SPILL MONITOR FOR SLOW EXTRACTION

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Abstract

This report describes the spill monitor used at present for the tuning of extraction system. It displays the duty factor giving the modulation level of the slow extracted beam and the extraction efficiency.

Low Frequency Structure of The Spill is observed by the secondary emission chamber (SEC), placed at the downstream of the external beam line. This monitor has the bandwidth of d.c. $\sim$ 15 KHz, and the gain is adjusted to be 1V per 10^{12} extracted protons during 0.3 sec. The signal from this monitor is sampled at intervals of 100 μsec for 102.4 msec in the middle of the spill.

The duty factor is employed as a measure of the low frequency structure in the spill signal, and is calculated by the formula[1,2]

$$D = \frac{[\int_0^\tau \ell(t)dt]^2}{T \int_0^\tau \ell^2(t)dt} \times 100 \ (\%) \ ,$$

where $\ell(t)$ represent the low frequency burst waveform in the interval of the measurement $0 \leq t \leq \tau$.

In actual calculations, the above integrations are converted into the following expression

$$D = \frac{[\sum_1^N \ell(i)]^2}{N \sum_1^N \ell^2(i)} \times 100 \ (\%) \ ,$$

where N = 1024, and $\ell(i)$'s are the sampled data.

The duty factor of the spill (D) represents the reduction of the spill time due to the modulation of the proton burst. Though the duty factor cannot deal with the overall spill structure by the limitation of the sampling time (102.4 msec), it is usufull for the adjustment of the feed back control systems. In normal operations the duty factor is about 90%.

Efficiency of Extraction

This system employs a convenient method to measure the extraction efficiency[3]. Circulating proton numbers are sampled before and after the slow extraction. The difference between the two is the proton number to be extracted. The number of protons extracted is measured by integrating the SEC signal and

$$\text{Efficiency} = \frac{\text{No. of prot. extracted}}{\text{No. of prot. to be extracted}} \times 100 \ (\%) \ .$$

Accuracy

To minimize the measurement errors we used the attenuators,

having three steps — × 1, × 1/4 or × 1/16, installed before the sampling circuits of each signals. The attenuators are adjusted automatically according to the circulating proton number (Fig. 1,2). By this method an error peculiar to the circuits is within 1.6% for the proton number ranging from 8×10^{9}ppp to 4.5×10^{12} ppp.

Accuracy of extraction efficiency is determined by that of the intensity monitor and SEC. For the calibration of this system, we used another SEC which was calibrated within 5%. Total error of efficiency displayed amounts to 8%.

The 8 data including the duty factor are averaged and the results are also displayed.

Conclusion

Though the accuracy of the efficiency is not enough, this monitor gives a measure of the performance of the extraction system, and helps us to tune it.

Reference

1) D.B. Bloss et al. IEEE Trans. NS-18, 1971, p.973.
2) R.A. Andrews et al. Proc. of the IX th International Conf. on High Energy Accel. (SLAC, 1974) p.456.
3) V.Ya. Gvozdev et al. Particle Accelerator Vol.6, 1974, p.53.

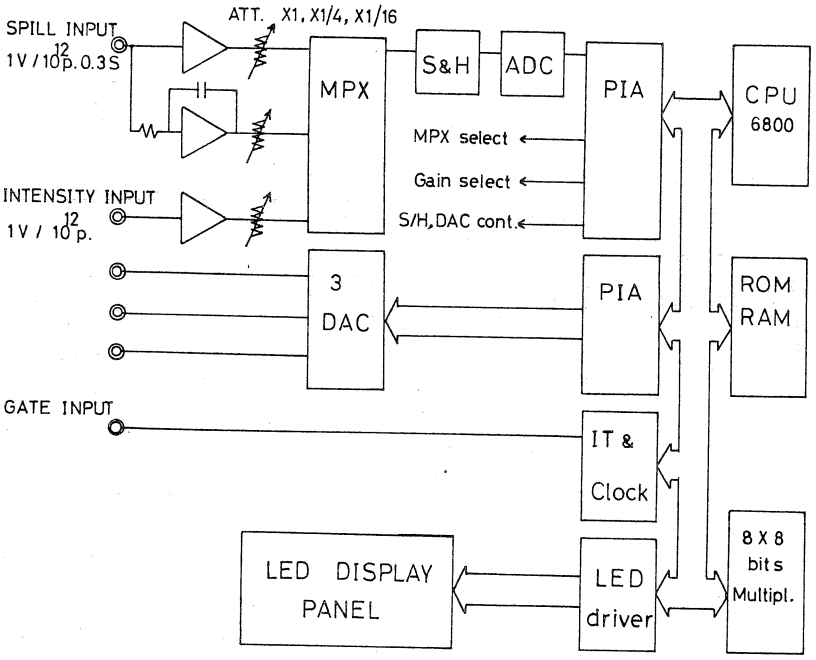
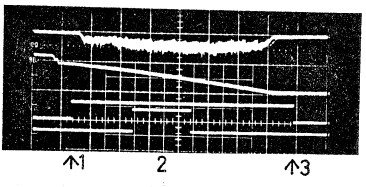


FIG. 1 BLOCK DIAGRAM



SPILL (SEC)
INTENSITY
GATE
1 sampling of prot. no. & attenuator select.
2 samplings of spill
3 sampling of prot. no.

FIG. 2 SIGNALS AND TIMING