PC-BBI, a Program to compute Bunched Beam Instabilites on a PC

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Abstract The program code BBI [1] has originally been designed and coded as a FORTRAN batch program. In its latest version at CERN [2] it runs under the VM System on an IBM computer. The aim of the program code is to compute bunched-beam instabilities for electron and proton storage rings. Its comprises the calculation of bunch lengthening, computation of stability for coupled bunch oscillations and the transverse mode coupling.

1 Introduction

In the context of the LEP running-in the idea was proposed to create an interactive version of the program BBI, with the possibility to modify input data for various computations without exiting the running program. Since interactive programming is achieved most easily on work stations or personal computers, this task was performed on an IBM- compatible PC. This offers very effective programming techniques combined with a high level transportability of the program code.

The program PC-BBI contains the most important parts of the original BBI program. However, since it has been designed for use in the running-in of LEP, the parts relating to proton machines have not yet been implemented.

2 Basic properties of PC-BBI and program description

The interactive program PC-BBI has been written on an IBM compatible personal computer (Olivetti 386) using the programming language QUICK-BASIC, which is a powerful BASIC-compiler offering fully structured programming capabilities together with quick executable programs. For proper execution PC-BBI requires an IBM compatible personal computer with 640 Kilobyte of internal memory, an EGA or VGA graphics card, the operating system MS DOS (version ≥ 2.2) and (for reasonable speed) at least an 8 MHz clock. In addition the user of PC-BBI should have the PC-program KEDIT.EXE on the same mass storage medium since it is used as a subroutine of PC-BBI.

The main program consists of a large loop where commands are input and decoded by a simple command processor. Then depending on the command an IF-chain transfers control to subroutines performing the commands. The loop closes then at the input statement for the next command. The typical PC-BBI command is given by

$$\boxed{\text{KEYWORD par1.par2.....parN}}$$

where KEYWORD is a character string defining the aim of the command while par1.....parN are parameters (numbers or character strings). For example the command:

$$\boxed{\text{USE lep}}$$

will load the input file named "lep.inp" from the mass-storage medium (diskette or hard disk) into the program memory. If a command needs a parameter but none is given, PC-BBI will explicitly ask for it. After loading the input files into the programs memory, they can interactively be modified by the command

$$\boxed{\text{EDI}}$$

which transfers control to the PC-program KEDIT. Quitting from KEDIT by "file" or "qq" will cause a return to the main program. The program PC-BBI comes on 5 1/4 or 3 1/2 diskettes which contain all necessary files for running the program. If the user whishes to run PC-BBI directly from diskette he can do so by just inserting the diskette into the active drive and typing

$$\boxed{\text{BBI}}$$

which will start the program execution. If it is desired to run the program from hard disk first an installation procedure has to be invoked by typing

$$\boxed{\text{INSTALL}}$$

This command will cause a transfer of PC-BBI and all the auxiliary files to the hard disk unit of the user where the program is stored in a subdirectory named PCBBI. Then the program can directly be started from the hard disk by again typing

$$\boxed{\text{BBI}}$$

3 Most important parts of the program

After having started PC-BBI all possible commands can be listed on the screen by invoking the help-facility typing

$$\boxed{\text{H}}$$

after the prompt: ENTER COMMAND: (HELP = h). The programs reaction to this command can be seen on the top of the following page. If a more detailed information is desired one can obtain it by typing the commands name in the given list followed by a question mark like

$$\boxed{\text{TMC ?}}$$

```
==================================================================
KEYWORDS:

use       l        save     edit     dir      print
copy      tmc      cbm      modes    sigma    vary
cls       h        start    long     trans    num
bunch     defaults end
==================================================================

Only the first three letters of any keyword are significant !
For detailed information:
Input: keyword ?

FOR A QUICK REFERENCE TYPE: qr

ENTER COMMAND (HELP=h):
```
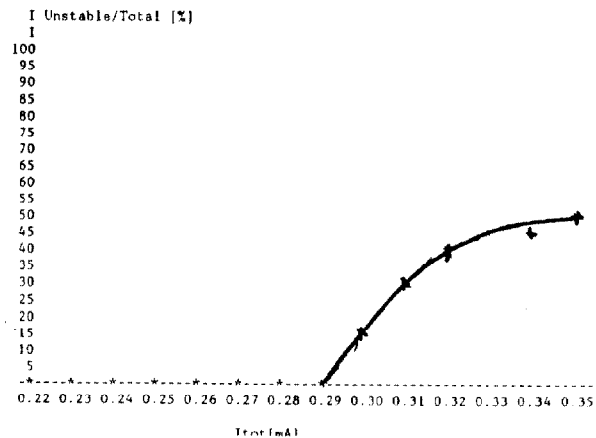
I Unstable/Total [%]

Figure 1: List of all Keywords obtained with command HELP

Figure 3: Threshold Current for Longitudinal Coupled Bunch Modes in LEP

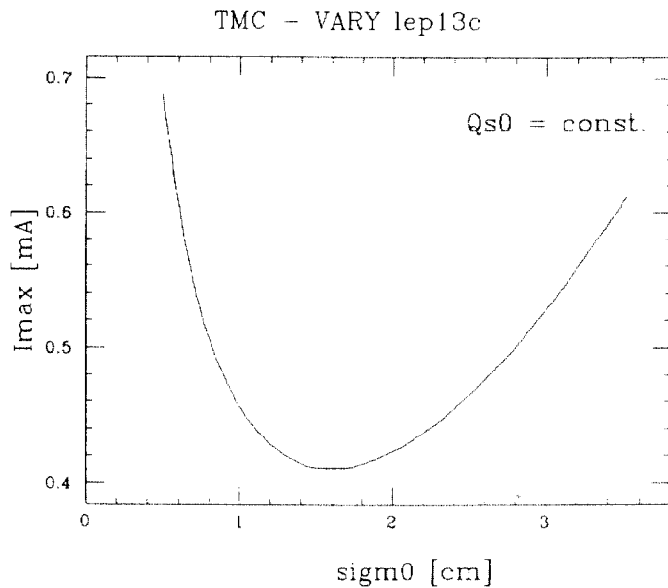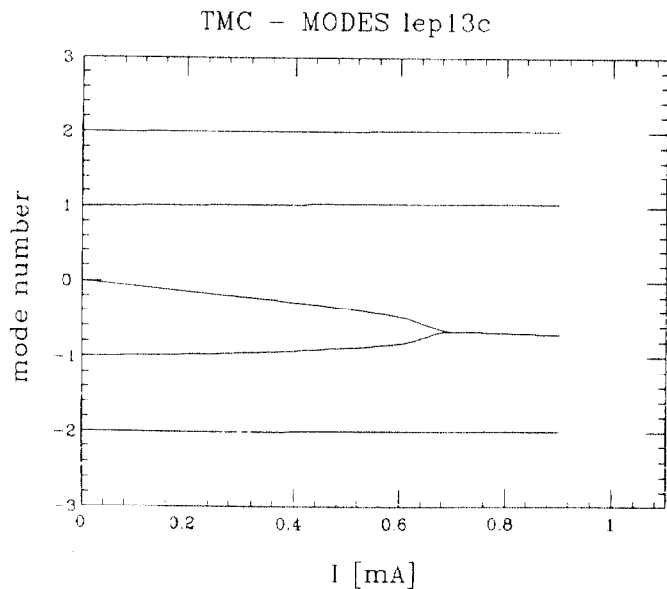TMC – MODES lep13c

TMC – VARY lep13c

$QsO = const.$

Figure 2: Transverse Mode Coupling in LEP - modes +2 to -2

Figure 4: Threshold current for TMC as function of Bunch length

Loading and saving files

On the programs diskette a complete input file LEP13.INP is stored which contains all important parameters for PC-BBI taken for the LEP machine at injection energy. By use of any editor or by invoking the KEDIT editor inside the program, the input file can be modified according to the users whishes. Loading a given file can be done by the "use" command as ex- pained in section 2. Saving a file under a given name to the mass storage medium is achieved by

$$\boxed{\text{SAV filename}}$$

Transverse mode coupling

The transverse mode coupling part of PC-BBI [3] is invoked by the command "TMC". Th program then uses the data given in the active input file (the one which has been loaded before) and asks the user for some additional information (the maximum current in the single bunch and the number of resonators being taken into account. Then the routine computes the lowest beam current at which a crossing of transverse modes occurs. The result together with the actual eigenvalues at the limiting current are displayed. Using the command:

$$\boxed{\text{MOD}}$$

a TOPDRAWER file [4] with name BBI.TOP is created containing all information for a plot of the transverse modes as a function of the beam current (see Fig. 1). In addition typing:

$$\boxed{\text{VAR tmc}}$$

it is possible to obtain the limiting current as a function of either the zero current bunch length or the zero current synchrotron time.

Coupled bunch oscillations

This part can be run under two modes. First for fixed resonator frequencies as they are given in the input file. For these frequencies the various coupled bunch oscillation modes are investigated for a given total beam current. The command is:

$$\boxed{\text{CBM ic}}$$

where "ic" is the total beam current in mA. A list of all possible modes up to certain limits is given and each mode is classified according to its stability properties (damped, Landau-damped, stable or unstable) [5] The second operation mode is the statistical one which is invoked by the command:

$$\boxed{\text{VAR cbm}}$$

This command has the following consequence: For a given interval of the total beam current all resonator frequencies (for all impedances) are varied randomly for a given number of times. For each randomly chosen frequency distribution all coupled bunch modes are checked for stability. Then for each current of the interval the probability for the occurrence of unstable modes is computed using the simple relation

$$\boxed{\text{P(unstable modes)} = \text{NU/NTOT}}$$

where NU is the number of occurrences of unstable modes while NTOT is the total number of experiments. This probability is then plotted as function of the total beam current.

Bunch lengthening

This routine, which is invoked by the command:

$$\boxed{\text{BUN imax}}$$

computes the bunchlength (potential well and turbulent) following the theory in [6]. The parameter "imax" represents the maximum beam current in a single bunch given in mA. The bunchlength as function of the beam current is given as a table. A TOPDRAWER File is also created from the table automatically. If "imax" is not specified, the program will ask for this value.

4 Conclusions

With PC-BBI a first interactive version of the well established and widely used program BBI for computing collective instabilities is presented. The reason of using a PC instead of a main frame computer for writing the program was first the fact that these type computers are used besides others in the LEP control room. In addition using the PC operating system MS-DOS guarantees very easy transportability of the code to any user working with an IBM-compatible computer.

While the program is equivalent to the batch version of BBI in its physics content, it contains also new features. The most important one is the statistical approach to coupled bunch oscillations as described in section 3.3 . The possibility of interactive work with PC-BBI proved to be very efficient in the practical control-room work, where parameters measured in LEP directly could be inserted into the running program to give predictions for the onset of collective instabilities [7] User's being interested to obtain a copy of the program can get one by contacting one of the authors of this contribution. A more detailed user's guide containing a complete list of all commands with explanations is in preparation and will appear as a CERN report[8].

References

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