FAST-SCANNING FABRY-PEROT INTERFEROMETER[1])

A. BRABLEC[2]), V. KAPIČKA[2]), F. ŠŤASTNÝ[2]), Brno

A modified universal Fabry-Perot interferometer, product of Carl Zeiss Jena, which makes it possible to shorten the recording time of the spectral line profile up to 5 ms is presented. The method described may be applied to every Fabry-Perot interferometer using a piezoeffect to scan the line profile and is especially suitable for the diagnostics of plasma discharges.

БЫСТРОСКАНИРУЮЩИЙ ИНТЕРФЕРОМЕТР ФАБРИ-ПЕРО

В работе обсуждается усовершенствование универсального интерферометра Фабри-Перо серийного произвоства фирмы Карл Цейс Йена, которое позволяет сократить время записи контура спектральной линии вплоть до 5 мс. Описанный способ усовершенствования применим к любому интерферометру, который сканирует контур спектральной линии на основе пьезоэффекта. Данный метод особенно удобен для диагностики плазменного разряда.

1. INTRODUCTION

Recently much attention has been given to the practical application of plasma discharges in industry. For the efficient use of such plasma discharges it is necessary to know the parameters of the plasma and conditions under which plasma burns. The most important equipment with a high distinguishing ability is the Fabry-Perot interferometer enabling us to determine the initial (theoretical) spectral line profile. In the classic arrangement the measurement of line profile extends over several minutes. However, this time is too long for some applications because the plasma parameters are being changed during the exposition time, which results in a distortion of the registered profile. For those reasons many authors have been endeavouring to construct a measuring equipment with the Fabry-Perot interferometer which makes it possible to shorten the exposition time of the line profile in a suitable way [1, 2, 3, 4]. In practice several measuring methods have been

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[2]) Department of Physical Electronics, Faculty of Sciences, Purkyně University, Kotlářská 2, 611 37 BRNO, Czechoslovakia.

suggested and realized. However, it is not possible to say that one method is much better than the others since every method has both advantages and defects.

In the diagnostics of plasma we must choose the most suitable exposition time for the line profile to have the minimum error of measurement. If the recording time is longer than the time within which the plasma parameters are constant, a distortion of the line profile occurs difficult to discover. On the other hand, with the increase of the scanning velocity the ratio of useful signal and noise decreases. For this reason it is advantageous to have a wide range of the scanning velocity at disposal.

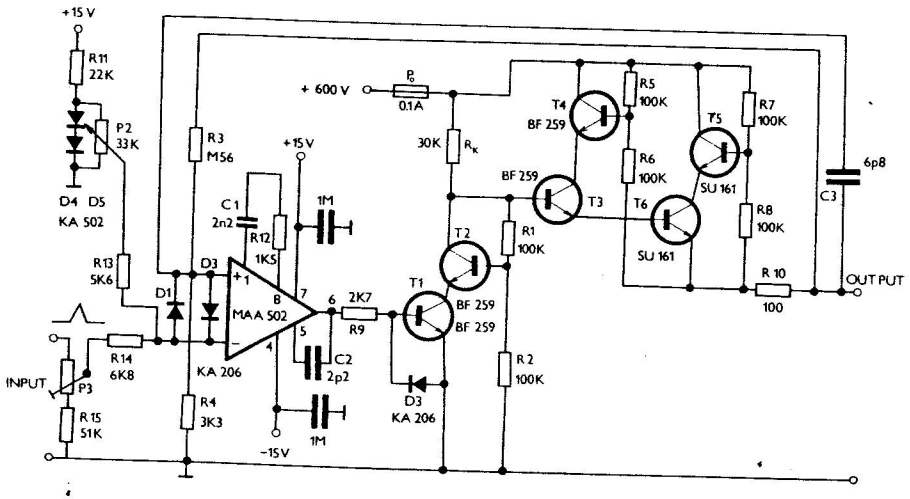

Fig. 1. Amplifier with high output voltage.

II. EXPERIMENTAL ARRANGEMENT

In our department the Fabry-Perot universal interferometer (UFPI), product of Carl Zeiss Jena, has already been used for several years to determine plasma parameters. The interferometer used for measurements of the movement of a mirror induced by a piezoceramics element. The signal from the photomultiplier was displayed on the recorder. The shortest recording time was cca 7 minutes. Since the construction of the mechanical components of the interferometer would have been a time-consuming procedure under the conditions of our department, we decided to use for our purpose the mentioned mechanical components of the Fabry-Perot interferometer.

To shorten the exposition time it was necessary to adapt the Fabry-Perot interferometer as follows:

1. to ensure that external mechanical vibrations from the neighbourhood do not influence the quality of the record. In case of a long exposition time of the spectral line profile all such external vibrations are supressed by the recorder which has a high value of the time constant,
2. to construct a precise generator of the linear-ramp voltage of the maximum value of about 500 V with the required slope,
3. to find the way to register a one-shot phenomenon at the required speed,

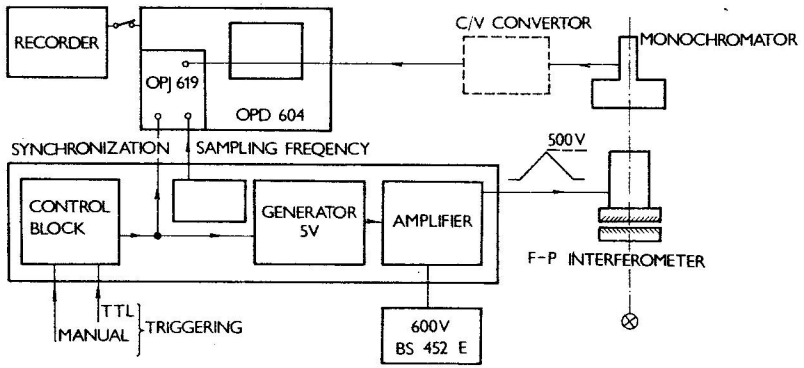

Fig. 2. Schematic block drawing of the experimental set-up.

4. to construct the arrangement in such a way that both the starting time point of the measurement and the recording of the signal can be controlled by the electric signal.

The mentioned adaptations were realized as follows:

1. To remove the influence of external vibrations we used 6 pneumatic springs. Such elements were developed at the Technical University at Liberec for jet looms. Tests confirmed that the usual vibrations do not influence the accuracy of our measurements. The springs make it also possible to change the height of the interferometer in a definite range. This is advantageous for the adjustment of the interferometer.

2. The constructed linear-ramp voltage source consists of a saw tooth voltage generator (the maximum value of the voltage is 5 V) and a logic controlling block which makes it possible to start the generation of the signal by an electric impulse. The idea is from [5]. The generator is formed by a counting-rate meter and two level comparators with two MAA 502 operational amplifiers, which provide both the one-shot and the periodical course of the voltage. The signal from the generator is transmitted to the input of an amplifier with high output voltage. We used the conclusions presented in [6]. The MAA 502 operational amplifier determines the accuracy and stability of amplification. The amplitude of the output voltage is increased by means of the voltage booster including three cascades with high

voltage transistors of BF 259 and SU 161. The C3 condenser and the R 10 resistor serve for insulation of the capacitive load because the piezoceramics element has a capacitive character and then oscillations of the amplifier occur. The accuracy of the generated saw tooth voltage is better than the accuracy of the record equipment. The voltage may reach its maximum value within the time from 2 s to 0.3 ms (Fig. 1).

3. It was shown that for the diagnostics of plasma the exposition time is up to 50 ms. In this case we used the OPJ 619 memory cartridge which is one part of the eight bit memory equipment (the others are the OPD 604 oscilloscope and the OPJ 612 memory time base) and makes it possible to record analog signals in digit form (1 kB storage capacity) and their subsequent displaying on the TV screen. After the modification of the cartridge (a change of sampling frequency) a lasting copy of the screen picture may be obtained on the recorder. In this case the exposition time is cca 35 s. We constructed a sampling frequency generator, too.

It turned out that the exposure of shorter signals required the OG 2-21 memory oscilloscope by RFT. Since the sensitivity of the memory device is insufficient for the low signal from the photomultiplier we constructred a current-voltage convertor with the WSH 218A hybrid operational JFET amplifier.

4. The control block of the voltage generator applied to the piezoceramics elements makes it possible to start the movement of the interferometer mirror or to start the record of the line profile both by hand and by means of the TTL level impulse with adjustable time lag. It will allow in future an easy transition to the computer control of the interferometer.

The schematic block drawing of the experimental set-up is in Fig. 2.

III. RESULTS, DISCUSSION

The modified abry-Perot interferometer allows to change the exposure time of a one line profile within the time range of 5×10^{-3}—3.6×10^{3} s. For a longer measurement time than 2 s the original way (mechanical) of voltage increase applied to piezoceramics is used. Using the mentioned current-voltage convertor we can display the spectral profile on the recorder. For a shorter measurement time it is more suitable to use the constructed linear-ramp voltage generator having the possibility to use either the OPJ 619 memory cartridge (as many as 50 ms) or the memory oscilloscope (in case of a very short exposition time).

At present we have at our disposal the Fabry-Perot interferometer with the wide exposition time range, which allows to choose the most suitable speed of the line profile scanning and thus to increase the accuracy of measurement, i.e. to determine the plasma parameters with a better precision that it has been done so far, which is necessary for solving many practical applications.

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