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ԵՐԵՎԱՆԻ ՖԻԶԻԿԱՅԻ ԻՆՍՏԻՏՈՒՏ
ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ
YEREVAN PHYSICS INSTITUTE

FAST, LOW NOISE TRANSIMPEDANCE PREAMPLIFIER

L.K. PARLARYAN

ЕРЕВАН

Նախնատիպ ԵրՖԻ 1439(9)-95

ԱՐԱԳ, ՑԱԾՐ ԱՂՄՈՒԿՆԵՐՈՎ ՏՐԱՆՍԻՄՊԵԴԱՆՍԱՅԻՆ ՆԱԽՆԱԿԱՆ ՈՒԺԵՂԱՑՈՒՑԻՉ

Լ. Կ. ՓԱՐԼԱԿՅԱՆ

Նկարագրված է արագագործ դիէլեկտրիկ դետեկտորի հետ աշխատող միականալ տրանսիմպեդանսային ուժեղացուցիչ: Հիմնական բնութագրերն են՝ աճման ժամանակ -1,5նվրկ, ուժեղացման գործակիցը -3.5 մվ/միկրոԱ (երկու սեկցիայով՝ 210մվ/միկրոԱ), միջին քառակուսային մուտքային աղմուկներ-30նԱ, ծախսվող հզորություն -22մվտ: Սնման լարման փոփոխմամբ հնարավոր է ընտրել պարամետրերի տարբեր արժեքներ լայն դիապազոնում:

Երևանի ֆիզիկայի ինստիտուտ

Препринт ЕрФИ-I440(IO)-95

БЫСТРОДЕЙСТВУЮЩИЙ, НИЗКОШУМЯЩИЙ ТРАНСИМПЕДАНСНЫЙ ПРЕДУСИЛИТЕЛЬ

Л.К. ПАРЛАКЯН

Описывается одноканальный трансимпедансный предусилитель, работающий с быстродействующим диэлектрическим детектором: время нарастания -I,5нсек, коэффициент усиления -3,5мВ/мкА (каскадированно - 2IO мВ/мкА), среднеквадратичное значение входных шумов -30нА, потребляемая мощность -22мВт. С помощью изменения напряжения питания возможен выбор разных значений параметров в широком диапазоне.

Ереванский физический институт

1. Introduction

Employment of dielectric detectors in time-of-flight spectrometers is also due to their higher speed of response [1-4]. But in this case the current pulses with about 1ns risetime and a few μA amplitude need to be amplified enough to be able to reliably trigger a discriminator. The speed of response of the preamplifier should be such, as not to affect the time characteristics of the detector. At the same time, the preamplifier should have low input noises (tens of nanoamperes) and a high gain factor. In general, these problems have opposite solutions, but we have made an attempt to find an optimal solution realized in the form of the proposed transimpedance preamplifier.

2. Design

The circuit schematic for the preamplifier is shown in Fig.1. Here is used cascode as the fastest (the Miller effect is neutralized), and with low intrinsic noise. The cascode cascade is involved in parallel, with a negative current feedback. As it is known, such feedback is the most effective when working with current generators like dielectric detector. The depth of feedback is chosen by R_F. This resistor, together with the input capacity Q_1, for the feedback signal form an integrating circuit with a time constant larger than the risetime, which results in formation of an overshoot on the output pulse. To reduce this effect, R_F is shunted with a 1pF capacitor. KT3101A-2 type transistors have been used, which in case of the necessary static working currents and voltages (I_E=2mA; U_{CE}=2V) being provided, have low noise (1.8÷3dB) and sufficient gain in the high frequency band. The circuit is fed from a single power supply. Q_3 is open at a negative input pulse, this allowing at a small emitter current to obtain large negative output pulses, their maximum height increasing with the supply voltage (Fig.2). It is worth mentioning, that this static current almost does not grow with the supply voltage increasing in a wide range from 5 to 15V. Performance of the transistors and the feedback are supported by a minimal number of elements, which is very important from the viewpoint of improving the stability of performance and minimizing the sizes. Input and output are AC coupled with 0.1μF capacitors. The circuit is hand built on a printed circuit board with sizes 2.5×2cm, having a continuous ground plane on one side.

3. Test Procedures and Results

Fig.3 and Fig.4 show a test setup using a current source. A charge analog-to-digital converter under CAMAC control has been used. The input current pulse width is 40ns, and the gate ADC pulse width is 60ns. The amplitude measurements in the range up to 150μA have shown the integral nonlinearity to be <0.25%. The gain factor at a 50 ohm load is measured to be 3.5mV/μA, this not changing noticeably with the supply voltage varying in the range from 5 to 15V. This dependence is shown in Fig.5. Stable performance of a single section allows one by connecting two sections in series to obtain a current gain factor of up to 4500 (225mV/μA), practically not changing the other parameters. The input impedance, remaining within hundreds of ohms, is in a significant dependence with the supply voltage (Fig.6), resulting in the strong dependence of the static emitter current of Q_1 on the supply voltage. The strong dependence of the risetime and input noise on the supply voltage (Fig.7) is caused by the same reason. Lower supply voltages give better noise performance at the expense of output swing and risetime. At 1ns risetime the r.m.s. input noise is 45nA, and in case of 5ns the noise decreases down to 15nA. Slower-risetime detectors allow to limit the unnecessary wide bandwidth, to avoid additional noise. Table 1 lists relevant parameters in case of +6V supply voltage.

4. Conclusion

Besides meeting the requirements mentioned above, the proposed preamplifier shows a stable performance with the fastest photomutiplier signals. Beside high speed of response and low intrinsic noise it also has a good linearity (<0.25%), which allows this preamplifier to be used successfully in pulse height spectral measurements as well as with current-generator-type detectors. Low power consumption makes it convenient for use in mutichannel systems.

Acknowledgements

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Table 1

Specifications (V_{CC} = + 6V)

Gain	3.5mV/μA (cascadable 210mV/μA)
RMS Input Noise	30 nA
Risetime, Falltime	1.5 ns
Input Impedance	300 ohm
Propagation Delay	1.6 ns
Integral Nonlinearity	<0.25%
Max. Output Voltage Swing	800 mV
Power Consumption	22 mW
Size	2.5 x 2 cm

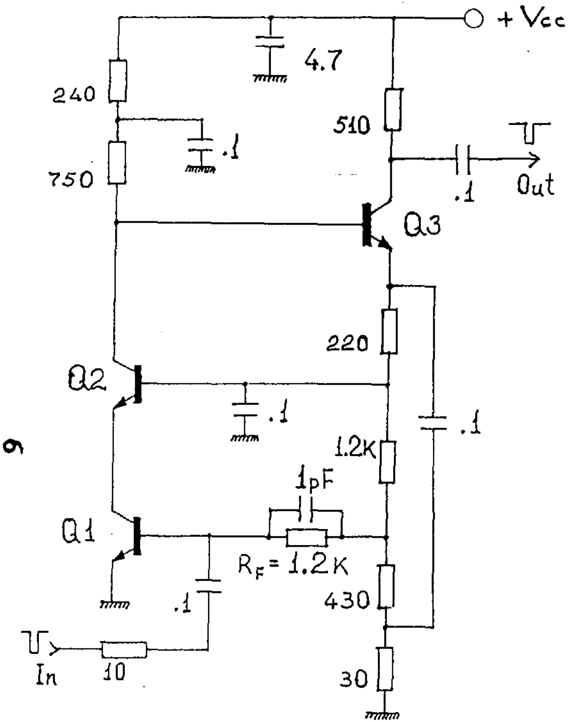

Fig.1 Circuit schematic of preamplifier.

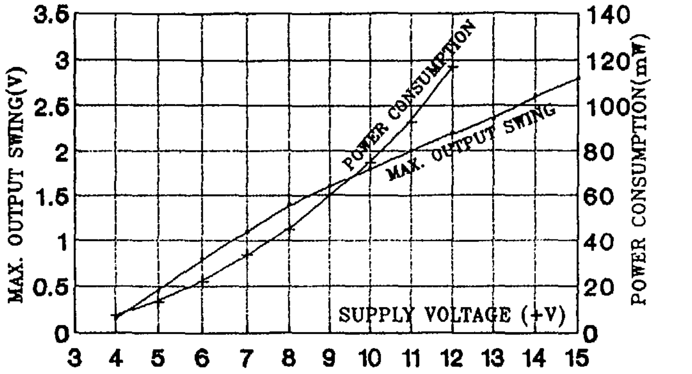

Fig.2

Maximum output voltage swing and power consumption vs. supply voltage.

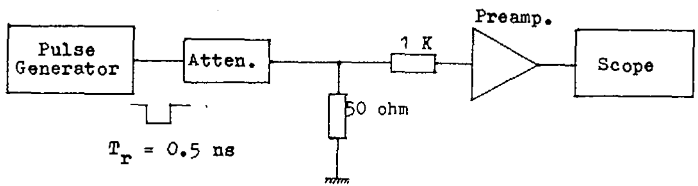

Fig.3 Test setup using a current source.

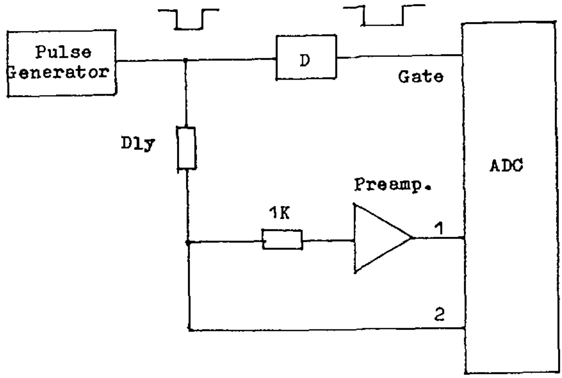

Fig.4 Setup for integral nonlinearity measurement.

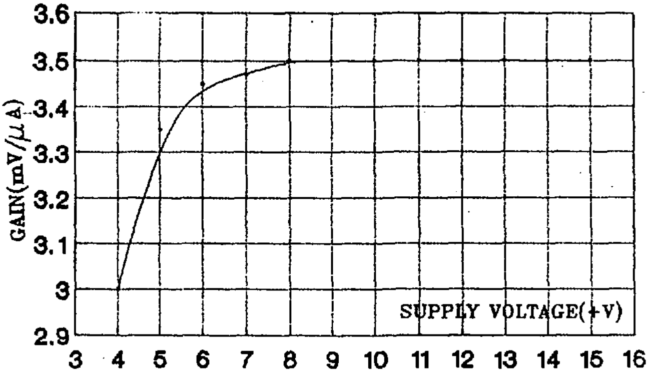

Fig.5

Gain vs. supply voltage.

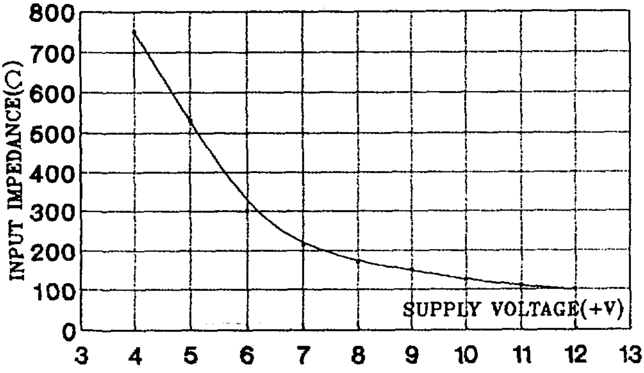

Fig.6

Input impedance vs. supply voltage.

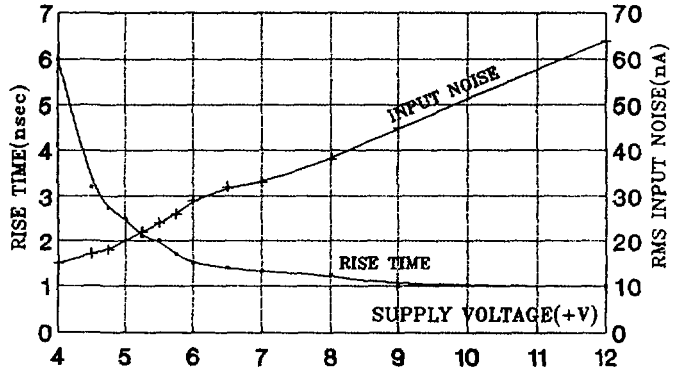

Fig.7

Risetime and r.m.s. input noise vs. supply voltage.

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Быстродействующий, низкошумящий трансимпедансный предусилитель.

Л.К. Парлакян

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L.K. PARLAKIAN

A single-channel transimpedance preamplifier for fast dielectric detectors is described. The main specifications of the preamplifier are: risetime is 1.5ns; gain is 3.5mV/μA (cascadable 210mV/μA); r.m.s. input noise is 30 nA; power consumption is 22mW. Depending on supply voltage, the parameters may vary in a wide range.

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