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SDC
SOLENOIDAL DETECTOR NOTES

CRYOGENIC PREAMPLIFIERS FOR SSPM/VLPC DEVICES FOR SCINTILLATING FIBER TRACKING

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CRYOGENIC PREAMPLIFIERS FOR SSPM/VLPC DEVICES FOR SCINTILLATING FIBER TRACKING*

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Abstract

The application of scintillating fiber technology for particle tracking [1] requires the development of solid state photodetectors, such as the Solid State Photomultiplier (SSPM) and the Visible Light Photon Counter (VLPC) under development at Rockwell International Science Center [2]. These devices are operated at about 7° K, and therefore the design of front-end electronics operating at cryogenic temperatures is needed. We report on the development of six alternative conceptual designs for the cryogenic front-end electronics using traditional JFET technology and GaAs FETs currently under development.

Introduction

Six alternative conceptual designs for the cryogenic front-end electronics of the Scintillating Fiber Tracking Subsystem for the SDC detector [3] were developed. We first studied the various design possibilities to determine which ones are compatible with the following electronic and thermal constraints of the system:

(a) The preamplifiers must operate at or below 77° K.

(b) The pulse width must be less than 16 nsec, and the rise time 5 nsec or less.

After detailed discussions with manufacturers of fast cryogenic electronic devices we developed six alternative conceptual designs (Fig. 1). The first two of them use traditional silicon JFET technology, while the other four are based upon Gallium Arsenide FETs currently available in prototype form.

We have also identified manufacturers to provide cables for cryogenic temperatures. We propose to use cables made from 2 mil SS304 stainless steel wires laminated in Teflon for the interconnection between the SSPM's and the wall of the cold He gas chamber. Teflon has very good characteristics at liquid helium temperatures and does not bond to the stainless steel wire. This eliminates stress produced by the different thermal expansion of the two materials. The stainless steel-Teflon ribbon will have a relatively low thermal conductivity. An alternative approach to the stainless steel-Teflon ribbons might be stainless steel-silicon-rubber ribbons. We have used copper silicon-rubber ribbons before in cold hostile environments, in the Apollo moon flight program.

* This research was conducted by the Fiber Tracking Group, a list of authors can be found in "Scintillating Fiber Tracking for SSC", et. al., these proceedings.

DESIGN ALTERNATIVES

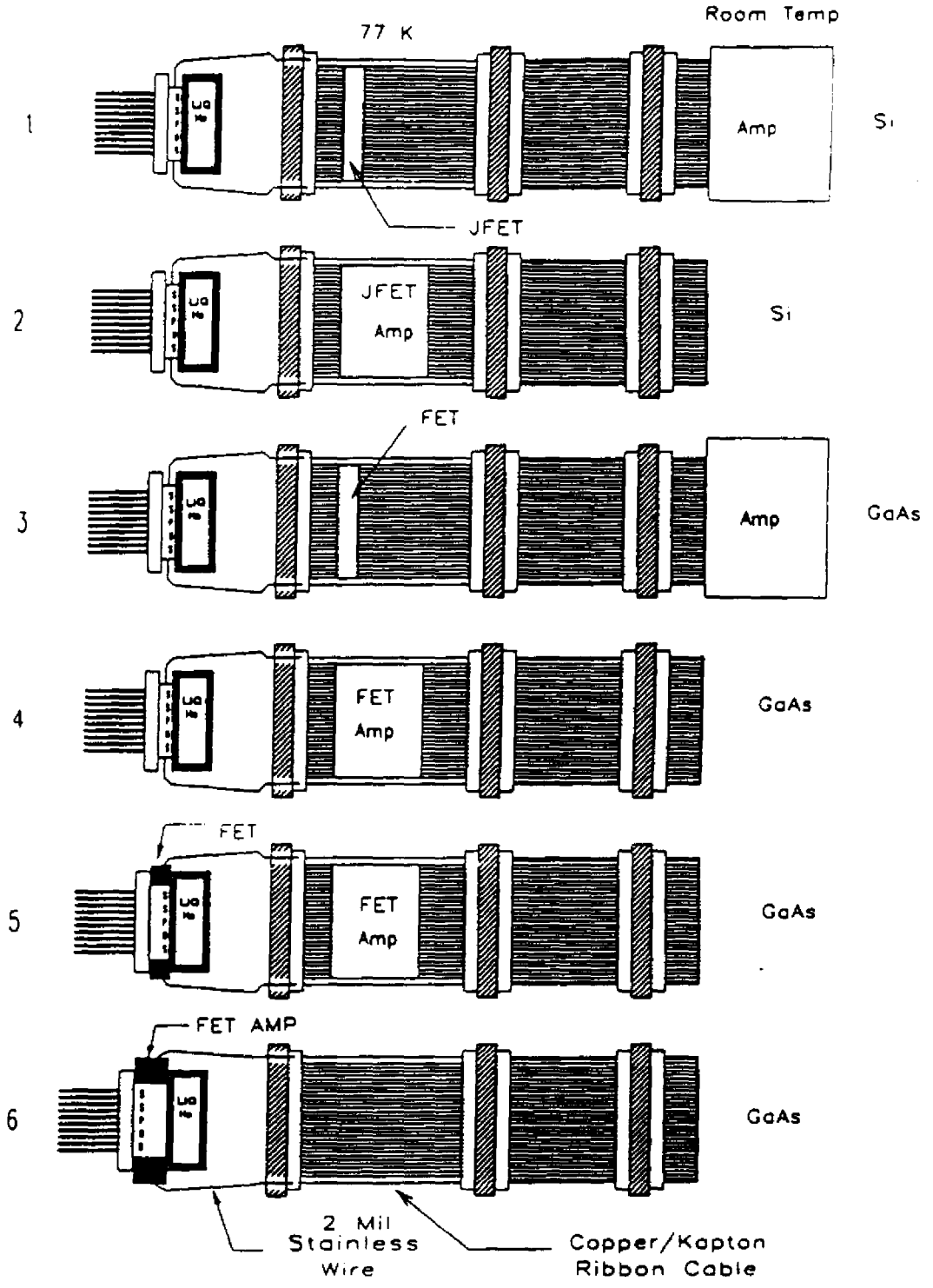

Figure 1. Various conceptual design alternatives for cryogenic preamps to be used in conjunction with VLPC/SSPM devices: 1-2 use silicon JFET technology; 3-6 are based on GaAs FETs currently available in prototype form.

We propose to use flexible copper-Kapton multilayer ribbon for the region from the cold He gas chamber out to the room temperature region. With copper trace widths as low as 4 mils, minimum heat transfer can be assured between devices placed in the cryogenic compartments. Surface mount preamplifier/amplifier devices can be directly applied to the multilayer ribbon cable.

Comparison of the Conceptual Designs

The various conceptual designs to be evaluated and tested are shown in Fig. 1. The first uses a single silicon JFET surface mounted on the copper-Kapton cable. It has the advantage of minimum heat transfer dissipation, and is the simplest device to implement, using mainly off-the-shelf components with minimum design cost. The third design is very similar to the first one, but uses GaAs FETs rather than silicon. The advantage of the third design over the first is the significantly faster rise time of the GaAs device. The second conceptual design shown in Fig. 1 has the advantage of a single smaller preamplifier/amplifier running at cryogenic temperature. This results in a lower noise level and more compact packaging. It does, however, restrict the design to the use of components which can operate at cryogenic temperatures. Placing the amplifier inside will also, of course, produce additional heat load for the cryogenic system. These same remarks also apply to the fourth design, which differs only in the use of GaAs devices instead of silicon JFETs. The most promising design will most likely be either design five or six. They use GaAs devices operating at helium temperature and directly coupled to the SSPM/VLPC devices. These GaAs devices have been tested below 10° K and have the additional advantage of eliminating the capacitance of the interconnecting cable. This fact will result in a system rise time limited only by the impedance of the SSPM. We are, however, concerned about the additional heat load produced by placing the amplifier system in the helium chamber. The difference between conceptual designs five and six addresses this concern.

The above two devices have the additional important characteristics of consuming relatively low power and have low impedance output (less than 100 ohm).

It is our opinion that these devices will enable the fiber tracking detector prototype to be constructed and tested at cryogenic temperatures and 60 MHz operation. The preamplifiers have additional important applications at room temperatures in the silicon tracker readout system and in some of the calorimetric devices to be used in the SDC detector.

Acknowledgments

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References

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