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Curve Generation for the RF Systems of the Antiproton Source
Console Program Specification & Implementation

Abstract:

The RF curves program is a PDP-11 console application to calculate the time dependence of amplitude, frequency, and phase for the RF systems of the Antiproton Source. The results of the calculation are formatted and scaled for the curve generator hardware. The user interface of the program is highly flexible with respect to the choice of parameters used to specify the desired curve. It consists of file management, plotting, editing, and hardware loading phases which are implemented as separate pages on the console display. This document provides the functional specification of the program and a discussion of the status of its implementation.

Functional Specification

1.1 General Aims

All of the RF systems used in the Antiproton Source have smoothly time dependent parameters which will be controlled by hardware curve generators; probably these curve generators will all be combinations of 070 time base and 071 value generators. Some will be connected with point-slope analog output modules and some will be either analog or digital point (staircase) generators. However, the possibility exists that it will prove convenient to use the 160 dipole function generator or 069 time base in some application. The flexibility to respond to such possible variants is to be incorporated into the program design. Many of the curve generators must be reloaded when the mode of Source operation is changed, for example, from from $\bar{p}$ production to Main Ring injection. Therefore, the curves must be available to the so-called mode select software as well as to the programs which monitor/control particular RF systems. This interprogram communication occurs through the creation of FSHARE files by the curves program and its reading of any such files created by the mode select or sequencer programs which specify acceptable or desired time intervals for particular processes.

1.2 File Management

The first display page which the user sees when he calls up the the curves program at the console is shown in Fig. 1. The user must identify which RF system he wants to deal with. When the system is chosen the program reads in the file containing the parameters of the ring, the parameters of the chosen RF system, and an index of the files containing the parameters of particular curves. The user then chooses an index slot which may be either occupied or empty. This file contains or will contain adequate information to completely specify the desired curve. The program associates with each file in addition to its target system the attributes full/empty/active and stack/unstack/bunch/debunch/diagnostic, where active means the file is available to the hardware in immediately loadable form. On the file management page the selected file is indicated in reverse video and the active file by cyan color (background or foreground according to whether the file is also selected or not). The title of the selected file also appears on the process selection line where it is available for editing. On this line the user indicates what is to be done with the file; the editing, plotting, or hardware loading page is called according to the choice made here. Various warnings and verification requests appear on the message line below for actions that may change the active file or destroy a saved file. The system descriptor line contains (<u>ad lib.</u>) such information as the frequency for the reference orbit the maximum RF voltage, <u>etc</u>. The file structure is described in the later discussion of program implementation.

1.3 Plotting

The user will be able to plot not only the basic V, f, & ϕ vs. time but the following important derived quantities as well: energy difference from the reference orbit (ΔE), radial offset from the reference orbit (ΔR), bucket area (S_b), synchronous phase (ϕ_s), frequency difference from the reference orbit value (Δf), rate of energy change (dE/dt), and adiabaticity parameter (α). Up to four quantities may appear on a single plot so scaled that a ten-tic vertical scale covers 2, 5, or 10 units in the first significant figure of each quantity. This choice makes it possible to read two significant figures easily for each quantity and simultaneously reduces the overplotting of one curve by another. The plotting page appears as Fig. 2. The contents are a precis of the selected curve and a command line for choosing the quantities to plot. The selected variables appear in reverse video with the background color to match the plotting color. An interrupt in the field named by a particular variable toggles the select off/on. The default plotting limits appear on lines 23 and 24 below the corresponding variable selection fields; they can be replaced by a user entry. The user may exit from the plotting page to either editing or file management.

1.4 Curve Creation and Modification

The editing page (see Fig. 3) is nearly filled by a table specifying a time dependance for the parameters of the selected RF system. If the process is file creation, the table is empty; for editing it contains the information in the selected file. Each part of a curve is called a sequence, and each type of sequence has one of the names INITIAL, CAPTURE, MATCH, MOVE, DEPOSIT, RESET, or END. For each sequence there are two lines in the table containing the twelve quantities name, Δt, ΔE, ΔR (RPOS), bucket area (BA), ϕ_s, Δf, V, dE/dt, adiabaticity (α), number of segments (NSEG), and initial time. There are program limits of 10 sequences and 100 segments per sequence. The parameter set contains redundant information. In specifying an edit change or a new sequence the user employs those parameters which are easiest or most meaningful to him; the program calculates the rest. If the specified set is not sufficient to to define a sequence the program assumes that the value of the missing quantity(ies) should be carried over from the preceeding sequence except in cases where such a carry over is in logical contradiction to the meaning of the sequence. For example, if a MOVE is specified without bucket area the value from the preceeding is used, but if no ΔE is specified a diagnostic for incomplete data will be displayed. Variables copied from the preceeding sequence will be represented by ditto marks ("). The user may explicitly force a copy by entering ditto marks into the desired variable field. Values entered by the user will be displayed in reverse video, those calculated by the program in normal mode. The routines which calculate missing parameters incorporate a priority ordering to resolve any inconsistent values for redundant parameters entered by the user. These routines also provide tests for RF voltage limits, acceptable adiabaticity parameter, etc. The exit line from the editing page allows transfer to plotting or file management.

1.5 Calculations

The numerical calculations in the curve program are distributed among the editing, plotting, and hardware loading phases. The editing phase calculates the twelve parameter set for the endpoints of each sequence. The plotting phase calculates the basic f, V, and ϕ vs. t for all segments. The hardware loading phase formats and scales the curves according to the particulars of the target system and converts amplitude curves to amplitude and counterphase angle for the systems using this technique to achieve low voltage. If a plot is to be made of one of the derived quantities ΔE, ΔR, S_B, ϕ_s, dE/dt, or α it is calculated from the f, V, and ϕ curves at each point and stored into a plot buffer.

The computation is reduced to managable proportions by including in every system file Taylor series coefficients for the important variables as functions of E, f, and R expanded about the reference orbit. Simillarly, the moving bucket area and height correction factors α and β are stored as cubic spline fits in $\Gamma = \sin(\phi_s)$. The machinery for producing these tables is in a program which fits SYNCH results for γ_{tr} vs. $\Delta p/p$ and appropriate combinations of γ_{tr}, β, γ, and R by orthogonal polynomials and transforms the results to Taylor series. This program is not and should not be a console program. It need only be rerun if a ring lattice is changed significantly.

1.6 Hardware Loading

The curves program is not necessarily the immediate source of information loaded into the curve generators. If the mode select software is adequately developed and if the proper type of curve is in the active file, the mode select program can oversee the loading of the needed curves. For systems which have two routine functions like the stacking and bunching functions of ARF-1, there are in fact two active files. The one that is (or should be) loaded is determined by the operating mode selected by the mode select program. However, for system development, for maintenance, and to circumvent inadequacies of the mode select or sequencer software it will be possible for the curves program to directly load the curve generators; suitable caution and diagnostic messages will discourage casual use of this capability. Also, the programs devoted to monitoring and control of particular systems may use the active file to reload the hardware. What active really means is that the point by point curves have been derived from the designated active parameter file and stored in hardware image form in a file known to all relevent programs. A *SEND command from the curves program forces the loading of this file at the next cycle (supercycle?)

Implementation Plans and Status

2.1 Overview

The code corresponding to the foregoing requirements comes from two sources. The first is a large system (CYBER) program written to test the strategies, perform the required calculations more or less exactly, and to do the fitting to provide the coefficients for the polynomial approximations used in the console application version. The second source is primarily new code now being written to employ the FSHARE file structure, to restructure the user interface for the console terminal, to produce the plots on the Lexidata device, and to make the computed curves available to the hardware. This new code has been refered to as file management, user interface, plotting, and hardware loading respectively. A major element in the user interface code design is the choice of what information is to be put on which display pages and by what conventions to symbolize processes desired by the user and actions taken by the program. This human engineering aspect is complete as it can be until tested by serious use.

This program serves a function similar to program MODIFY (PA0112) by R. Johnson and R. Goodwin, but there are enough differences in the application that very little code can be appropriated directly except that for plotting. Some of the differences arise by necessity from the storage ring nature of the Antiproton Source rings and some few arise from a retrospective choice to make the program more flexible in user input. However, an effort is being made to retain a qualitative simillarity in the user interface and to borrow whatever clever ideas appear applicable. The general idea of polynomial fitting, for example, suggested by PA0112, is applied even more widely in the curves code.

The present coding effort is targeted on a development version of the code expected to be complete in December which uses simplified plotting facilities, reduced curve size, and no touch panel. The motivation for this tactic is not only to avoid some of the inessential coding temporarily but also to postpone the development of an overlay strategy. However, the code is highly segmented internally into functional modules (including function specific common blocks) and temporal phases in such a way that overlay is expected to be straightforward. The curves program is basically simpler than MODIFY because it deals only with the RF systems and because $B = 0$. There is somewhat greater complexity in curve parameterization, but this shows up primarily in some extra instructions and not in data storage. The fact that the curve generators for the Antiproton Source are the 070/071 combination with a potential for 1024 point curves instead of the 32-point 160 dipole function generators generally used in the Tevatron clearly means one will avoid keeping many complete curves in storage at one time.

2.2 File Management

All files will be in the FSHARE system on the directory branch RSX$FSHARE_APPLICAT_PBAR_RF:. The file containing the system parameters will have the name of the system and an extension of .PAR, e.g., ARF1.PAR. This file will contain the necessary lattice parameters, the properties of the RF system, the expansion coefficients for system dependent variables, the index for the curve parameter files, and the attributes of the index slots (full/empty/active and stack/unstack/bunch/debunch/diagnostic). The names of the curve parameter files will have the form Syst_nn.CRV, e. g., ARF109.CRV will be file number 9 for ARF1.The active files containing the hardware load images will be named in the form Syst_t_n.ACT, where Syst is the four character system name, t is a tag which differentiates separate functions for a given system, and n numbers separate curve generator modules. "t" can take on the literal values S (stacking), U (unstacking), B (bunching), D (debunching), and X (experimental or diagnostic). The values n reflect the specific target module according to the convention 0 (070 time base), 1 (amplitude), 2 (frequency), 3 (phase), 4 (counterphasing angle), 5 (amplitude in point-slope form), and 6 (frequency in point-slope form). The .PAR files and .CRV files will have relative organization with block lengths of 120 and 44 bytes respectively and the .ACT files will have sequential organization. The access method will be direct (read/write) for the .PAR and .CRV files and sequential (write) for the .ACT files.

The current status of this file structure is that a .PAR file exists for ARF-2 which is being used for test data. The .CRV and .ACT files will be written by the curves program. The user interface has been defined; coding is in progress.

2.3 Plotting

Plotting will probably ultimately be passed to the Goodwin plotting package SA0050, but during the development phase Al Thomas' PLTPKG will be used, modified as necessary. The code for computation of derived curves and scaling of all curves to the same axes is complete. The user interface has been defined and coding is underway.

2.4 Editing

The code for the editing function consists of a screening of input parameters to determine that a sequence is completely defined, calculation of parameters not specified, and the user interface to get parameters from the console terminal. The code for the first two phases is complete and the user interface is defined and being coded. The development version will require considerable keyboard and cursor gymnastics. When the basic program is working well it is intended to humanize it with alternative touch panel entries. Both entry modes will be available to accomodate differing tastes.

2.5 Computation

The computation code has been substantially shrunk from the CYBER version by the consistent use of Taylor and cubic spline approximations. The supporting code for producing the approximation coefficients from SYNCH output and the moving bucket factor table exists and is debugged. The computation code for the console program is also mostly written and debugged in its CYBER incarnation. The integration of this code with the new user interface seems to be proceeding smoothly with the writing of the new code.

2.6 Hardware Loading

The interface to the hardware consists of writing the .ACT files and, if requested, identifying the target curve generator from the data base and loading it with the calculated curve. Discussions with those configuring the hardware and related software (i. e., mode select program, sequencer program, and system specific monitor/control programs) has begun and the broad organization of this program phase seems plausible. Unfortunately, some of the relevent information is unavailable or subject to frequent change so that it is not easy to tie down this part of the code. Fortunately, it is a small fraction of the total coding and is sufficiently independent of the rest that all else can be developed to final form with little danger of serious incompatibility. As the curve generators are installed and defined with respect to scaling transformation and point or point-slope function they can be efficiently accommodated ad seriatum.

```
                              FRI  02-NOV-84  20:14

P1                    Antiproton Source RF Curves                  #TV2SS
SYSTEMS - select one:
   1  ARF-1: Accumulator Stacking & Extraction Bunching (h=84)
   2  ARF-2: Accumulator Unstacking (h=2 suppressed bucket)
   3  ARF-3: Accumulator Bunch Narrowing (h=2)
   4  DRF-1: Debuncher Bunch Rotation (h=90)
   5  DRF-2: Debuncher gap & diagnostic (h=4 suppressed bucket)

FILES - select one:
   1                                 2 02 Nov 84 opt debunch
   3 11/2/84 TEST CYCLE              4 02 NOV 84 (EDIT TEST)
   5 Design Report Parameters        6
   7                                 8
   9                                10
  11                                12
  13                                14
  15                                16
  17                                18
  19                                20
  21                                22
  23                                24
#PLOT   #EDIT   #CREATE #DELETE Title:02 NOV 84 (EDIT TEST)
                                                           #ACTIVATE
```

Figure 1: File Management

```
 0         10        20        30        40        50        60      68
-----------------------------------------------------------------------
 1| P1                                                          *TV2SS
 2|            Antiproton Source RF Curves - PLOTS
 3| FILE: .............................  Status: .....  Type:  x
 4|
 5|   Sequence    t init        dt    Delta E    Delta f   V/      Phi S
 6|                  [s]       [s]      [MeV]       [Hz]  Vmax    [deg]
 7|  1 INITIAL   nn.nnn    nn.nnn   snnn.nn    snnn.nn   .nnn   snnn.n
 8|  2
 9|  3
10|  4
11|  5
12|  6
13|  7
14|  8
15|  9
16| 10
17|
18| *PLOT  -  choose up to 4  -                     t0=nn.nnn tf=nn.nnn
19|
20|    dE      Rpos      BA      PhiS      df      V       dEdt    Alpha
21|       .n       .n       .       .        .n     .nn        .       .n
22|       .n       .n       .       .        .n     .nn        .       .n
23|
24| *LXCOPY                                         *FILES  *EDIT
```

FIGURE 2: Plotting page layout

```
 0         10         20         30         40         50         60       68
-----------------------------------------------------------------------------
 1| P1           Antiproton Source RF Curves - EDITING                *TV2SS
 2|    Sequence   Delta t   Delta E      Rpos         BA       PhiS
 3|     Delta f         V     dE/dt     Alpha       Nseg t initial
 4| nn XXXXXXX    .nnnnn       .nnn      .nnn        .nn   .nnnnnn
 5|
 6|
 7|
 8|
 9|
10|
11|
12|
13|
14|
15|
16|
17|
18|
19|
20|
21|
22|
23|
24| SET TAG:Stack   Unstack Bunch   Debunch Diagnos      *PLOT   *FILES
```

FIGURE 3: Editing page layout