SPS/RF/TL/EEK

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RF Team Report on SPS Runs :
3rd, 6th, 7th and 10th May, 1976

T. Linnecar, A. Millich

1. Parasitic tests on 3rd May

During the first turn tests and multiturn tests, the signal levels in the radial,phase, and wideband pick-ups together with beam induced signals in the cavities were measured. The levels were correct and the mixing and AVC systems worked as expected. The decay of the 200 MHz signal on the phase pick-up was observed and thus indicated a delay time of the order of 1.1 msec, the structure reappearing with progressively smaller amplitude.

2. RF tests on 6th May

a) After setting up and closed orbit tests the RF team were given control at approx 16.00 hrs. An attempt was made to lock the PS-200 MHz structure using the signal sent over the PS-SPS link. This was unsuccessful and the phase discriminator indicated a frequency difference between the bunch induced signal and the PS signal of the order of 6KHz. (With the values of voltage and field in use, the calculated bucket height expressed as a frequency is only of the order of 2KHz.)

b) A capture scheme using a frequency synthesiser to lock the RF frequency was then used and optimum trapping was found at 199.526 MHz. (cf PS frequency = 199.520 KHz). The injection magnetic field was then varied to try to bring the frequencies closer together but the closed orbit distortions started to become significant indicating that this method of adjustment is not easy.

c) Since the phase of the frequency synthesiser generating the RF is uncorrelated with the phase of the incoming bunches, phase oscillations are induced. This allows measurement of the synchrotron frequency (fs) either on the phase discriminator or on the detected wideband signal (2 x fs). This value of fs allows in turn a calculation of the voltage in the cavity seen by the beam. With a slight variation from pulse to pulse fs was measured as ∿ 970 Hz, very close to the predicted value.

d) Attention was now paid to the phase loop even though the "quantity" of beam captured varied from pulse to pulse. The adjustment of the off-set of the phase discriminator was found to be impossible even after phase oscillations had died out due to the jitter in phase from one cycle to another. It was considered that further operation with loops was too difficult and possibly dangerous for the windows in the cavities.

e) The frequency synthesiser was again used at the optimum setting so that enough RF structure could be maintained to allow Q-measurements.

Conclusions

i) The RF high level system is behaving as predicted.

ii) Bunch into bucket transfer required a very careful setting up of the two machines and is more difficult than thought.

iii) The RF low level system has not yet been tested with beam.

RF Tests on 7th May

a) The RF team was given control at 18.00 hrs. The closed orbit had been well adjusted and the tuning seemed to be very good, the losses on the flat bottom as indicated by the BCT being very small. The CPS was asked to raise the 9.5 MHz frequency standard by 260 Hz at the same time increasing the B field so as to maintain the ejection energy constant. This should allow efficient trapping on the same frequency as used in the CPS to modulate the beam at 200 MHz. This was nearly successful except that the B was slightly too high and the best trapping frequency was now 199.528 KHz compared with the PS frequency of 199.526 KHz.

b) It was decided to continue in this mode and, if necessary, to ask later for the B field in the CPS to be changed. During the frequency changing manoeuvre in the PS the 200 MHz modulating amplifier had switched off and this was left off at our request to prevent possible beating effects in the SPS between the bunch frequency and the RF.

c) Using the frequency synthesiser a very stable capture situation was found. This allowed the phase offsets to be accurately adjusted and the phase loop to be switched on without difficulty.

d) The radial loop error signal was then adjusted for sign and the radial loop was switched on, again without difficulty.

e) At this point a small pulse was inserted on the radial steering input to move the beam during 60 msecs. This was successful; the loops reacted as expected and the control was very stable from one cycle to the next.

f) At this point (20.30 hrs.) the beam losses were becoming important again and a retune of the machine was asked for. The Q's were first lowered by 0.05 and then raised by 0.1 and at 20.50 a stable situation again existed.

g) The coarse frequency programme (derived from B train) was then connected and the beam dump was displaced to 500 msecs to allow a small amount of acceleration. This enabled the measurement of the capture efficiency which proved to be of the order of 75%.

h) The next stage was to add the stable phase program, (derived from the $\dot{B}$) but while controlling the output for level and sign the situation again become very unstable and it was decided to stop the run because of risk to the cavities.

<u>Conclusions</u>

i) The RF low level systems, phase loop, radial loop and coarse frequency program behaved exactly as required. The stable phase program is untested with beam.

ii) The early tests on the bunch into bucket transfer confirm the result obtained on the 6th May that this is a delicate operation.

iii) Observation of the BCT with and without RF show that the experimental losses are independent of the presence of RF.

RF tests on 10th May

a) The RF team were given control at 16.12 hours. Before setting up the closed orbit in the SPS the CPS was asked to decrease their B field by 1 Gauss to try and correct for the frequency discrepancy in the SPS between the modulated bunches (i.e. the optimum trapping frequency) and the PS frequency at injection x 21. This was successful, the optimum trapping frequency with the modulation present on the incoming bunching being the same as the PS frequency, i.e. 199.526 MHz.

b) The BCT showed an exponential decay of the same amplitude with or without RF. Following the procedure used on the 7th May, the phase loop was closed but a very unstable situation was found. The CPS was asked to stop the 200 MHz modulation and the optimum trapping frequency was found to increase to 199.527 MHz. The radial loop was closed and a pulse put on the radial steering to move the beam and allow a calibration of the radial PU's. A closed orbit measurement of the mean radial position was requested 215 msecs after injection. The results from this indicated that PU3 and PU 4 had an equivalent sensitivity of the order of 90 mV/mm $\left(\frac{\Delta}{\Sigma}\right)$ and that PU2 had an inversion sign with half the sensitivity.
L. Burnod also measured the variation in position from cycle to cycle on PU312. The changes were found to be large, $\pm$ 5 mm, showing the very unstable situation.
c) The RF team then asked for a change of tune. The Q was raised by 0.7. Without RF the BCT showed an extremely stable beam with no decay from beginning to end. However, with RF, losses of the order of 50% occurred within the first 30 msecs. The timing of the phase loop and the radial loop was changed several times, the last setting being at 10 revolutions after injection, (i.e. just sufficient time for the AVC networks to settle), but the losses remained constant.

d) Accepting the unstable situation, the dump was moved at 20.40 to 500 msecs to observe the acceleration. Of the 50% of beam left, only 50% was captured. (cf 75% as found on the 6th May).

e) At 20.52 the dump was moved to 700 msecs and the BCT showed a very sudden loss of beam occurring at $\sim$ 580 msecs. An examination of the PU signals showed a very sharp movement towards the wall just before this time during $\sim$ 80 msecs with corresponding error signals in the phase and radial loops but no obvious explanation was found.

Conclusions

i) A very different situation existed in the latter half of this run as compared with the 7th May run. On that run the losses were constant and independent of RF whereas on this run the losses were negligeable without RF and large with RF. This may be explained by the fact that the machine was sitting near a resonance.

With the inevitable increase in Δp due to capture in large buckets it is possible that a large proportion of the protons were being forced into the resonance.

ii) The sudden loss at 580 msecs is not easily explained. Perhaps there is a frequency dependent offset in the phase loop or perhaps a transverse resonance is crossed during acceleration.

T. Linnecar

Copies of this report
can be obtained for the BT Secretariat.