technical reprint

R/P097

multi-channel high voltage and control system for photomultipliers

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1 introduction

We describe a multi-channel, high-voltage, power supply system with individual channel control and monitoring via a PC. A power base voltage divider generates the individual HV requirement for each photomultiplier. We describe how the inclusion of an active voltage divider in each power base ensures outstanding performance with regard to rate effect, pulse linearity, and dc linearity.

The HVSys is a multi-channel HV power supply system, with individual channel control and monitoring, for powering an array of up to 254 pmts. The system is controlled by a PC with a PCI card and RS485 interface, operating under Windows® 2000/XP or higher. The PC performs independent setting and monitoring protocols for voltage, current and temperature. Using additional RS485 cards can expand the system. Pulse and dc linearity and low power consumption are the main benefits.

The HV of any pmt may be set to within 0.5V and then independently monitored to confirm the actual operating voltage. The software provided allows up to 16 preset voltage settings per channel, current and voltage overload trip setting, and real-time graphical display of current and voltage for every channel.

2 design concepts

Our approach is to provide the HV where it is actually required – that is, at the base of the pmt. We thus avoid the use of expensive and bulky HV cables while offering the inherent safety and simplicity of +12 V operation. Furthermore, we provide the voltage distribution to the dynodes of the pmt, sparing the user the inconvenience of having to source a separate voltage divider.

Electron Tubes power bases normally have active voltage dividers. In its simplest form, a voltage divider consists of a series of resistors connected to a source of HV, as shown in **figure 3(a)**. The action of the pmt, when viewing a light signal, changes these potentials by injecting current into the divider. The overall HV is fixed, but the redistribution of the voltages always causes a shift in gain. The active divider, shown in **figure 3(b)** and first described by Kerns[1], consists of a resistor divider coupled in parallel to a series of FETs, operating as source followers. These FETs are able to sink the dynode currents, generated in the multiplication process of the pmt, while maintaining fixed voltages.

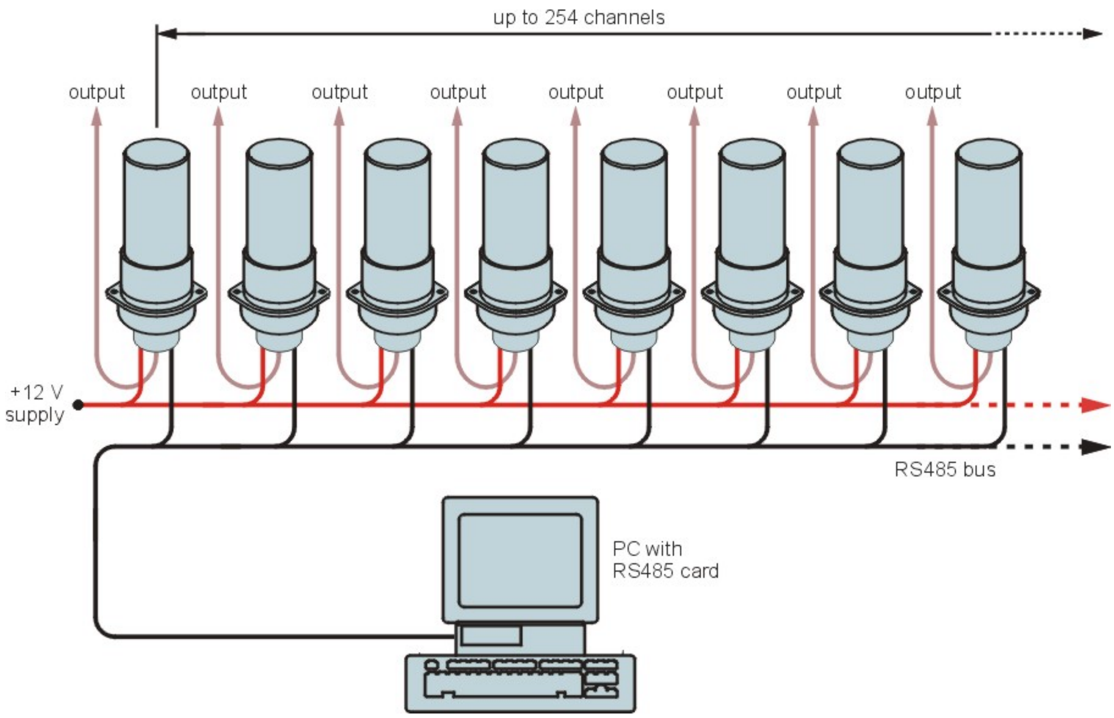

figure 1 illustrating the system configuration for the control and supply of up to 254 pmts. Only a single 12V supply is required with the HV generated by the individual power bases.

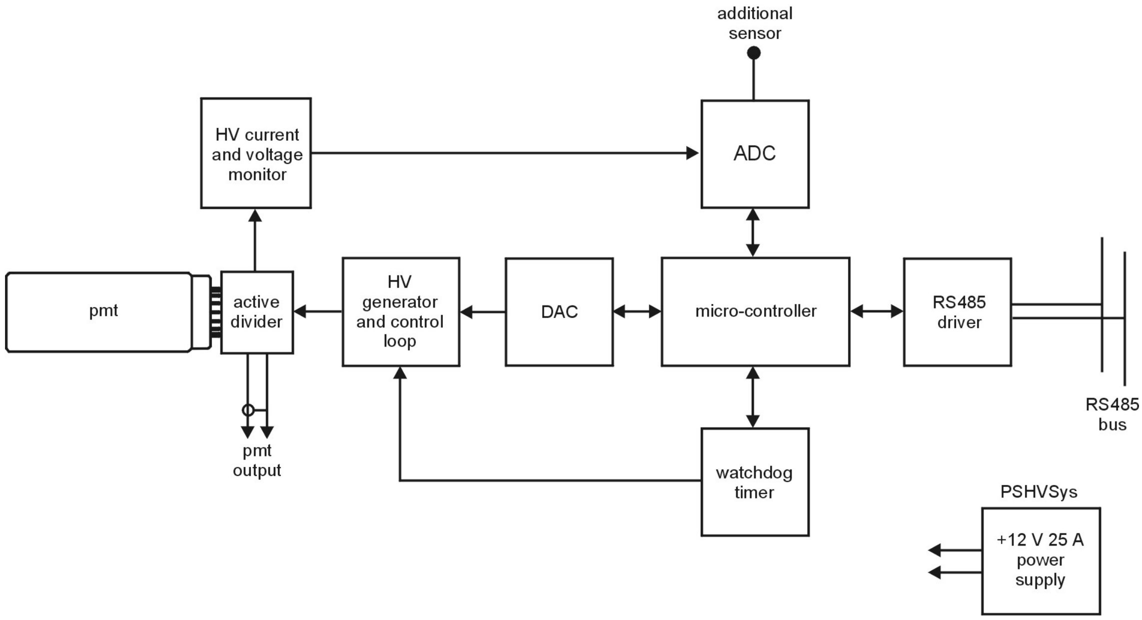

figure 2 functional diagram of 1 channel. The hardware shown is integrated within each power base enclosure.

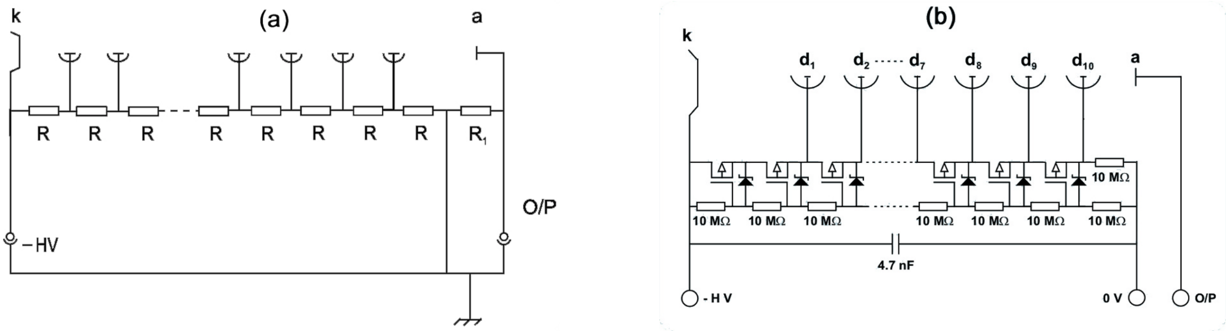

figure 3 simplified voltage divider schematics **(a)** conventional type **(b)** the active divider in which the resistor and FET strings draw only ~5 μA each when $I_a = 0$. Otherwise the divider provides anode current, I_a, on demand with $I_D = I_a + 10$ μA where I_D is the current drawn from the supply.

Voltage divider performance is illustrated in **figure 4** where we note that the severity of non-ideal performance is related to the standing current I_{D0} through the divider. Where the divider uses interdynode resistors of 680 kΩ, for example, we note that the gain changes by about 1% per microamp of anode current until the anode current approaches I_{D0}, whereupon the gain drops rapidly.

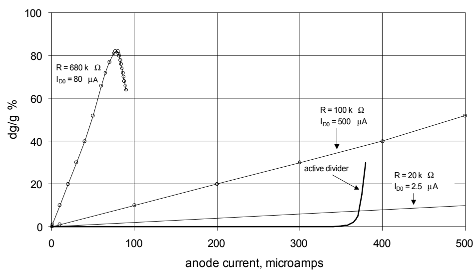

figure 4 illlustrating the superior performance of an active divider compared with conventional resistor types. One of the basic requirements of any detector is that its gain should remain constant and independent of input signal strength.

Gain stability is improved by increasing I_{D0} as shown, but the gain will always shift with mean anode current – this is the well-known and annoying effect known in HEP as 'rate effect'.

Photomultipliers should not be operated for any length of time at anode currents in excess of 100 μA but we note a gain change of about +2% even with I_{D0} impractically high at

2.5 mA. The active divider maintains the gain to better than ±0.5% for anode currents of up to 360 μA. The performance under pulsed light conditions is equally important and we see from **figure 5** that it is as expected, for this pmt type – the 9125B.

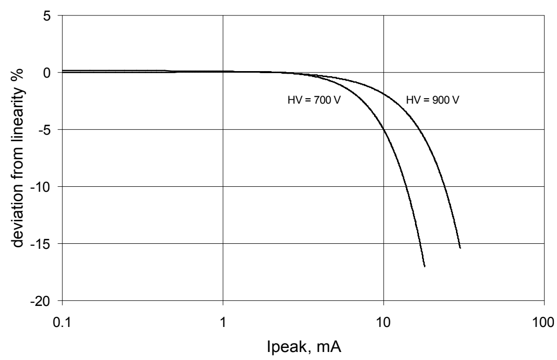

figure 5 linearity performance for pulses of width 1 μs. The deviation from linear amplification is a limitation of the pmt, and not to the divider.

Electron Tubes power bases are designed to minimise power consumption. This is always of concern in the use of large arrays of pmts. Figure 6 illustrates the relationship between the anode current and the supply current from the low voltage, 12V source. In the majority of applications, pmts are operated at mean anode currents of the order of 0 to 10 µA where the supply current required is 22 mA. This implies a supply current of only 5.6 A for the full set of 254 channels.

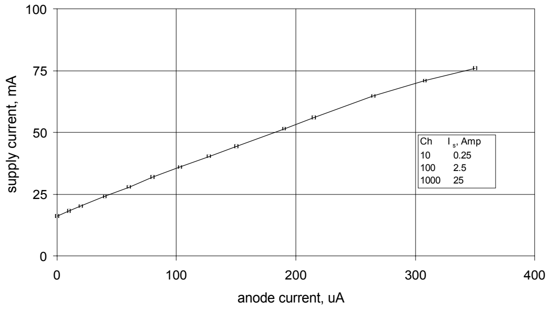

figure 6 current per channel as a function of mean anode current with 12 V supply. The inset illustrates the low power consumption for multiple channels.

3 specification

HV control (programmable)				0 to 1800 V
HV resolution				0.5 V
HV monitor				0 to 1800 V
Monitor resolution				0.5 V
HV line regulation				< 100 ppm/Volt
Temperature stability of HV				< 200 ppm/°C
Current clamp (programmable)				20 – 200 mA
Current monitor				20 – 200 mA
Temperature monitor (optional)				± 0.1 °C

	unit	min	typ	max
Supply voltage	V	11	12	13
Supply control(1)	mA		22	
Continuous I_a max	mA			100
HV ripple at anode(2)	mV p-p			0.1
HV setting time(3)	ms			50
HV discharge time(4)	Ms			500
Temperature range	°C	+5		+55

(1) at 1 kV, per power base (2) 100 kW //5 pF load
(3) to within 1% (4) to 40 V output

4 summary and features

1 eliminates expensive and bulky HV cable and connectors
2 one PCI card can control up to 254 individual power bases
3 system expansion is possible via additional RS485 cards
4 programmable options for setting and monitoring parameters
5 utilises up to 16 preset voltage settings
6 low power consumption per power base
7 exceptional dc and pulse linearity
8 facility for monitoring temperature or other transducers
9 high voltages are restricted to the power supply and photomultiplier – this reduces the electrical shock hazard associated with traditional multi-channel power supplies
10 graphical display of parameters
11 easy maintenance

5 references

[1] C R Kerns, IEEE Trans NS-24 No 1, (1977), 353

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