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The Compact Muon Solenoid Experiment

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A stabilised blue-violet LED for VPT photocathode evaluation

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Abstract

A highly stable blue-violet light source (peak wavelength 431 nm) based on the IPL10630PAL self-monitoring LED is described. A thermoelectric cooler has been used to stabilise the 10630PAL device and the external LED current-control electronics to ± 0.1 K. The light intensity was measured to be stable to ±0.03% for five hours, the repeatability was ±0.1%. The output spectrum of the LED is a good match to the scintillation emission of $PbWO_4$, and this source will be used to evaluate the spatial and angular uniformity of VPT photocathodes for the endcap calorimeter.

1 Introduction

As part of the evaluation of prototype vacuum photo-triode photodetectors for the electromagnetic endcap a stable DC light source was needed to measure the relative response of the photocathodes as a function of position and angle of incidence. Available laser sources (HeNe at 633nm, Ar^+ at 514 and 488 nm, HeCd at 442 nm) were tried and found to be incapable of reproducing data sets to better than 2%. A similar problem, of CCD camera calibration, had been solved using a special green LED with a built-in photodiode and a transconductance amplifier[1] Very recently a blue-violet version of the self-monitoring LED has been produced[2] and since its peak output (quoted to be 425 nm) is close to that of scintillation light from $PbWO_4$ we developed a system with a design goal of relative stability of ± 0.2% using it. The key specifications of the self-monitoring emitter are given in table 1:

Parameter	Unit	Typical value
Maximum continuous LED current	mA	20 @ 30 °C
LED Irradiance	$\mu W.mm^2$	0.6 (at 20mA LED current and 100 mm from LED)
Peak wavelength	nm	425
Spectral bandwidth (FWHM)	nm	65
Beam angle (1/2 power)	degrees	6
Monitor frequency response	kHz	100

Table 1: Manufacturer's typical data for the IPL 10630PAL blue-violet self-monitoring LED

2 Description

The system schematic is shown in Figure 1. The self-monitoring blue-violet LED is driven from the output of an LM611 operational amplifier, via a pass transistor. The non-inverting input to the op-amp is referenced to a voltage proportional to a highly stable on-chip voltage reference. The inverting input is connected to the output from the 10630PAL transconductance amplifier. This feedback loop ensures that the light output from the LED is kept stable. In the RGO design a negative supply rail was added to improve LED performance when pulsed. Although our circuit will operate perfectly in DC mode on a single supply, the negative rail was retained in case AC operation was subsequently desired. In order to reduce further reduce the sensitivity of the system to normal laboratory temperature fluctuations, and with the additional goal of having a stable reference light source for absolute quantum efficiency measurements, the 10630PAL and the LM611 were mounted on a cooled aluminium-alloy block.

The aluminium-alloy block was attached to a large fan-cooled heatsink via a 33W single-stage Peltier device. The temperature of the aluminium-alloy block was measured with a Pt-100 thermometer, and the current to the Peltier was controlled by a CAL 3200[3] temperature controller. The controller is a full PID device with autotune capabilities. The key control parameters of the CAL 3200 were set to:

Parameter	Unit	Value
Proportional band	K	2.0
Derivative rate	s^{-1}	2
Integration time	s	0.4
Cycle time	s	1.8

Table 2 PID temperature control parameter values

3 Performance

The temperature controller was set up to keep the aluminium block at 10.0 ºC. The cool-down time from ambient (22 ºC) was 180 s after which the temperature of the block was stable to ±0.1K over periods up to 4 days. The light intensity was monitored with a 1 mm^2 silicon pin diode and a Keithley 614 electrometer. After a period of 24 hours for the monitoring equipment to reach thermal equilibrium, the diode current was measured over a period of five hours. The photodiode current was stable to ±0.03%. In a second test the LED system was switched off, allowed to warm up to ambient temperature and then switched on. After five minutes the photodiode current was measured. This procedure was carried out a total of five times, and the absolute repeatability was ±0.1%.

The emission spectrum of the LED was measured using a Chromex 250 imaging spectrometer and a Lambda

2000 diode-array detector. The spectrum, shown in figure 3, was corrected for the QE of the linear diode detector and for the diffraction grating efficiency. The resolution was 3.4 nm. For our LED the peak wavelength was 431 nm and the FWHM 65 nm.

4 Conclusions

The system described here more than meets our design specification. It shows excellent stability (±0.03%) and repeatability (±0.1%). The measured LED output spectrum is a good match to $PbWO_4$ scintillation emission, and is thus appropriate for evaluating VPT devices which will be used in the CMS endcap electromagnetic calorimeter.

References

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[1] S Tulloch "Design and use of a light source for linearity measurements in CCD cameras", RGO Technical Note 111, Royal Greenwich Observatory, August 1997

[2] 10630PAL from Integrated Photomatrix Ltd, The Grove Trading Estate, Dorchester, Dorset DT1 1SY, UK

[3] CAL Controls Ltd, Bury Mead Road, Hitchin, Hertfordshire, SG5 1RT, UK

Figures

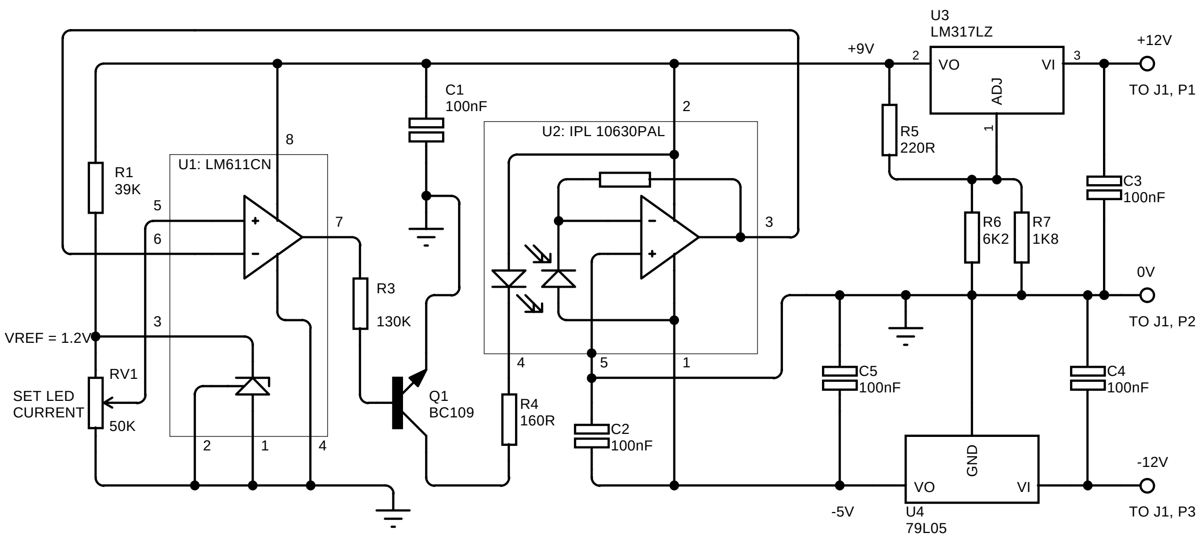

Figure 1 LED control circuit

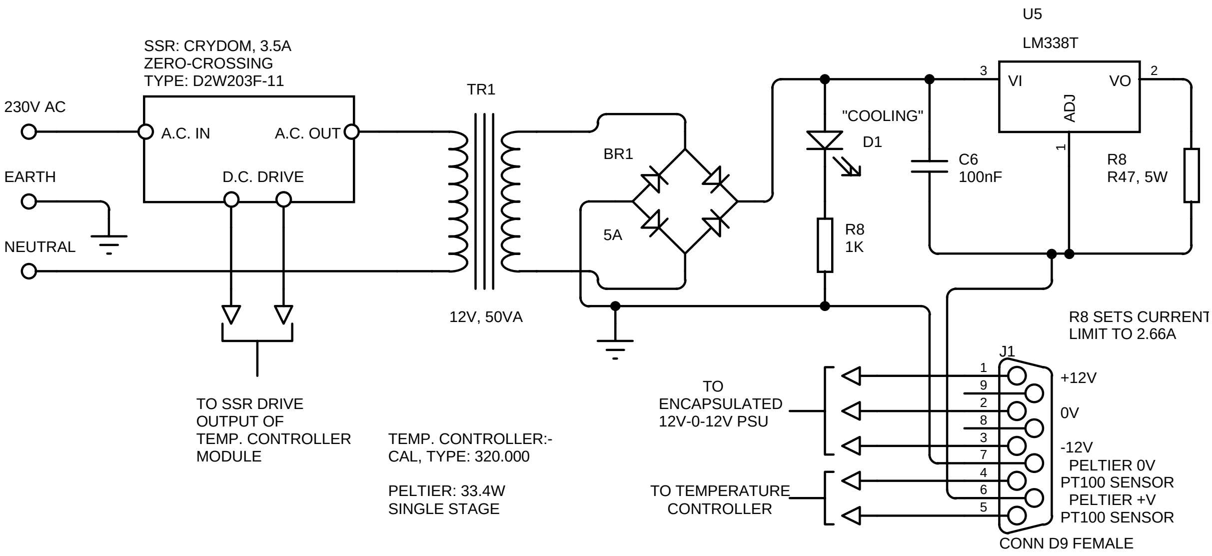

Figure 2 Peltier control circuit

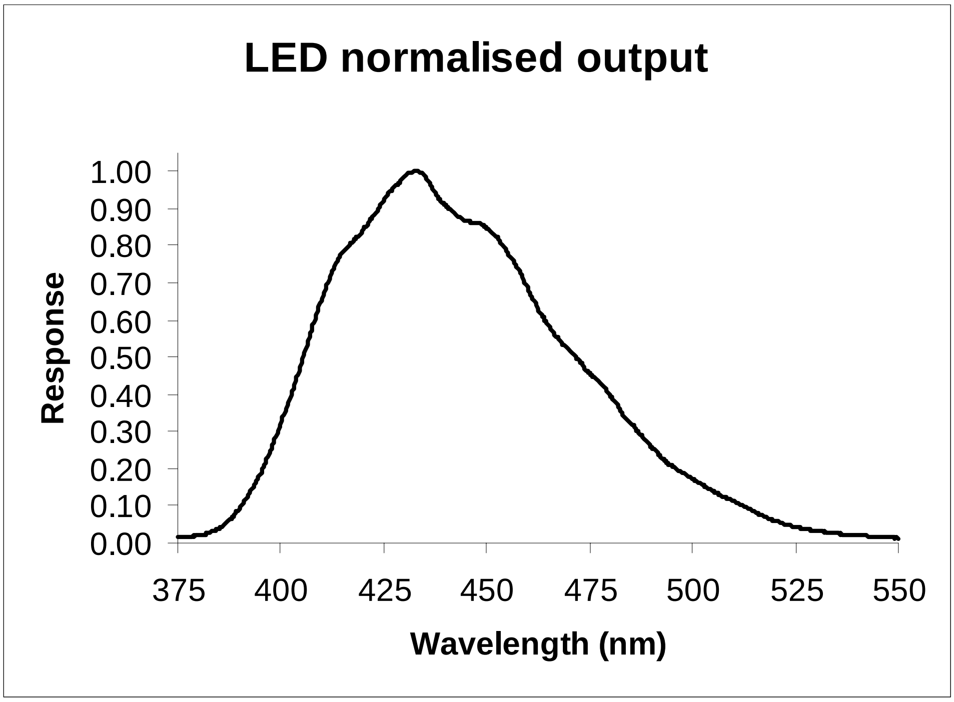

Figure 3 Measured LED output spectrum corrected for detector QE and grating efficiency