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A Circuit for Pulse Shape Discrimination

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LETTERS TO THE EDITOR

A CIRCUIT FOR PULSE SHAPE DISCRIMINATION

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The scintillation materials NaI(Tl), KI(Tl), CsI(Tl), NE 150, NE 213, etc. show a dependence of the shape of the light pulses on the ionization density produced by the ionizing particles. Alexander and Goulding[1]) have reported one of the electronic principles to distinguish between different pulse shapes. It consists of an integration of the current pulses of a multiplier with a time constant between the two main decay time constants of the light pulses. After the integration, a clipping or slow differentiation causes a zero-crossing of the signal with a zero-crossing time depending on the amplitude relation between the slow and fast components of the light pulses.

Lately this principle has been successfully used for identification of electrons, protons, deuterons and alpha-particles in NaI(Tl), KI(Tl) and CsI(Tl) crystals[2,3]).

We have used a simple circuit for a NE 213 scintillator based on the Alexander and Goulding principle. The circuit has proved to be reliable and faultfree in the last two years. Fig. 1 shows the circuit diagram. The input signals are current pulses from the 11th dynode of a XP 1040-multiplier. There are two output signals, the pulse amplitude of the first being shape dependent and the second one carrying the integrated charge of the input signal.

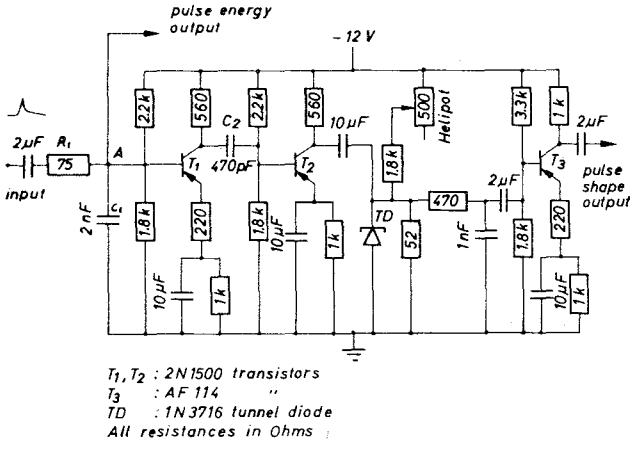

Fig. 1. Circuit diagram of the pulse shape discriminator. The input signals are current pulses of a dynode of a XP 1040 multiplier seeing a NE 213 scintillator. Output pulses are pulse shape analog pulses and energy analog pulses.

The input signal is integrated with the R_1C_1-integrator and then voltage amplified with transistor T_1. The capacitance C_2 causes the slow differentiation for the zero crossing. Transistor T_2 is a current amplifier and inverter. The tunnel diode network drives a positive current into the integrating 1 nF capacitance during the time interval between the start and zero-crossing of the current pulse from T_2.

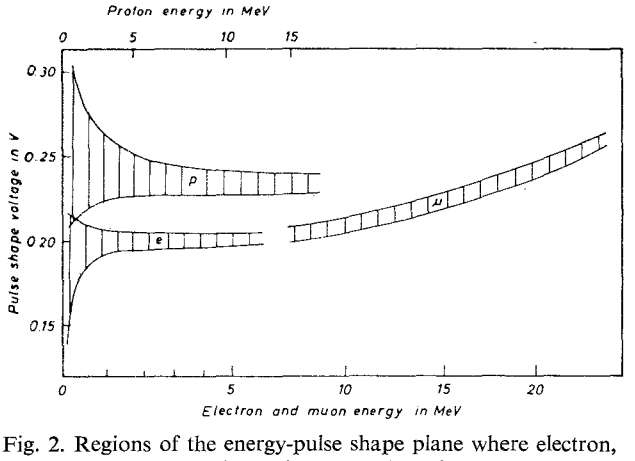

Fig. 2. Regions of the energy-pulse shape plane where electron, proton and cosmic muon events fall in.

The tunnel diode is normally in the valley point of its characteristic curve. A positive current from T_2 switches the tunnel diode to the Zener-region and when the current from T_2 approaches zero the voltage-current point on the characteristic curve of the tunnel diode approaches the peak point. If the 52 Ω resistor and the helipot are correctly adjusted, the positive maximum of the integrated tunnel diode pulse is proportional to the zero-crossing time. Transistor T_3 is a voltage amplifier.

The integrated charge of the input signal can be decoupled at point A by an amplifier similar to T_3.

The 150 ns input integration-time-constant is large enough to make the stray capacitances negligible on

the signal way between the multiplier dynode and the circuit input. The circuit can be soldered on one 105×120 mm^2 transistor card with all input and output connections through a 24 pole connector.

Fig. 2 shows the regions of the energy-pulse shape plane where electron, cosmic muon and proton events fall in. The electron and proton events were obtained from a Po-Be source as well as from the neutron beam of the Karlsruhe cyclotron. The muon events were obtained in a 120 mm diameter 120 mm thick NE 213 scintillator. The variation of the pulse shape signal in the upper energy region is a saturation effect of the fast component of the light pulses in the multiplier or in the first stage of the circuit. This saturation makes the electron and muon events more "proton like".

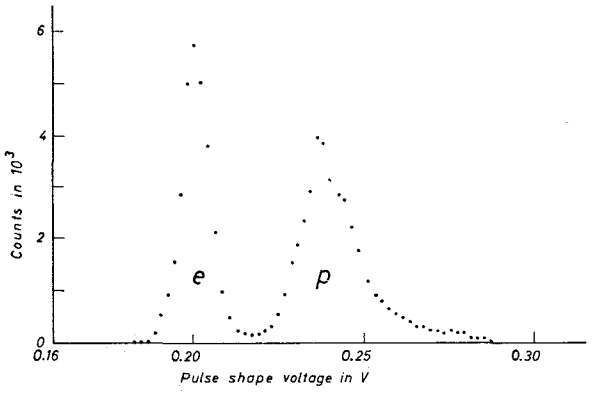

Fig. 3. Pulse shape analog amplitude distribution for a Po-Be source. Energy threshold was set at 0.47 MeV electron or equivalent proton recoil energy.

Fig. 3 is shown for comparison with results of other circuits. It is the pulse shape signal amplitude distribution obtained with a NE 213 scintillator and a Po-Be source. A coincidence pulse from the energy signal was fed to the multichannel analyser for electron energies above 0.47 MeV or equivalent proton recoil energies.

References

1) T. K. Alexander and F. S. Goulding, Nucl. Instr. and Meth. **13** (1961) 244.
2) R. Bass, W. Kessel and G. Majoni, Nucl. Instr. and Meth. **30** (1964) 237; Nucl. Instr. and Meth. **34** (1965) 169.
3) R. Fülle, Gy. Máthé and D. Netzband, Nucl. Instr. and Meth. **35** (1965) 250.