DEVELOPMENT OF FILM-MODE WALL CURRENT MONITOR AND ITS APPLICATION IN HLS

Wang Guicheng*, Leng Yongbin, Fang Zhigao, Wang jihong, Zhao Feng, Tao Xiaoping, NSRL
Liu Guangjun, Li Guangyeng, Fang Lei, Anhui Institute of Optics and Fine Mechanics, Hefei

Abstract

A film-mode wall current monitor was developed in NSRL in cooperate with Anhui Institute of Optics and Fine Mechanics, Academia Sinica. It is in an advantageous position of continuity and uniformity of the film and used on line with success in HLS. The beam current toroids used in the LINAC of HLS are just employed for measuring theμs bunch beam current, it is limited by band width of toroid and preamplifier. We embed a film-mode resistor inside of every toroid to respond to ns wall current, diagrams of structure of the film-mode wall current monitor and cross section of film-mode resistor are given in this paper.

1. THE PRINCIPLE AND STRUCTURE OF WALL CURRENT MONITOR

The non-interaction monitor is related to the use of the wall image current induced by relativistic particle bunch.

1.1 Principle of Current Monitor

The principle of current monitor is shown in Fig.1

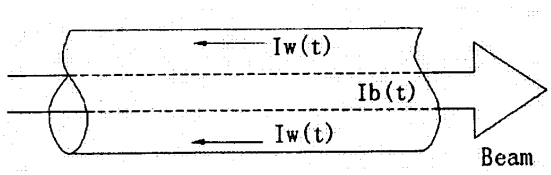

Fig1 The particle beam and it's induced image current

Making Assume:
* Particle-beam with γ >10;
* Metallic chamber is perfectly conducting or with skin depth << wall thickness.
From continuity equation

$$\frac{\delta p}{\partial t} + \nabla J = 0$$

We have: $i_w(t)=-I_b(t)$
Therefor the induced image current and its azimuthal distribution can be used to monitor the beam intensity (see Fig1).

Email: Gchwang@ustc.edu.cn

1.2 Structure of Current Monitor

As an original model, ceramic ring of 1cm in length is inserted into the vacuum tube, with 20 inductance-less resistors, of 1 kilo ohm each, welded across the ring and evenly distributed to allow the wall current to pass (see Fig2).

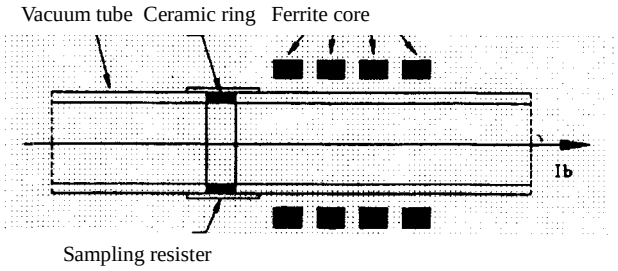

Fig.2 Structure of wall current monitor

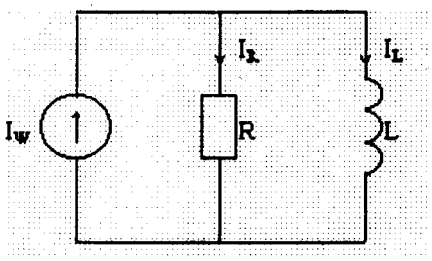

Fig.3 Equivalent circuit of wall current monitor

From the equivalent circuit of the wall current monitor (see Fig3) we can get:

$$\begin{cases} i_r R = L\dfrac{di}{dt} \\ i_w = i_R + i_L \qquad (when\ t=0,\ i_l = 0) \end{cases}$$

Where, i_w- Wall current
R - Sampling resistor
L - Inductance between sampling point And ground
Thus we obtained:

$$i_R = i_W \cdot \exp(-\frac{t}{\tau})$$

i_R(the current passing through sampling resisters) is an

exponentially decay of the wall current with time constant τ.When the beam current pulse width is 2ns, and if τ=10ns, R=50Ω,then L=0.05□h. This is a small inductance , can be formed by vacuum tube itself, it means that under the condition of beam current pulse width is 2ns we can use the film resistor as wall-current sampling resistor without the ferrite core for enhancing the inductance L. Finally, we mount the film resistor into the gap between surface of vacuum tube and coil (Tor) used for monitoring □s pulse beam current (see Fig4).

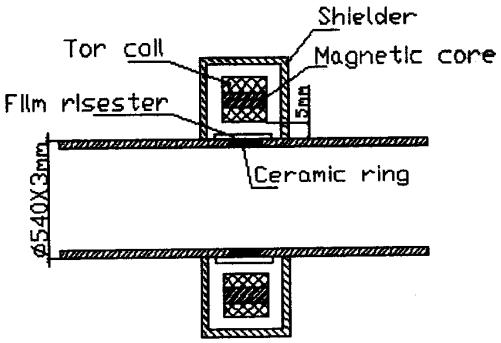

Fig.4 structure of film-mode wall current monitor

2. STRUCTURE OF FILM RESISTOR

A cross section of film-mode resistor with length of 20cm and width of 7cm is shown in Fig5. Both conductor-bands and resistor-band are carried by a PET-film of 200nm in thickness. The resistor-band is made of high purity Nickel located at the center of 2cm in width and 40-60nm in thickness. One SiO2 layer of 100nm in thickness is evaporated on the resistor-band for protecting it from decline. Resistance of resistor-band is controlled in around 5Ω-10Ω. On the surface of four conductor-bands, each of both of front and back side has tow bands, they are gold-plated to take form an output band.

Pay attention to clean the surface of PET film and keep the material of Ni in high purity for preventing the resistance of resistor-band from decline.

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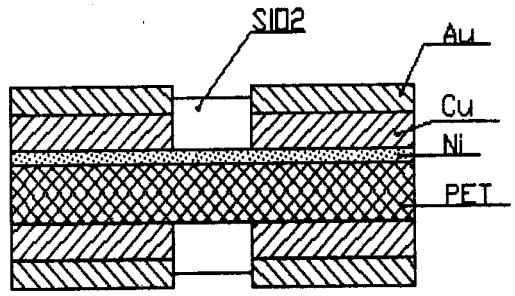

Fig.5 Diagram of cross section of film-mode resister

3. APPLICATION IN HLS

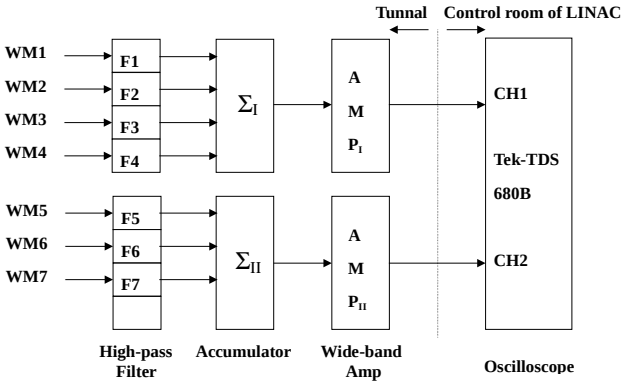

Fig.6.Diagram of wall current monitor

There are 7 sets of film-mode wall current monitors in the LINAC of HLS. They are Divided into tow groups one includes 4 sets another 3 sets. The signals from one group are feed together to one accumulator, then to an APM, to one channel of oscilloscope. See Fig.6.

In fact, much noise are picked up by the film-mode resistor which connect immediately with the wall of vacuum tube of LINAC. Main peaks of spectrum of noise concentrate at around 1MHz in frequency domain. High-pass filters, with 10MHZ cut-off frequency, employed for suppressing the low frequency noise are fixed in the front of accumulators [2].

The cables from monitors to filters are cut out for different length in proper order, such as WM1-F1 is 5m; WM2-F2 is 10m; WM3-F3 is 15m and so on. At the end one can make a pulse packet including four wall current pulses to be displayed on a sweep line of Tek-TDS680B. Usually, one can spread out any one of pulse by turning time delay and changing the time base, see the Fig.

4. CALIBRATION OF SYSTEM

The calibration of whole system has been done with calibration set [3], see Fig.7. In our case for ns beam current the sampling resister is film-mode used without the ferrite core. The wall current and input signals are shown in Fig.8. As a result, the efficiency of this calibration set is 70%. Adjusting the amplification of preamplifier one can keep the whole gain from out of toroid to input of oscilloscope at 6dB.

Finally, the calibration coefficients of every film-mode wall current monitor are listed in table 1.

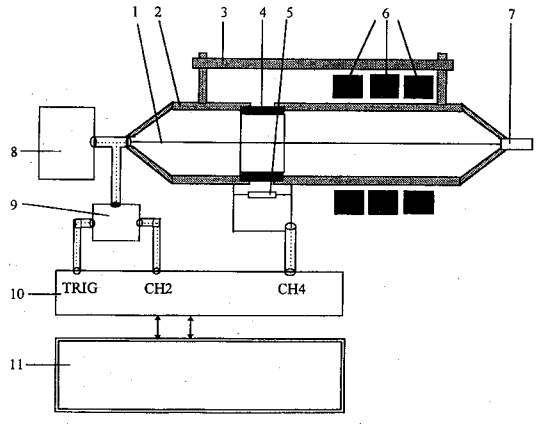

Fig.7 Diagram of calibration system

Annotations on the Fig.7:
1-Signal wire through inside of vacuum tube;
2-Vacuum tube;
3-Metal pole;
4-Ceramic ring;
5-Sampling resister (film-mode for ns signal);
6-Ferrite core;
7-Terminal load for matching;
8- Pulse generator (HP8082A);
9-Power divider(HP11667B);
10.-Probe (HP54121A, 20GHZ test set);
11- Oscilloscope (HP54120B).

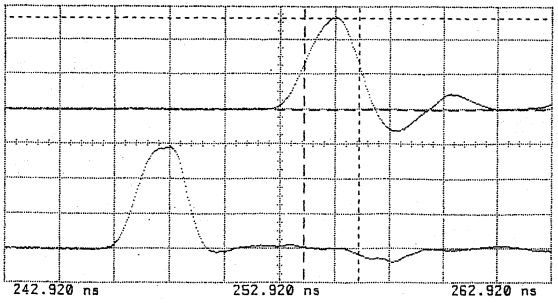

Fig.8 Calibration signal and sampling output

In Fig.8:
Up-line: output signal from sampling resister;
Down-line: Calibration signal.

Table 1 Calibration coefficients of film-mode wall current monitors

Monitor No.	Resister	Efficiency
1	10.5Ω	14.7 ma/mv
2	10.0Ω	14.7 ma/mv
3	10.5Ω	14.7 ma/mv
4	11.5Ω	16.1 ma/mv
5	5.0Ω	7.0 ma/mv
6	50.0Ω	70.0 ma/mv
7	10.0Ω	14.0 ma/mv

5. REFERENCES

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[2] Fang Zhigao, Li Hui, Leng Yongbin, Nuc. .Sci.& Tech. Jan. 1998, 79-83

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