MULTI-CHANNEL ELECTRONICS FOR SECONDARY EMISSION GRID PROFILE MONITOR OF TTF LINAC

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According to theTTF beam experimental program, a measurement of the time dependence of the energy spread within the bunch train should be done by means of a standard device for profile measurements, that is Secondary Emission Grid (SEMG). SEMG on the high-energy TTF beam is placed in the focal plane of the magnet spectrometer. It should measure the total energy spread in the range from 0.1% up to a few percents for any single or any group of electron bunches in the bunch train of TTF Linac. SEMG Profile measurements with new high sensitive electronics are described. Beam results of SEMG Monitor test are given for two modifications of an electronic preamplifier.

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1. INTRODUCTION

According to the TTF beam experimental program [1], a measurement of the time dependence of the energy spread within the bunch train should be done by means of a standard device for profile measurements, that is Secondary Emission Grid (SEMG).

The SEMG Monitor on high-energy TTF beam is placed in focal planes of magnet spectrometers. It should measure total energy spread in the range from 0.1% (σ_x =1 mm) up to a few percents [2].

SEMG Monitor was tested to measure profiles of any single bunch or any group of electron bunches in the bunch train for TTF beam with the next parameters:

a) Repetition frequency of bunch trains – 1 Hz.
b) Repetition frequency of bunches within bunch trains - 1 MHz.
c) Bunch charge – (0,5...5) nC per bunch.

In contents of this paper SEM Grid electronics are described. Results of SEMG Monitor test on TTF beam are given for two modifications of the electronic preamplifier. Some discussion of results is given too.

2. SEMG ELECTRONICS

The schematic diagram of the tested electronics is shown in Fig.1. The electronics consists of the internal (right near the SEMG) front-end and external (outside the TTF linac tunnel) parts.

The front-end part is made in the Eurocard crate and has three 16-channel preamplifier modules and one Multiplexing module. The Multiplexing module (MPLX) includes an analog 48-channel multiplexing circuit and an controlled calibrator to test the electronics. The external part is made in the VME crate and consists of a Control Unit (CU) module. The ADC and Output Register were installed in this crate also. CU includes the External Amplifier (AMP) with an Oscilloscope and ADC outputs, the Timing and Control Circuits (CC).

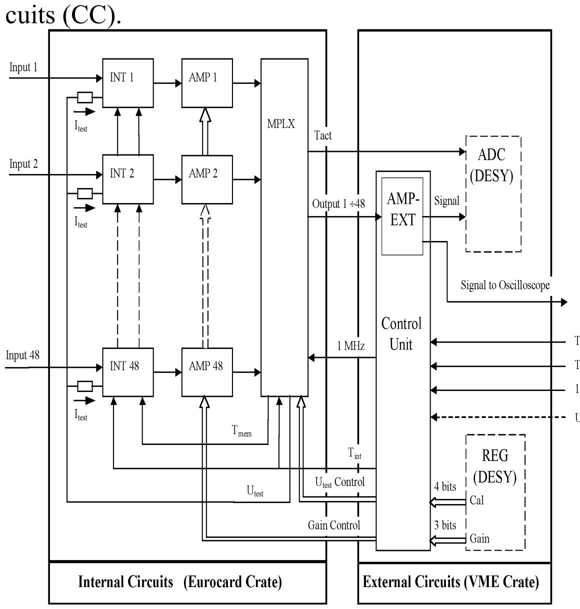


Fig.1. The diagram of INR electronics

CC organizes MPLX operation for the beam profile output to the Oscilloscope and ADC inputs. Also the CC transmits the digital signals from the Output Register through MPLX to the preamplifier to change the gain of the amplification and the level of the calibration signal on the entrance of the preamplifier. The input permanent pulses 1 MHz are used for the channel switching of the multiplexing circuit and to create a set of 48 synchronizing signals.

The schematic circuits of two possible modifications of tested front-end electronic channels for profile measurements are shown in Fig. 2.

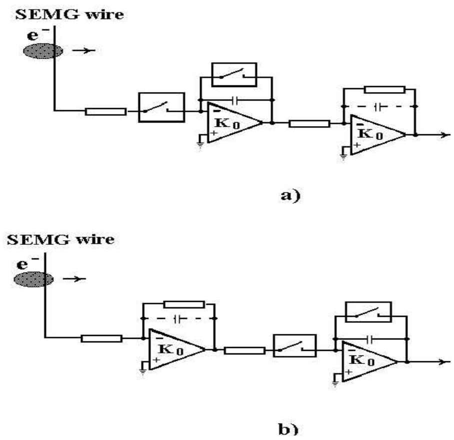


Fig.2. SEMG electronics: a - the channel with two switch integrator at the input, b - the channel with operational amplifier at the input

3. DETAILED TIME DIAGRAM OF PREAMPLIFIERS

The integration time interval T1 (Fig.3) defines the time position and the duration of charge accumulating for the investigated group of bunches within the bunch train the profile of which should be measured. Two switches (or keys) are installed at every preamplifier current integrator for organizing of the time diagram: input key and feedback key. The keys in feedback nets of all integrators are opened during T3 interval and areclosed during the whole interval between bunches being investigated or bunch groups in the bunch trains.

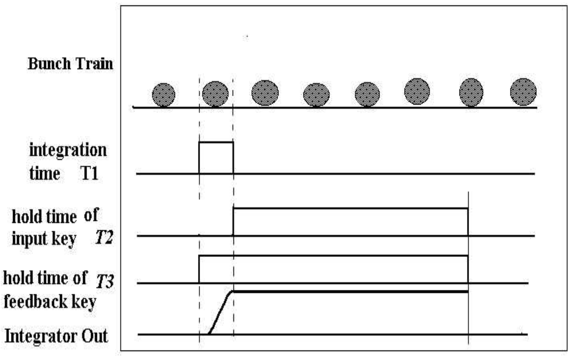


Fig.3. Detailed time diagram of preamplifier switches

The keys in input nets of integrators are opened during the T2 (T2=T3-T1) interval and are closed during the whole interval between bunch groups. Then the integrators in both channels have to store charges from wires during T1 and keep stored potentials during the time T2 needed for reading values of these potentials by means of 1 channel VME ADC through the multiplexing module. Hence, the closing of the input key in the whole interval between the measurements prevents storing of charges on the input cable capacitance from previous bunches of the train before T1 for the scheme with an input integrator (Fig. 2,a). But some distortions of measurements are possible due to charge accumulating on the cable capacitance from last bunches of the train during T2 interval after T1. However there are not these distortions with charge storing on the cable capacitance for the scheme with the input preamplifier and the integrator as an analog memory (Fig. 2,b).

4. RESOLUTION OF PREAMPLIFIER CHANNELS

In Fig. 4 shown are both circuit modifications of electronic preamplifier channels for the signal/noise ratio analysis, where

I_s – current source i.e. a wire in a beam, that emitted secondary electrons,

dQ/dt – charge injection current source due to electronic switches of integrator circuit

C_{cab} – input cable capacitance,

C_{fb}, R_{fb} – feedback capacitance and resistance of preamplifiers with the gain coefficient K_0,

C_w - wire capacitance,

R_{ini} R_{ino} – resistors at the inputs of preamplifier circuits,

R_{key} – resistance of the electronic key at the input of the integrator circuit,

$R_{fb\ key}$ – resistance of the electronic key in the feedback circuit of integrator,

U_{int} – interference source in the ground wire.

Fig.4. Front-end channel schematics

4.1. SIGNALS OF SEMG PREAMPLIFIER CHANNELS

The signal charge q_s from the SEMG wire is transmitted to the input of the preamplifier by wire pair, loaded by R_{ino} for resistive amplifier or R_{ini}+R_{key} for integrator. TTF bunch has duration a few ps. And we shall take it as δ-function. The wire charge will be transformed on the wire capacitance to the potential U_s. If R_{ino} or (R_{ini}+R_{key}) is the same as R_{wv} – wave impedance of wire pair, then the signal on C_w will go to 0 with time constant of $\tau_{wv}=C_wR_{wv}$. That is with very short time constant because $C_w \approx 3...5$ pF and $R_{wv} \approx 100\Omega$ ($\tau_{wv}=5\cdot10^{-10}$s).

For the resistive preamplifier some part of charge can be lost for this very short input signal, therefore the value R_{ino} is taken as $11R_{wv}$ to prevent charge losses. Then whole charge of secondary bunch will flow through R_{fb}/K_0 without losses. The shape of the output pulse is defined by the time constant of an input net of the resistive preamplifier $C_{cab}R_{ino}$=150 pF·1.1k=$1.5\cdot10^{-7}$s, and this pulse transformed into the current will be integrated in the integrator. Thus very short input pulse is transformed into the pulse with the front defined by the bandwidth of the resistive preamplifier and the edge defined by the input net. That is the resulting pulse is short enough for measurements of the single bunch profile at a bunch frequency of 1 MHz. The integrator used as an analog memory device at the output of this preamplifier stores the larger charge proportional to the bunch charge on the detector wire. In this case the influence of the charge injection source dQ/dt due to switch operation is in many times smaller than for the integrator at the input of the preamplifier because the signal charges on the current integrator inputs is in ~10^2 times more. The output signals for both types of channels in Fig.2 are

a) $U_{oi} = (q_s/C_{fb})*R_{fb}/R_{ino}$ – for the current integrator preamplifier stage with the resistive operational amplifier after it.

b) $U_{oo} \cong (q_s/C_{fb})*R_{fb}/R_{wv}$ – for the resistive operational preamplifier stage with the integrator as an analog memory, if the time constant $\tau_i = R_{wv}C_{fbi}K_0 >> T2$.

4.2. NOISE

The total noise of equivalent sources is the noise sum of all ones: the stationary noises as a thermal noise of resistance and not stationary noises as some interference U_{int} at the input circuits. Measurements of the noise level of SEMG preamplifiers had showed that noises of stationary sources are smaller than the low frequency noise of input interference. It was checked with connected and disconnected input cables. That is, it was observed that the nonstationary source of interference is the main source of noises in SEMG Monitor.

The interference signal for both types of preamplifiers is defined by the transmission coefficient for U_{int} at the output of these channels. As can be seen (Fig.2 and 4) the signals of the interference ratio are the same for both channels approximately without taking into account the input switch charge injection.

5. RESULTS

5.1. BEAM PROFILE ALONG THEBUNCH TRAIN

In this test we checked a possibility to observe time dependence of transverse beam profile along bunch train by means of SEMG with current integrator preamplifier channels (Time dependence of bunch profile behind spectrometer dipole is the dependence of energy spread along the train, if the beam optics and a beam will be adjusted for this parameter observation.) In Fig.5 (A,B,C,D) the group profiles within the bunch train of 30 bunches are shown. Bunches have charges from 2 to 3 nC and approximately 200 MeV average energy.

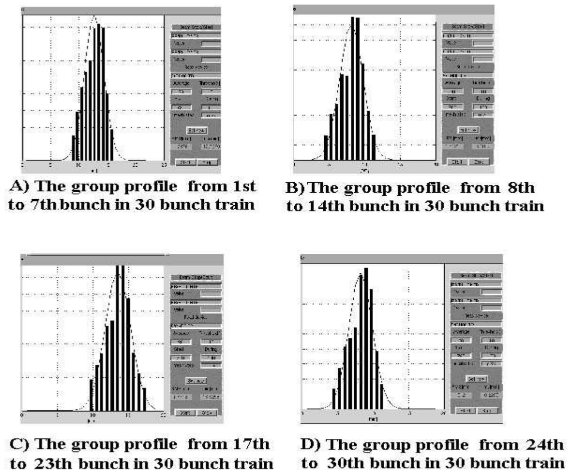
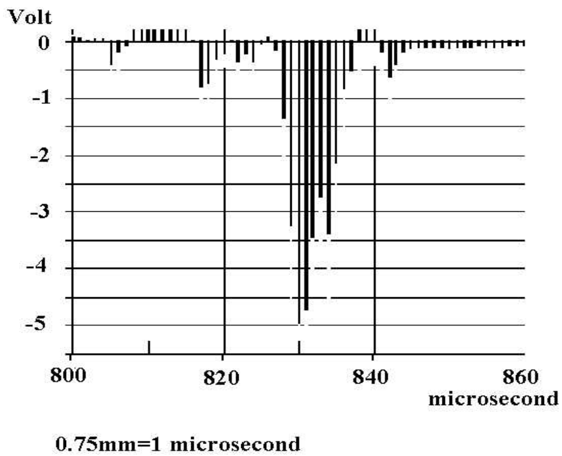


Fig.5. SEMG Profiles of bunch groups within the bunch train of 30 bunches

Bunches were focused on the SEM grid behind the spectrometer dipole. In Fig.5 the profiles are shown on the panels of MATLAB application after subtracting of pedestals and with Gauss fitting in applications. Group profile time positions were moved along 30 μs bunch



trains from beginning to the end of the bunch train.

Integrator preamplifier channels permit to investigate profiles along the bunch train by groups contained 7 bunches or more.

5.2. SINGLE BUNCH PROFILE MEASUREMENTS

The preamplifier in fig. 2,b was tested on a single bunch with result resolution in ~10 times better of the current integrator with switches. In fig. 6 the profile of a single bunch in the bunch train is shown. This application picture shows row profile with pedestal after digitizing in ADC without MATLAB fitting for more sensitive resistive preamplifier channels. That is, only resistive operational preamplifiers added before the current integrators permit to observe TTF beam single bunch profiles, and all preamplifier channels should be modified in this way for investigations of long bunch train energy spread in the bunch by a bunch manner.

Fig.6. Single bunch profiles on resistive preamplifier channels

6. CONCLUSION

Now the SEMG Monitor with current integrator preamplifiers can be used for bunch group profile measurements on TTF beam with bunch charge from 0.5 nC at a 1 MHz bunch repetition rate.

For single bunch profile measurement in the bunch by a bunch manner the front-end channels with resistive preamplifiers at the channel inputs are effective.

7. ACNOWLEDGMENTS

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REFERENCES

1. TTF LINAC - Design Report // *TESLA 95-01,* March 1995, item B1, p.15 and p.394.
2. M. Bernard, R. Chehab, T. Garvey, et al. Secondary Emission Grids for Low- and High-Energy Electron Beams // *Proc. Fifth EPAC'96, Sitges (Barcelona), 10-14 June 1996,* p. 1680.

МНОГОКАНАЛЬНАЯ ЭЛЕКТРОНИКА ДЛЯ ВТОРИЧНО-ЭМИССИОННОГО МНОГОПРОВОЛОЧНОГО МОНИТОРА ПРОФИЛЯ ПУЧКА ЛИНЕЙНОГО УСКОРИТЕЛЯ TTF

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В соответствии с экспериментальной программой тестового линейного ускорителя TTF измерение временной зависимости энергетического разброса ускоренных электронов вдоль макроимпульса должно производиться с помощью стандартного прибора для измерения профиля пучка – многопроволочной вторично-эмиссионной камеры (ВЭММ). ВЭММ на пучке высокой энергии ускорителя TTF расположен в фокальной плоскости магнитного спектрометра и должен измерять энергетический разброс ускоренных электронов в диапазоне от 0,1% до нескольких процентов. В работе излагаются измерения профиля пучка вторично-эмиссионной многопроволочной камерой с новой высокочувствительной электроникой. Результаты испытаний ВЭММ на пучке ускорителя TTF и их обсуждение приводятся для двух модификаций электронных предусилителей.

БАГАТОКАНАЛЬНА ЕЛЕКТРОНІКА ДЛЯ ПОВТОРНО-ЕМІСІЙНОГО БАГАТОДРОТОВОГО МОНІТОРА ПРОФІЛЮ ПУЧКА ЛІНІЙНОГО ПРИСКОРЮВАЧА TTF

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Відповідно до експериментальної програми тестового лінійного прискорювача TTF вимір часової залежності енергетичного розкиду прискорених електронів уздовж макроімпульсу буде зроблено за допомогою стандартного приладу для виміру профілю пучка – багатодротової повторно-емісійної камери (ВЕММ). ВЕММ на пучку високої енергії прискорювача TTF розташований у фокальній площині магнітного спектрометра і буде вимірювати енергетичний розкид прискорених електронів у діапазоні від 0,1% до декількох відсотків. У роботі викладаються виміри профілю пучка повторно-емісійної багатодротовой камерою з новою високочутливою електронікою. Результати іспитів ВЕММ на пучку прискорювача TTF і їхнє обговорення дано для двох модифікацій електронних передпідсилювачів.