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PMT DARK CURRENT REDUCTION USING THERMOELECTRIC COOLING UNIT TE-206TSRF

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Abstract

Photomultiplier Tube (PMT) type EMI 9863Q with its housing and power supply of rang (1.5-3) kV, beside of the cooling unit type TE-206TSRF are used to perform this research. The evaluation of PMT dark current pulses count are carried out in laboratory at different high voltage and at different temperatures ,the results of these test, are plotted as a testing curves for this type of PMT. The research includes two tests ,one for perform the affect of cooling on the dark pluses counts, and the second test for determined time intervals for PMT housing can be kept the cooling . The maximum dark pluses count at 0°C Temp is 18000, where at -10 °C is 4000, and at -20 °C is 1000 at same H.V (2.5 kV).The PMT housing cooling stage times are sec for -10, sec for -20, sec for -30.

Introduction

The photomultiplier dark current (pluses), as measured at the PMT anode, represents the combined contributions of electron emission from the cathode and dynodes together with electrical leakage within the tube, the thermally generated electrons usually make the major contribution.

In low level applications the dark current is considered an unwanted signal; a reduction of several orders of magnitudes is possible by cooling. The lower temperature limit depends upon the type of photocathode of PMT, since the materials which are used in producing photocathode are semiconductors. Their cathode conductivity decreases with decreasing temperature until the photocathode become so resistive that a sizeable voltage drop may occur across the cathode surface when cathode current flows.

Such a voltage drop may result in loss of linearity of the output current as a function of light level.

Thermoelectric cooling unit TE-206TSRF specification

Thermoelectric cooling [1]is based on the phenomenon of cooling or absorption of heat at the junction of two rods of metal or semiconductor when a current is made to pass through them. In order for thermoelectric cooling devices to be effective, the absorbed heat as well as the heat generated as a result of I^2R losses must be removed from the hot side of the device. Air or liquid heat exchangers are used in TE-206TSRF to accomplish this cooling technique see the unit specification in Fig.(1). This PMT housing cooler is provided a complete shielding for the magnetic, electrostatic and RF interference.

Advantages of thermoelectric cooling unit

Thermoelectric [2] modules have no moving parts and do not require the use of chlorofluorocarbons. Therefore they are safe for the environment, inherently reliable, and virtually maintenance free. They can be operated in any orientation and are ideal for cooling devices that might be sensitive to mechanical vibration. Their compact size also makes them ideal for applications that are size or weight limited where even the smallest compressor would have excess capacity. Their ability to heat and cool by a simple reversal of current flow is useful for applications where both heating and cooling is necessary or where precise temperature control is critical. Exchangers are used in Products for Research housings to accomplish this.

Thermoelectric coolers are used for the most demanding industries such as medical, laboratory, aerospace, semiconductor, telecom, industrial, and consumer. Uses range from simple food and beverage coolers for an afternoon picnic to extremely sophisticated temperature control systems in missiles and space vehicles.

A thermoelectric cooler permits lowering the temperature of an object below ambient as well as stabilizing the temperature of objects above ambient temperatures. A thermoelectric cooler is different from a heat sink because it provides active cooling unlike a heat sink which provides only passive cooling.

Thermoelectric coolers can be used for applications that require heat removal ranging from milli-watts up to several thousand watts. However, there is a general axiom in thermoelectric: the smaller the better. A thermoelectric cooler makes the most sense when used in applications where even the smallest vapor compressor system would provide much more cooling than necessary. In these situations, a thermoelectric cooler can provide a solution that is smaller, weighs less, and is more reliable than a comparatively small compressor system.

Photomultiplier tube cooling testing

In this research two tests are carried out on the PMT in its darkness mode. The PMT type EMI 9863Q [4] with thermoelectric cooling unit TE-206TSRF are used in research see Fig.(2). The output pluses of PMT is amplified using preamplifier and amplifier with a gain of 48db totally [5].The amplified PMT output plusses are entered into discriminator unit (tunnel diode circuit [6], a fixed discrimination level is used to keep the PMT dark current as a dominate monitoring result .The resultant output pluses from the discriminator unit are counting and monitored as a test resultant.

Test One

Because of the direct relationship between PMT dark pluses and the PMT high voltage (H.V.) power supply [5], the test is carried out at different setting of H.V. The value of dark pluses count reaches approximately 18000 counts at 0°C temperature for maximum PMT H.V. setting (2.5 kV), This pluses count is reduced to approximately 3000 counts, 1200 counts at temperature-10°C,-20°C respectively.

Many of dark pluses measurements are carried out at different H.V. setting below the maximum values, these measurements are plotted in curves at different cooling temperatures (-10°C,-20°C) as shown in Fig.(3), these curves are very useful to the astronomical observer in faint star photon counting photometry [3].

Test Two

This test is carried out on the PMT housing to determine the time interval that can be kept the cooling temperature after switch off the cooling unit. In a same PMT darkness mode and after cooling the PMT to any desiderate value, we notices that the dark pluses count increased to reach its maximum value after a time interval. For example dark pluses counts (at H.V. power supply value (2.3kV) and cooling value of -10°C) is approximately 2800 counts ,we notice that this value after switch off the cooling unit will be increased to reach its maximum value (43000 counts) after a time of 30 minutes.

Many Measurements at different cooling values (-10°C,-20°C,-30°C,-40°C) are carreied out at a fixed H.V. power supply value (2.3kV), recording the dark pluses counts for different time interval until reach the maximum values of dark counts. The results of these measurements are plotted in a set of curves as shown in Fig.(4).

Conclusion

The important result for this research is explained the huge reduction in dark pluses counts by using the cooling unit the TE-206TSRF , This research is also testing the good ability of PMT housing type RS for shielding from outside temperature effects. Fig.(4) is explained that low temperature storage is closed to the curve of TE-206 TSRF manufacturing product in Fig.(5).Therefore from this research we can be recommended to use these equipments in low light level photometry applications, such as in faint star astronomical photon counting photometry.

TE206RF and TE206TSRF	
Guaranteed ΔT - Ambient air to photocathode	$\geq$ 60°C with ambient air warmer than 10°C
Cool down time to stability of photocathode	3 hours Performance Graph (12K)
Standard window material	Evacuated Double Pane Plexiglas 80% transmission from 366 nm to 1125 nm
Mounting	Front and bottom mounting holes are provided
Front Mounting via 6 inch (15.2 cm) Standard Front Mounting Adapter Compatible with Model PR302 Light Shutter Assembly	
Weight	Chamber - 17.5 lbs. (7.9 kg) Power supply - 20.5 lbs. (9.3 kg)
Power required	200 Watts at either 115 V~, 50/60 Hz or 220 V~, 50/60 Hz
Options: **TE206RF** includes Options 7, 9 and 11 • **TE206TSRF** includes Options 7, 9, 11 and 36 Options 3, 10, 20, 21, 24, 27, 28 and 31 - not available	

Fig.(1) : Specifications of Air Heat Exchanged Multi-Stage Thermoelectric TE206TSRF [2].

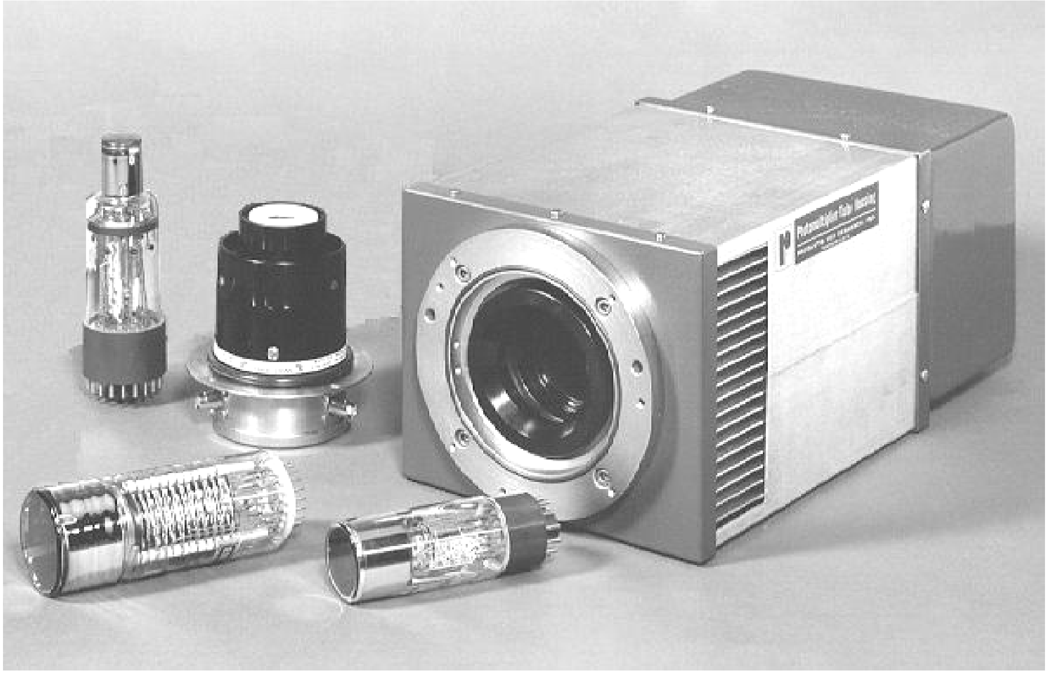

Fig.(2) :Photograph showing Cooled Photomultiplier Housings for PMT EMI 9863Q [1].

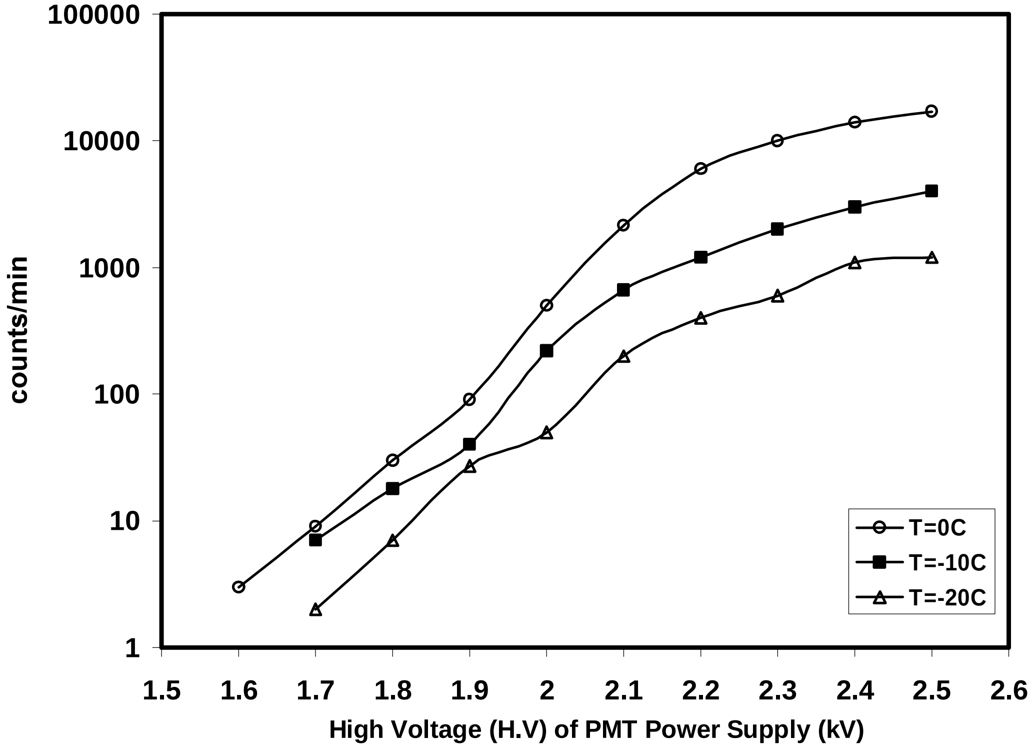

Fig.(3) : PMT Dark Counts Against H.V. With Cooling.

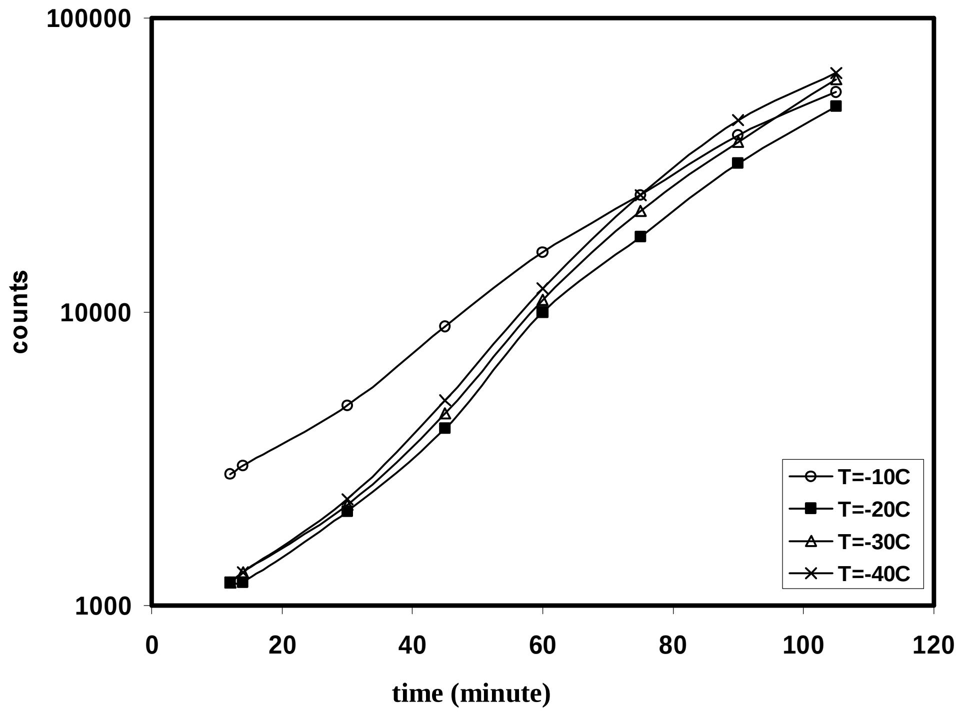

Fig.(4) : PMT Dark After The Cooling Unit Switch OfF.

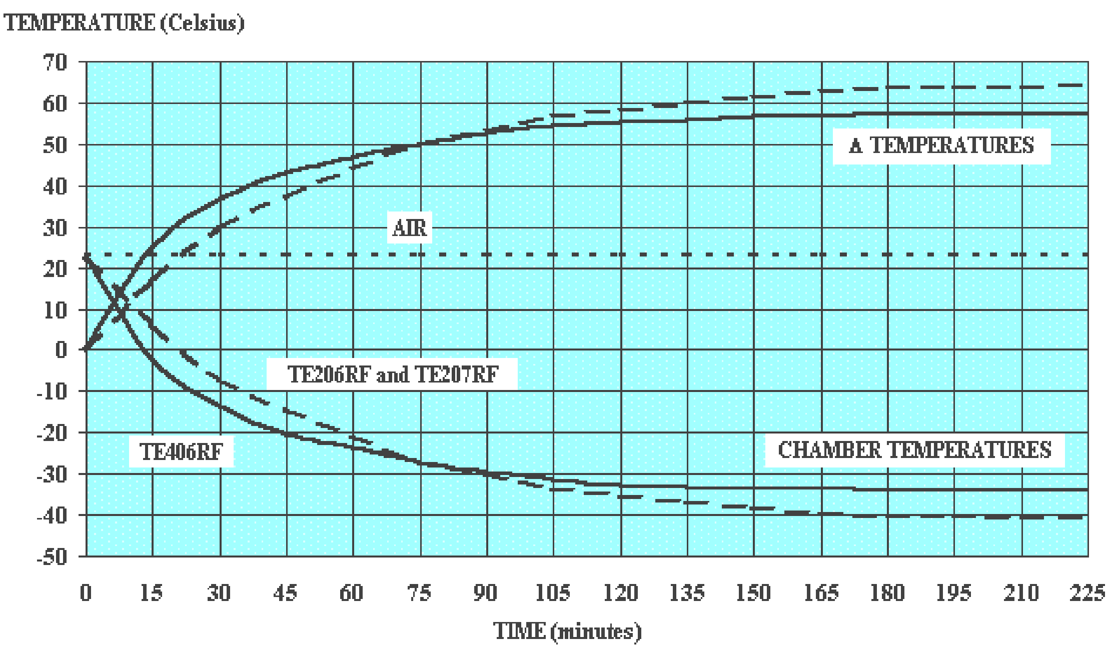

Fig.(5): Air Heat Exchanged Multi-Stage Thermoelectric Coolers Cool-Down [7].

References

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الخلاصة

استخدم في هذا البحث صمام مضاعف الفوتونات (PMT) من نوع EMI9863Q مع حافظة خاصة به ، مجهز قدرة عالية بمدى (1.5-3 kV) و استخدم ايضا جهاز تبريد نوع TE-206TSRF. تم اجراء قياسات لتحديد مقدار تيار الصمام في حالة الظلام (dark) في المختبر تحت درجات تبريد مختلفة وقيم مختلفة لمجهز القدرة. ورسمت نتائج القياسات (الاختبارات) على شكل منحنيات خاصة للصمام.

تم اجراء اختبارين على الصمام الاول لايجاد تأثير التبريد على عدد نبضات تيار الصمام في حالة الظلام و الاختبار الثاني حساب الفترة الزمنية التي يحافظ فبها الصمام على درجة تبريده بعد انطفاء جهاز التبريد. ان اعلى مقدار لنبضات الظلام للصمام في درجة حرارة 0° هو (18000) وفي 10°C - هو 4000 وفي 20°C - هو 1000 وان فترة حفاظ درجة تبريده في 10 °C- هو 30 دقيقة و20 °C- هو 15 دقيقة.