

A 4-Quadrant photodiode detector system

Four quadrant detectors are very useful when performing alignment of optical systems, particularly when laser beams are involved. Segmented detectors are available from numerous manufacturers, but complete detection systems tend to have a restricted dynamic range or are costly and these days generally involve some form of computer. In addition, most simple commercial systems do not provide the direct outputs of the detector segments and thus nay form of waveform monitoring is usually not possible. There are occasions when a stand-alone unit is useful and where time-varying outputs are required; for those occasions, the design presented here has been found useful. In general, knowledge of the *exact* degree of mis-centering of a beam is not so useful and we thus utilised analogue centre-zero moving coil indicators to indicate balance, i.e. beam when the beam is in the centre. Similarly an exact knowledge of the beam intensity is useful and for this purpose, a digital panel meter is fitted. However, the unit's flexibility is enhanced by preceding the digital meter with an analogue switch which allows the meter to be switched to read either total intensity, the Left-Right detector signal, the Up-Down signal or each of the detector signals

The photodiode detection system consists of three interconnected units: the photodiode head/preamp, the signal processing unit and the DC power supply. The first two are shown in Figure 1; the DC power supply is a small wall-plug unit capable of delivering at least +7V and less than +12V A switched capacitor negative voltage generator and regulators are used to derive $\pm 5V$ which powers all operational amplifiers. We use two DC input connectors to allow slave operation of the DC power unit; there are never enough mains power outlets!

This system is intended for general-purpose measurements of visible and NIR light signals in the range DC to 500 kHz and accepts input powers of around 1 mW down to well below 0.1 μW . The detector is a standard silicon diode (Centronic type QD-75) with a typical average responsivity of around 0.2 AW^{-1} . The block diagram of the system is shown in Figure 2.

The design of the system is fairly conventional and is based around trans-impedance amplifiers in the head unit. This also houses a summing amplifier which ensures compatibility with some of our other photodetection systems. Other types of 4 quadrant photodiodes can be fitted; it should be noted that the basic head uses common cathode detectors, resulting in a negative-going output at the four individual channels and a positive-going output at the summing amplifier output. Common anode detectors will result in outputs of the opposite polarity.

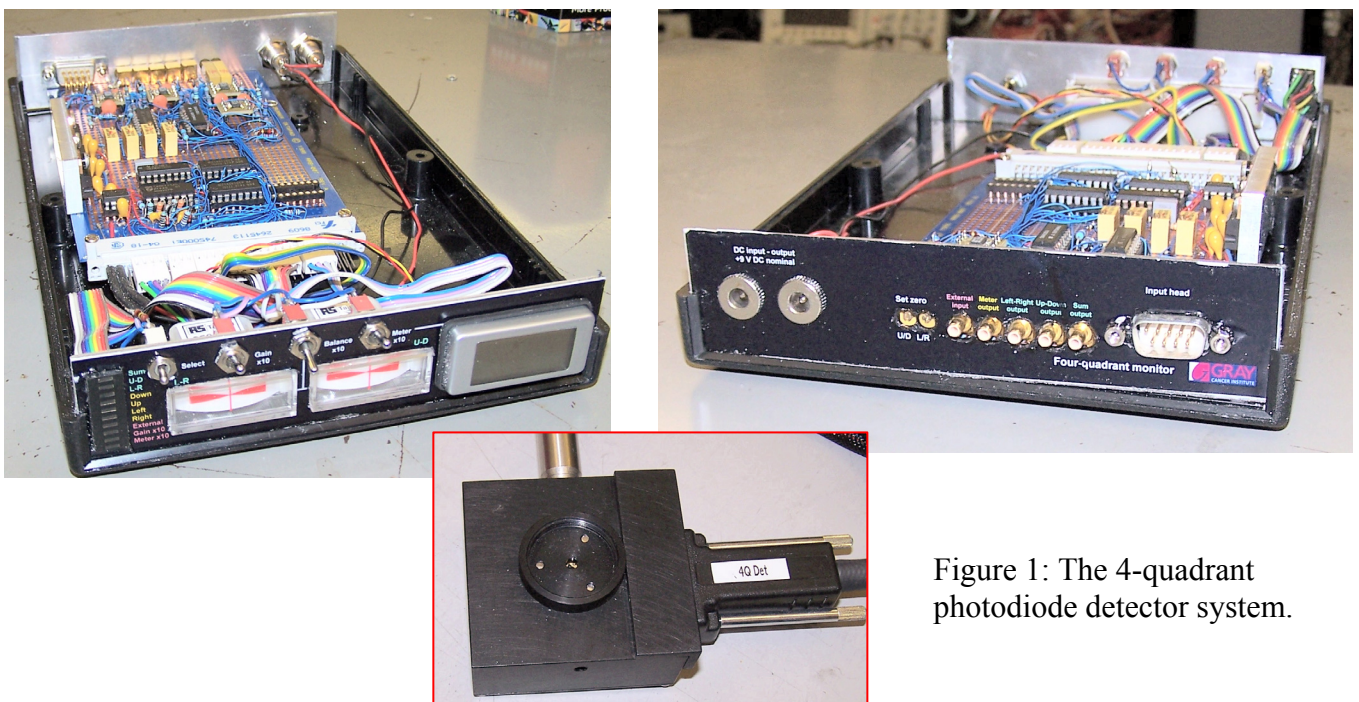


Figure 1: The 4-quadrant photodiode detector system.

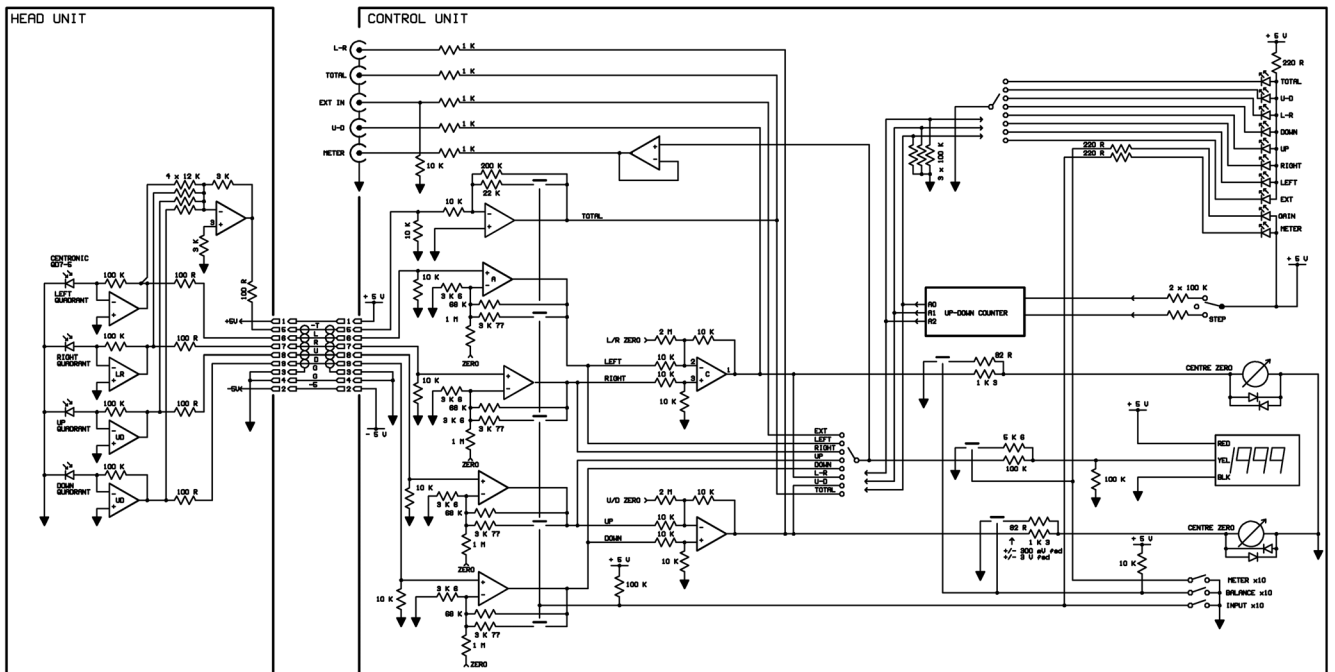


Figure 2: Block diagram of the 4-quadrant photodiode detector system

The inputs to the meter are sequentially switched using a biased centre-off toggle switch coupled to an up-down counter; the state of the counter is indicated on an LED strip on the side of the front panel. The gain of the input amplifiers can be increased by a factor of $\times 10$ using analogue switches and similarly the sensitivities of the digital meter and that of the balance meters can also be set with the aid of analogue switches.

The circuit diagram of the complete unit is shown in Figure 3. We use very-low offset voltage ($< 100 \mu\text{V}$) operational amplifiers and precision resistors to set gains. Nevertheless, at full gain, the least significant digit of the digital meter represents $100 \mu\text{V}$. This is equivalent to $10 \mu\text{V}$ at the head operational amplifier output and we are thus forced to provide a simple offset circuit to ensure that true balance is indicated as zero.

We also provided a digital control interface, should this be required in the future. A single 8 bit word is used to set and read all the functions. Two input bits (up/down) are used to toggle the up-down counter in a manner analogous to the front panel switch, the counter outputs are available on 3 output lines, and a further 3 input lines are used to set the meter gain ($\times 1/\times 10$), the balance gain ($\times 1/\times 10$) and the input gain ($\times 1/\times 10$). This digital port and the relevant analogue signal are available on a separate header. It should be noted that the manual controls are effectively 'OR'ed with the digital inputs and it is thus necessary for the manual switches to be left in the appropriate positions if digital control is required.

There are few unusual components used in this detector (other than the photodiode). We used Multicomp MC34H/100-0-100 centre-zero meters available from Farnell (order code 143-510), an Avago Technologies HDSP-4832 multicolour indicator for the status display (Farnell order code 100-3271) and a Lascar EMV1025S-01 digital panel meter (Farnell order code 9932844). The unit was constructed in Hammond 1598FBK 250 x 160 x 40mm case (Farnell order code 722-662).

The full circuit of the unit is presented in the figure at the end of this document, which was first prepared by B. Vojnovic and R.G. Newman in January 2004, and updated in August 2011.

We acknowledge the financial support of Cancer Research UK, the MRC and EPSRC.

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