQ (radio-frequency quadrupole) and the MEBT (medium energy beam transport). For the ECR ion source, superconducting magnets and dual high power RF sources of 28 GHz and 18 GHz are used to improve its performance [1]. The high voltage ion sources could get from two different high voltage platforms (50kV and 80kV). The Vacuum control system for the ECR ion source is consisted of Allen-Bradley PLC (AB PLC) modules. The AB PLC chassis consists of four chassis and are installed each of the electrical potentials racks. Each vacuum control devices are connected with AB PLC modules to control turbo pumps and to read pressure of the vacuum chamber. Vacuum gauge controller (XGS-600) is used to read pressure and to communicate with AB PLC through serial cable using RS232 protocol. Similarly, OSAKA turbo pump controller and LAYBOLD turbo pump controller are used to operate turbo pumps with AB PLC through serial cable. In order to construct the network system for connection among multi-voltage stages, we used remote IO modules 1756-AN2TR and 1734-AENTR of AB PLC. 1756-AN2TR and 1734-AENTR modules are used to connect each of two racks on ground state through LAN cable by MOXA switch. And 1783-ETAP2F modules has used to connect among one rack of ground state and two racks installed on high voltage stages (50 kV and 80 kV) directly through optical fibers because communication failure occurred when LAN cable is used. The basic configuration of the control system is indicated by the network diagram shown in Fig. 1. Dashed lines are optical fibers and solid lines are LAN cables. Each chassis are installed at each platform as below figure 4. Internet Protocol (IP) address is assigned to two areas 192.168.1.* (area A) and 100.100.100.* (area B) according to voltage platforms level to reduce the risks from high voltage difference. The area 'A' is connected to total network of the test facility that included the ECR ion source facility. The area 'B' is local network that connects between remote IO modules of the AB PLC only. Because the IP address is not enough when configure the total network system of the test facility. The control system performs the interlocks for the vacuum system of the ECR ion source. And this system will be integrated with the Experimental Physics and Industrial Control System (EPICS) to operate the system record the parameter values by EPICS Input Output Controller (IOC) using "process variables" in real-time.

* Work supported by ...

MANUSCRIPTS

Templates are provided for recommended software and authors are advised to use them. Please consult the individual conference JACoW2014A4.texhelp pages if questions arise.

General Layout

These instructions are a typical implementation of the requirements. Manuscripts should have:

- Either A4 (21.0 cm × 29.7 cm; 8.27 in × 11.69 in) or US letter size (21.6 cm × 27.9 cm; 8.5 in × 11.0 in) paper.
- ***Single-spaced*** text in two columns of 82.5 mm (3.25 in) with 5.3 mm (0.2 in) separation. More recent versions of MSWord have a default spacing of 1.5 lines; authors must change this to 1 line.
- The text located within the margins specified in Table 1 to facilitate electronic processing of the PDF file.

Table 1: Margin Specifications

Margin	A4 Paper	US Letter Paper
Top	37 mm (1.46 in)	0.75 in (19 mm)
Bottom	19 mm (0.75 in)	0.75 in (19 mm)
Left	20 mm (0.79 in)	0.79 in (20 mm)
Right	20 mm (0.79 in)	1.02 in (26 mm)

The layout of the text on the page is illustrated in Fig. 1. Note that the paper's title and the author list should be the

width of the full page. Tables and figures may span the whole 170 mm page width, if desired (see Fig. 2), but if they span both columns, they should be placed at either the top or bottom of a page to ensure proper flow of the text (Word templates only: the text should flow from top to bottom in each column).

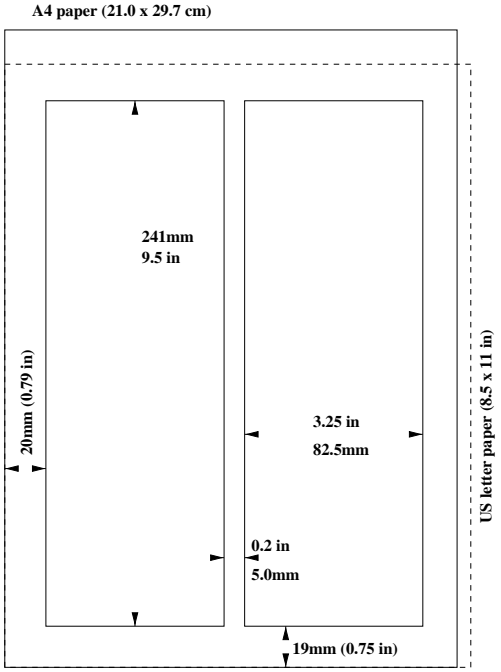

Figure 1: Layout of papers.
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Fonts

In order to produce good Adobe Acrobat PDF files, authors using a LaTeX template are asked to use only Times (in roman [standard], bold or italic) and symbols from the standard set of fonts. In Word use only Symbol and, depending on your platform, Times or Times New Roman fonts in standard, bold or italic form.

Title and Author List

The title should use 14 pt bold uppercase letters and be centered on the page. Individual letters may be lowercase to avoid misinterpretation (e.g., mW, MW). To include a funding support statement, put an asterisk after the title and the support text at the bottom of the first column on page 1—in Word, use a text box; in LaTeX, use `\thanks`. JACoW2014A4.tex The names of authors, their organizations/affiliations and mailing addresses should be grouped by affiliation and listed in 12 pt upper- and lowercase letters. The name of the submitting JACoW2014A4.texor primary author should be first, followed by the co-authors, alphabetically by affiliation.

Section Headings

Section headings should not be numbered. They should use 12 pt bold uppercase letters and be centered in the column. All section headings should appear directly above the text—there should nevJACoW2014A4.texer be a column break between a heading and the following paragraph.

Subsection Headings

Subsection headings should not be numbered. They should use 12 pt italic letters and be left aligned in the column. Subsection headings use *T*itle *C*ase (or *I*nitial *C*aps) and should appear directly above the text—there should never be a column break between a heading and the following paragraph.

Third-level Headings are created with the LaTeX command `\subsubsection`. In the Word templates authors must bold the text themselves; this heading should be used sparingly. See Table 2 for its style details.

Paragraph Text

Paragraphs should use 10 pt font and be justified (touch each side) in the column. The beginning of each paragraph should be indented approximately 3 mm (0.13 in). The last line of a paragraph should not be printed by itself at the beginning of a column nor should the first line of a paragraph be printed by itself at the end of a column.

Figures, Tables and Equations

Place figures and tables as close to their place of mention as possible. Lettering in figures and tables should be large enough to reproduce clearly. Use of non-approved fonts in figures can lead to problems when the files are processed. LaTeX users should be sure to use non-bitmapped versions of Computer Modern fonts in equations (Type 1 PostScript or OpenType fonts are required, Their use is described in the JACoW help pages [1]).

Each figure and table must be numbered in ascending order (1, 2, 3, etc.) throughout the paper. Figure captions (10 pt font) are placed below figures, and table captions are placed above tables. Single-line captions are centered in the column, while captions that span more than one line should be justified. The LaTeX template uses the 'booktabs' package to format tables.

A simple way to introduce figures into a Word document is to place them inside a table that has no borders. This is done in Word as described below.

Note: If the figureJACoW2014A4.tex spans both columns, do all steps. If the figure is contained in a single column, start at step 5.

1. Insert a continuous section break.
2. Insert two empty lines (makes later editing easier).
3. Insert another continuous section break.
4. Click between the two section breaks and Page Layout → Columns → Single.
5. Insert → Table select a one-column, two-row table.JACoW2014A4.tex
6. Paste the figure in the first row of the table and adjust the size as appropriate.

Figure 2: Example of a full-width figure showing the JACoW Team at their annual meeting in 2012. This figure has a multi-line caption that has to be justified rather than centered.

7. Paste/Type the caption in the second row and apply the appropriate figure caption style.
8. Table → Table properties → Borders and Shading → None.
9. Table → Table properties → Alignment → Center.
10. Table → Table properties → Text wrapping → None.
11. Remove blank lines JACoW2014A4.texfrom in and around the table.
12. If necessary play with the cell spacing and other parameters to improve appearance.

If a displayed equation needs a number (i. e., it will be referenced), place it flush with the right margin of the column (see Eq. 1). The equation itself should be indented (centered, if possible). UJACoW2014A4.texnits should be written using the roman (standard) font, not the italic font:

$$C_B = \frac{q^3}{3\epsilon_0 mc} = 3.54\,\mu\mathrm{eV/T} \qquad (1)$$

References

All bibliographical and web references should be numbered and listed at the end of the paper in a section called **REFERENCES**. When citing a reference in the text, place the corresponding reference number in square brackets [2]. The reference citations in the text should be numbered in ascending order.

A URL may be included as part of a reference, but its hyperlink should NOT be added. Multiple citations should appear in the same square bracket [1, 3, 4] or with ranges, e.g., [1]– [4] or [1–4, 10].

Examples of correctly formatted references can be found at the JACoW website (http://JACoW.org). Once there, click on the 'for Authors' link at the top and then on the 'Formatting Citations' link in the left-hand column [1].

Footnotes

Footnotes on the title and author lines may be used for acknowledgments, affiliations and e-mail addresses. A non-numeric sequence of characters (*, #, †, ‡) should be used. Word users—DO NOT use Word's footnote feature (**Insert**, **Footnote**) to insert footnotes, as this will create formatting problems. Instead, insert the title or author footnotes manually in a text box at the bottom of the first column with a line at the top of the text box to separate the footnotes from the rest of the paper's text. The easiest way to do this is to copy the text box from the JACoW template and paste it into your own document. These "pseudo footnotes" in the text bJACoW2014A4.texox should only appear at the bottom of the first column on the first page.

Any other footnote in the body of the paper should use the normal numeric sequencing and appear as footnote[1] in the same column where they are used.

Acronyms

Acronyms should be defined the first tJACoW2014A4.texime they appear.

STYLES

Table 2 summarizes the fonts and spacings used in the styles of a JACoW template (these are implemented in the LaTeX class file).

PAGE NUMBERS

DO NOT include any page numbers. They will be added when the final proceedings are produced.

[1] This text should appear in the column where it was referenced.

Table 2: Summary of Styles

Style	Font	Space Before	Space After
Paper Title	14 pt Upper case except for required lower case letters Bold	0 pt	3 pt
Author list	12 pt Upper and Lower case	9 pt	12 pt
Section Heading	12 pt Uppercase bold	9 pt	3 pt
Subsection Heading	12 pt Initial Caps Italic	6 pt	3 pt
Third-level Heading	10 pt Initial Caps Bold	6 pt	0 pt
Figure Captions	10 pt	3 pt	6 pt
Table Captions	10 pt	3 pt	3 pt
Equations	10 pt base font	12 pt	12 pt
References	9/10 pt, justified with 0.25 in hanging indent, reference number right aligned	≥0 pt	≥0 pt

TEMPLATES

Templates and examples can be retrieved through web browsers such as Firefox, Chrome and Internet Explorer by saving to disk.

Template documents for the recommended word processing software are available from the JACoW website (`http://JACoW.org`) and exist for LaTeX, Microsoft Word (Mac and PC) and OpenOffice for US letter and A4 paper sizes.

Use the correct template for your paper size and version of Word. Do not transport Microsoft Word documents across platforms, e.g., Mac ↔ PC. JACoW2014A4.texWhen saving a Word 2010 file (PC), be sure to click 'Embed fonts' in the Save options. Fonts are embedded by default when printing to PDF on Mac OSX.

Please see the information and help files for authors on the JACoW.org website for instructions on how to install templates in your Microsoft templates folder.

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- Use only Times or Times New Roman (standard, bold or italic) and Symbol fonts for text—10 pt minimum except references, which can be 9 pt or 10 pt.
- Figures should JACoW2014A4.texuse Times or Times New Roman (standard, bold or italic) and Symbol fonts when possible—6 pt minimum.
- Check that citations to references appear in sequential order and that all references are cited [10].
- Check that the PDF file prints correctly.
- Check that there are no page numbers.
- LaTeX users can check their margins by invoking the `boxit` option.

CONCLUSION

Any conclusions should be in a separate section directly preceding the **ACKNOWLEDGMENT**, **APPENDIX**, or **REFERENCES** sections, in that order.

ACKNOWLEDGMENT

Any acknowledgment should be in a separate section directly preceding the **REFERENCES** or **APPENDIX** section.

APPENDIX

Any appendix should be in a separate section directly preceding

the **REFERENCES** section. If there is no **REFERENCES** section, this should be the last section of the paper.

REFERENCES

[1] JACoW.org website: `http://jacow.org/index.php?n=Authors.UsingLaTeX`{no hyperlink, no period after URL}

[2] A.N. Other, "A Very Interesting Paper", EPAC'96, Sitges, June 1996, MOPCH31 (1996), `http://www.JACoW.org` {no hyperlink, no period after URL}

[3] F.E. Black et al., *This is a Very Interesting Book*, (New York: Knopf, 2007), 52.

[4] G.B. Smith et al., "Title of Paper", MOXAP07, *These Proceedings*, IPAC'14, Dresden, Germany (2014).

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[10] B. Gnats, A. Jones, Phys. Rev. ST Accel. Beams 1, 011502 (1998).