PERSONAL COMPUTER SYSTEM IN OPERATION OF THE 160cm CYCLOTRON

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ABSTRUCT

A small computer was equipped to the cyclotron to calculate operational parameters and set radio frequency (RF) parameters automatically. Then, operation of the cyclotron, especially beam energy change, became easy and fast. This system can also stabilize the frequency on line, monitor the beam current and aquire data of the operation.

1.INTRODUCTION

The RIKEN 160cm cyclotron was constructed in 1966 and research programs were started in February, 1967. From that time, total operating time of the cyclotron exceeds 50000 hours for these eighteen years and it has been working very efficiently.

The cyclotron is of a weak focusing type and has four sets of trim coils on the pole faces. The RF system, of a self oscillated type, has 180 degree two dees. The frequency range is 6 MHz - 12 MHz. Various particles (H, D, He,.. O, Ne) are accelerated using three types of ion sources. The control system was designed as a central remote system using DC 48V, but in manual.

2.PERSONAL COMPUTER

It is essential to provide the operations staff with fast and easy setting of the operational parameters for any ion species and energy. A small computer was equipped, for this purpose, to the cyclotron control system in July 1983. Figure 1 shows this computer control system with the cyclotron. The NEC PC-9801 (CPU; i8086) small computer was purchased at the end of March 1983. We have prepared isolation amplifiers to detect the actual positions of the cyclotron moving devices connected to the potentiometer circuits[1]. And we have modified the push button switch units (control units) of the control desk. A 14 inch high resolution color graphic display (640 x 400 dots), a dual drive 8-inch floppy disk unit and an 18 pins dot-matrix printer with a 64kB buffer memory are providing us with faster development of programs. The PC-9801 has a main memory of 128kB RAM (96kB is opened for users N88 BASIC program), a 96kB graphic VRAM, a 32kB Text VRAM and 32KB BASIC ROM booter.

We basically developed five programs for the cyclotron operation as follows:
1) CYCLO
2) RF-SET
3) F-STABILIZE
4) IONPLOT
5) CY-PLT, INTEGRA.

Main programs are written in N88-BASIC and some subroutines for I/O control and some graphic commands are written in assembly language. An assembled monitor code is called from the BASIC main program.

3. CYCLOTRON PARAMETER CALCULATION

When we start up the cyclotron, we use the program "CYCLO". If we only input the particle name, charge number and the energy, then all the operational parameters are displayed on the colour CRT and printed out. Continuously, all the RF parameters are set automatically.

A magnetic field, RF frequency, dee voltage and the other resonant frequency or magnetic field's coil current of the nearest m/q particle are calculated from


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CYCLOTPON PARAMETER CALCULATION ( WITH NEW CALIBRATED ENERGY ) Ver.7.6
                                        84/08/18  17:43:31
   PARTICLE= C13

   Q=   4 +,   MO=13.00340,  M=13.10460,  GAMMA= 1.0078

   E=   95.00 MeV .     ( NEW CALIBRATED ENERGY =  90.94 MeV )

      E/u = 7.30769 MeV/u

      M/Q=3.250850      M/Q (Relativ)= 3.276150


   F   =   8.060 MHz .

   V dee =   82.0 kV .   V peek=115.9 kV (at Deflector=749.5mm)

   Iex= 356.4 A .     B  = 1.7237 Tesla


      SH1(A),     SH2(A),     SH3(A),     SH4(A)·
        3.8         5.0         4.3         8.8

   Q-01 = 14.0 A

   Q-02 = 11.5 A

   Beam Cours= 5 ,        SWI = -34.1 A
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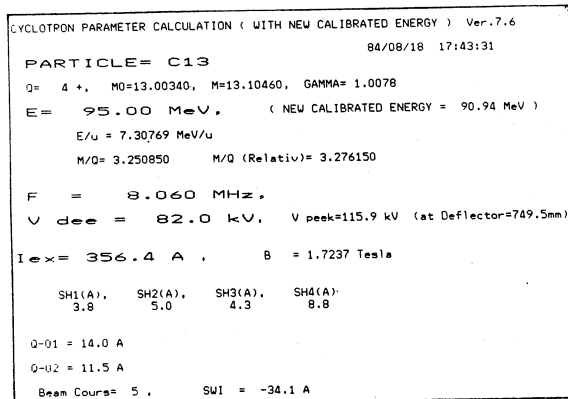
Fig.2; Example of the cyclotron parameter calculation output.

the input energy. Main and trim coils currents are calculated from the required field using a third to fifth order polynomials, whose coefficients were obtained using a least squares method with an experimental values.

Figure 2 shows an example of output of this program.

4. RF CONTROL SYSTEM

Before the computer installation, the RF parameters are set and controlled using a push button switches on the control desk manually. Especially, a plate capacitor was set in the RF exciter room by hand.

We changes following hardwares of the RF system in order to set the RF parameters automatically using the computer :

1) Plate capacitor was replaced by a variable vacuum capacitor with motor drive mechanism and its position is detected using a potentiometer.

2) A heliostat type potentiometer was equipped to the driving system of the shorting plate, instead of a self-synchro meter.

3) Not only an interlock of the air valve power switch for a contact finger of the shorting
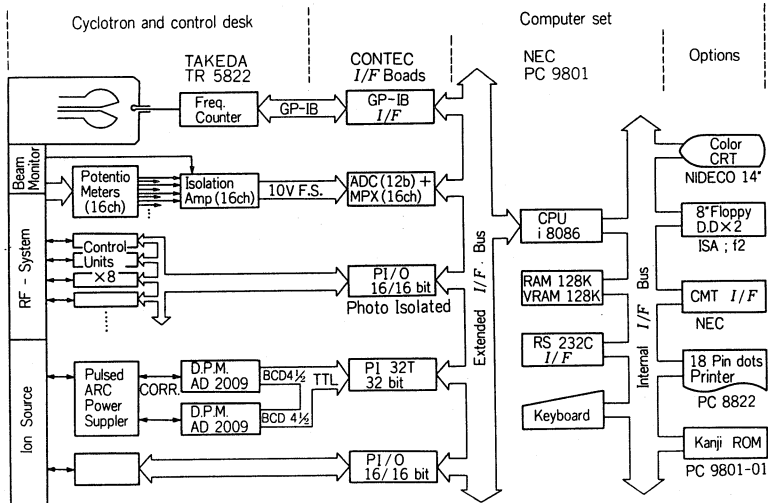
Fig.1; Block Diagram of the small computer system with the 160cm cyclotron.

plate but also a pressure detection switch of the contact finger were led to an interlock condition of the shorting plate driving system.

A frequency counter (Takeda-Riken; TR-5822) measures the cyclotron RF ten times a second and its data output is led to the computer through a GP-IB interface unit. All the external interface boards between cyclotron devices and the CPU are comercial ones. A parallel I/O interface unit (CONTEC Co.,Ltd; PI016/16) has photo isolation ICs and driving transisters. We changed those transisters to connect our 48 V relay control circuit.

Figure 3 shows a flow chart of the cyclotron parameter calculation program (upper half of this figure) and the RF set program (lower half). Seven parameters for the RF system (see Fig.3; lower half) are calculated from the given frequency (Fp) as preset values. Next, the computer sends a signal to turn off the air valve of shorting plate finger and sends a signal to set the above seven parameters through control units until each measured position becomes equal to the preset values within 1% accuracy. All the parameter calculations were done using first- to sixth-order polynomial equations. Before these programming, we derived the coefficients of those polynomials from the

newest data of cyclotron operation using a least squares fitting method in BASIC language.

The program "RF-SET" is used only for the RF parameter setting and has the same function as the latter half of the "CYCLO", independently.

The program "F-STABILIZE" is used for stabilizing the cyclotron radio frequency, more stably than the digital comparating circuit[2] does which has been used before. The frequency counter sends a frequency datum (F) to the computer 5 to 10 times per second. If the datum is of reasonable value (6 MHz $<$ F $<$ 12MHz, | F $-$ Fp | $<$ M x 50kHz, etc.), the datum is registered in a Fn data, where n means a data number and M is determined by the particle and a mode of the ion source operation. The averaged frequency data Fa of the past four data. If the Fa exceeds some limitation values, the computer determines a pulse width of the moving command from this value and judges whether it has to send the command to move the upper, lower or both earth plates or not to do. Thus, unnecessary movements of the above frequency compensating devices must be decreased. These procedures also can be done to the dee voltage.

5. HISTOGRAM PLOT

The program "CY-PLOT" is used by all night experimental staff to monitor the beam intensity, dee voltage etc. with a beam current buzzer. Similar program "INTEGRA" is added a factor of an integration of the beam current. These programs, including "F-STABILIZE", manage to print out the frequency, dee voltage and beam currents data in a certain interval of time and also manage a histogram plot of the data within past three to sixty minutes on a colour graphic display. Fig.4 shows an example of this plot.
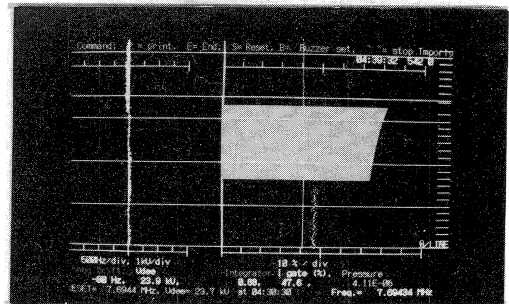
Fig.4; Histogram plot of the beam current, frequency and dee voltage drift, vacuum pressure of the cyclotron in operation. Vertical scale is a time of 10 sec./Div and 60 sec./line. This graphic plot flows up like a recorder chart.

6. ION SOURCE POSITION DATA LOGGING

The program "IONPLOT" displays the cyclotron ion source positions (three dimensions) on line with comparing logged data of the ion source positions, particles and energys from the floppy disk.

7. EPILOGUE

The interpreter language, BASIC, is not fast for processing for the on line control program, but good enough to control the mechanical driving system in our cyclotron on the 16 bit CPU. Moreover, development of programs on the BASIC interpreter is quite faster than other compiler languages. We also developed other data logging and plot program using a C-compiler language for a fast process with the personal computer.

References

1. T.Inoue, I.Kohno and S.Takeda: Reports I.P.C.R., (in Japanese), 46, 103(1970).

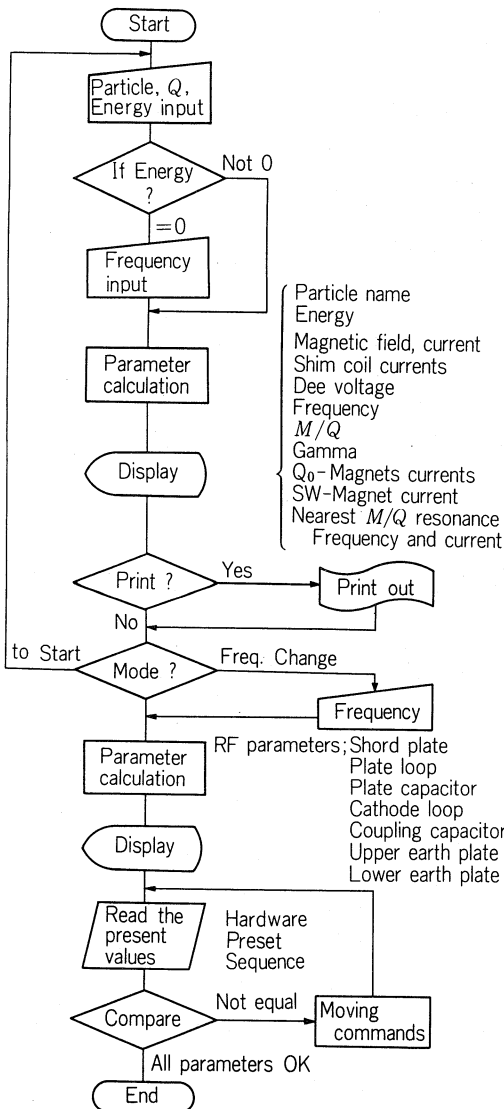2. H.Takebe, K.Ogiwara and Y.Yamada: I.P.C.R Cyclotron Progr. Rep., 14, 6(1980).

Fig.3; Flow chart of the program "CYCLO" to calculate the operational parameters for any ion species and energy and automatic setting of the RF parameters.