HIGH VOLTAGE SUPPLY FOR REMOTE LOCATED GEIGER MUELLER COUNTER

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АЛСАД БАЙРЛАСАН ГЕЙГЕР МЮЛЛЕРИЙН ТООЛУУРЫГ ӨНДӨР ХҮЧДЭЛЭЭР ТЭЖЭЭХ БЛОК

Ванчигийн Баяр, д-р Душан Поникварх

Алс зайд өндөр хүчдэлийг дамжуулах систем боловсруулагдаж, Гейгер Мюллерийн тоолуур дээр шалгагдсан. 5км хүртэл алсад дамжуулах хүчдэлийн дээд хэмжээ 700В байна. Системийн ерөнхий бүтэц, техникийн үзүүлэлтүүдийг нэгтгэсэн.

INTRODUCTION

Geiger Mueller (GM) counter device consists of an high voltage power supply part, a radiation detection part and a detector signal receiver part. GM pulses from the signal receiver part counted by a 8253 type counter and proceeded by a personal computer in the future calculation.

Figure 1 shows this subsystem in general point of view. GM counter needs high voltage in the range of +400V and +600V to detect gamma radiation level in air. It is not economical and unsafe to transfer the high voltage supply over a long distance from a main controller system to the GM counter. Because it should be placed far away from the main controller system.

During the experimental period it was established by measurement that the distance between GM counter and the high voltage supply should not exceed 0.8 meter. If it exceeds the high voltage drops sharply. This problem has been solved by designing a special electronic circuit of long distance high voltage supply for remote located GM counter. After the GM detector has been supplied with the necessary high voltage supply, it can be used to detect the gamma radiation level in air. But another serious problem arises here together with the high voltage power supply. The detected signal by the GM detector is super imposed on the high voltage level. Therefore there is a need to separate the detected signals from the high voltage level and to send them for further processing to the main controller system. The separated and detected analog signal from the GM detector is received by a special type of receiver through the 4mA to 20mA current interface over a long distance to the PC.

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The GM detector signal receiver is a special part, because it converts the high level, approximately +30V, of digital signals from the current transmitter, into TTL standard level digital signals which are compatible for the serial port of the D8253C-2 type counter.

HIGH VOLTAGE AND RADIATION DETECTION

Remote located GM detector should have its high voltage power supply directly to it or near at the maximum distance of 0.8 meter. To satisfy this requirement we have used a two-wire and 4mA to 20mA current loop. Reference voltage of +7.2V from LM723 has been used to get a stable high voltage supply for the GM detector, using an idea of a Switching Power Supply.

Figure 2 shows a schematic drawing of the developed high voltage power supply part and radiation detection part. The reference voltage is applied to a serially connected pair of inductors L1 and L2. L1 is primary and L2 is secondary windings. They are used to amplify the applying low voltage up to +500V due to their physical behavior.

Wrapper quantities of the inductors are determined experimentally, because we had different type of inductor wires with different diameters. A connected point (a middle point) of these two inductors is applied to a drain of a "BF-258" type MOSFET transistor. The BF-256 is P-type and high voltage (maximum −200V) transistor and this is a switching transistor for the high voltage power unit. Simple digital pulse generator is applied to a gate of this transistor. The "4093" type CMOS-NAND gate is used for the pulse generator and it gives 1KHz clock pulses. This pulse generator is controlled by a feedback connection from the pair of inductors through a "High Voltage Dropper" and a "Feedback Control Block".

The high voltage dropper consists of five "1N4148" type diodes and two 1M resistors. The high voltage connected to the cathode of the diode D4 through the resistor R7. This backward connection of the each diode enables to drop the high voltage down by approximately +100V due to its backward electrical characteristics. Therefore these five diodes drop the +500V down approximately to +1.5V. This keeps a "BC182" type N-P-N transistor closed and the pulse generator generates pulses to the gate of the switching transistor. This enables the inductor voltage to increase.

If output of the inductors exceeds +500V the output of the voltage dropper gives enough voltage to the base of the feedback transistor which opens it. This open transistor disables the pulse generator by grounding the input of the NAND gate. It forces the switching transistor to close which causes to decrease the high voltage. This is the general switching procedure to get the high voltage of −500V for the GM counter. Then this high voltage is applied to the GM detector and the GM detector is able to detect the gamma radiation.

However the detected signal stays at the high voltage level. Thus we have used a simple voltage divider to separate them. The voltage divider consists of 1M2 and 680K resistors and it gives approximately +30V output voltage. After this stage the detected signal is sat on the +30V level voltage. To get approximately +7.2V level voltage signal we have used three pieces of "4093" type CMOS-NAND gates.

After designing this circuit one AND gate is left unused. Thus we decided to use this along with a small piezo electrical speaker to receive an audio signal of the working GM counter. This audio signal helps to save some time during the testing and adjusting period of the developing subsystem.

Also it is possible to use "J-K" type flip-flops as a pulse divider by two before the detected signal goes to the ADC through the current transmitter. It gives longer period of detecting pulses which helps to increase the exactness of the pulse counting procedure by the main system using a specially developed software.

The "4027" type CMOS "J-K" flip-flop is used in this particular case. In the case of using "J-K" flip-flop as a pulse divider by two, DO NOT forget to multiply by two the counted number of pulses in a data processing and analyzing program in the connected personal computer to get the real number of detected pulses by the main controlling system. Use of CMOS type ICs for this part has been based on the following considerations:

- The reference voltage V(reference) = +7.2V can be used directly as a power supply to the CMOS integral circuits.
- It is possible to apply higher voltage level signal to the CMOS IC inputs (approximately not more than +30V) than to the inputs of the standard TTL ICs.

An output of this part is transmitted over a long distance (maximum five kilometers) through the two-wire and 4mA to 20mA current interface to the next part of the main controlling system.

GM COUNTER SIGNAL RECEIVER PART

In this part we have used the standard operational amplifier LM311 with series of resistors, so that output of this circuit gives TTL level digital signals.

Figure 3 shows a schematic drawing of the GM counter signal receiver part. The GM detector signal which is transmitted over a long distance through the 4mA to 20mA current transmitter should be converted into voltage. For this purpose, a voltage converter is used. It consists of R1=47K and R2=39K resistors. After this stage the current signals from the current transmitter should be converted as:

- Current signal of [4mA] converted to 4mA * 47K = 188 mV;
- Current signal of [20mA] converted to 20mA * 47K = 940 mV;

Then these voltage signals are received by the inverting input of the operational amplifier. Values of the resistors R3=6K, R4=1K, R5=39K and R6=5K are chosen. so that the output of the LM311 type operational amplifier gives 470 mV input signal as TTL level logic "0" and 940 mV input signal as TTL level logic "1".
The standard TTL output signal is received by D8253C-2 type down counter. This counter is programmed from the PC to count a number of incoming pulses per second and then this data are transferred to the PC for a further processing by a special program.

LITERATURE:

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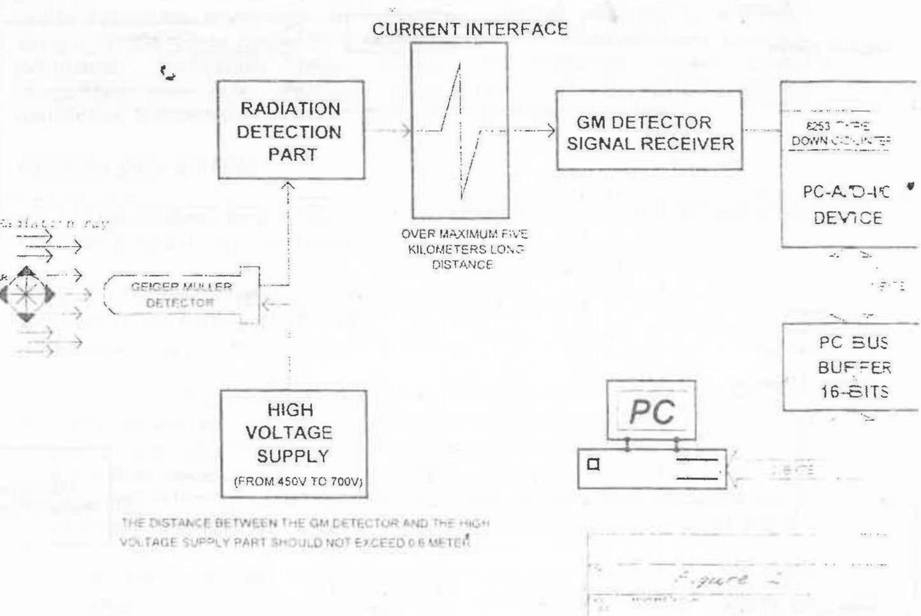

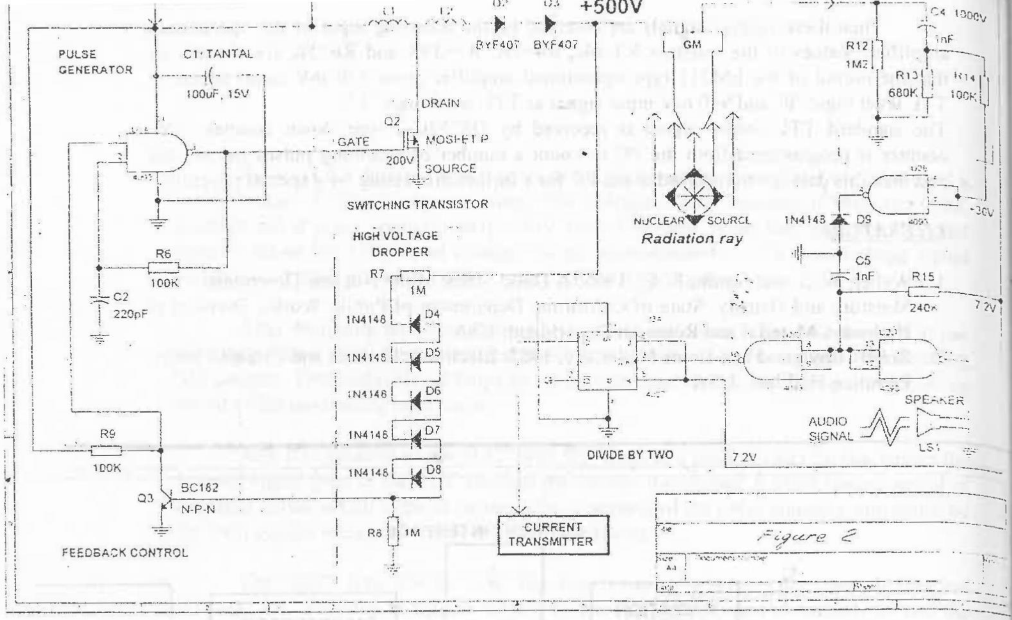
+500V
BYF407
BYF407
C4 1000V
1nF
PULSE GENERATOR
C1 TANTAL
100uF, 15V
DRAIN
Q2
GATE
MOSFET P
200V
SOURCE
SWITCHING TRANSISTOR
GM
R12
1M2
R13
680K
R14
100K
NUCLEAR SOURCE
Radiation ray
1N4148
D9
-30V
HIGH VOLTAGE DROPPER
R6
100K
C2
220pF
R7
1M
1N4148
D4
1N4148
D5
1N4148
D6
1N4148
D7
1N4148
D8
C5
1nF
R15
240K
7.2V
SPEAKER
AUDIO SIGNAL
LS1
DIVIDE BY TWO
7.2V
R9
100K
Q3
BC182
N-P-N
R8
1M
CURRENT TRANSMITTER
FEEDBACK CONTROL
Figure 2
Size
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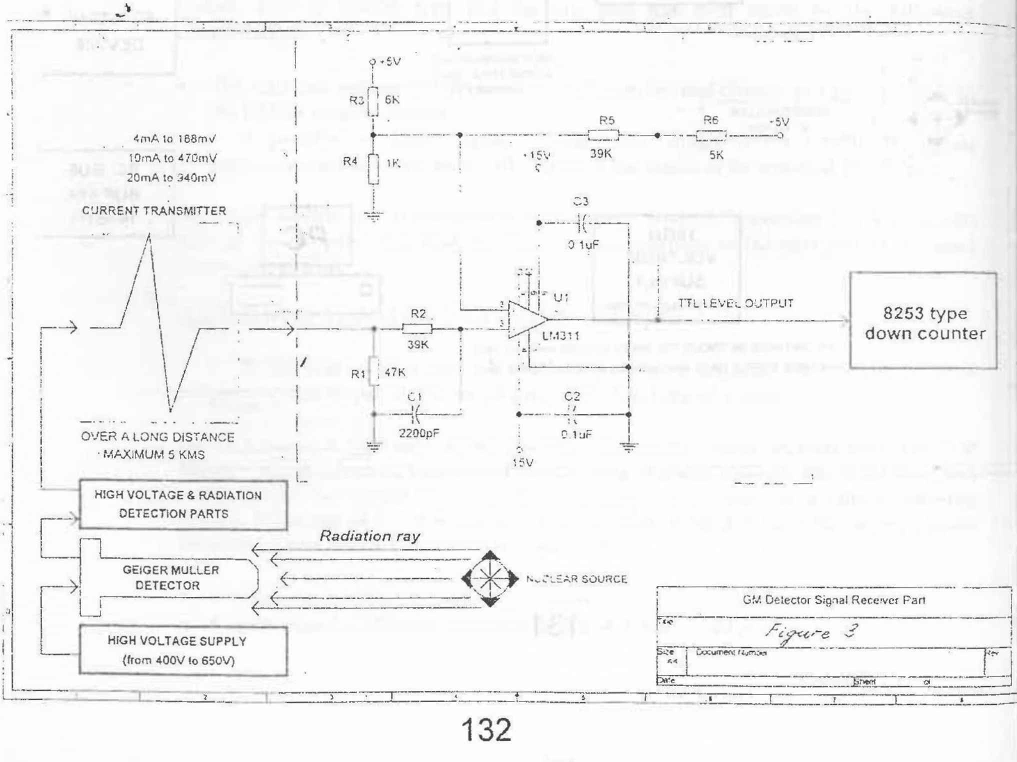
Document Number


+5V
R3
6K
R4
1K
R5
39K
R6
5K
-5V
+15V
4mA to 188mV
10mA to 470mV
20mA to 940mV
CURRENT TRANSMITTER
C3
0.1uF
U1
LM311
TTL LEVEL OUTPUT
8253 type down counter
R2
39K
R1
47K
C1
2200pF
C2
0.1uF
15V
OVER A LONG DISTANCE
MAXIMUM 5 KMS
HIGH VOLTAGE & RADIATION DETECTION PARTS
Radiation ray
GEIGER MULLER DETECTOR
NUCLEAR SOURCE
GM Detector Signal Receiver Part
Figure 3
HIGH VOLTAGE SUPPLY
(from 400V to 650V)
Size
A4
Document Number
Rev
Date
Sheet
of