487 DC Current Amplifier/ Integrating ADC
User Notes

BENTHAM

Overview
The Bentham 487 module combines a two-input trans-impedance amplifier and an integrating analogue to digital converter. This unit is typically housed in the Bentham 417(T): power supply, USB interface and display.

Mounting
The 487 is normally supplied already mounted in the Bentham 417 bin/power supply unit. If you are fitting a 487 into an existing 417 you should refer to the 417 manual which provides information on the installation procedure..

Amplifier
The 487 amplifier consists of a six decade (10^{10} to 10^{5} V/A) trans-impedance amplifier based on an operational amplifier followed by a voltage amplifier.

The input of the 487 is a virtual ground input, with effectively zero impedance; therefore no voltage is generated across the detector as a result of the generated photocurrent. This short circuit operation enhances detector linearity and reduces the effect of cable capacitance.

The present gain range is indicated by an amber LED, range overload by a red LED and the selected input by a green LED.

Whilst this amplifier is typically computer controlled via USB/I^2C, it is possible to operate locally, by depressing the black remote button. One may change the present gain range by depressing the upper and lower gain range buttons and change the input used using the IP1/IP2 button.

The output of this amplifier, 0-10V, is input directly to the ADC. The output is also supplied to the 417(T) bin display channel C.

The ideal current generator has infinite source impedance, yet in practice all detectors have a finite impedance (shunt resistance). For photomultipliers and silicon photodiodes the shunt resistance can be ignored, however, for some other detectors, such as room temperature germanium (shunt resistance ~100kΩ), it may be seen that use of the most sensitive ranges of the 487 leads to a positive or negative offset appearing at the output. Detectors which give rise to these offsets are better used with chopped light source and a current sensitive lock-in amplifier (Bentham 477 + 485).

ADC
The ADC uses a continuously running voltage to frequency converter to produce a pulse train whose frequency is proportional to the instantaneous input voltage. The pulses are then accumulated in a counter. The ADC provides 2000 counts per volt with a maximum of 20000 counts.

At 100ms intervals, the contents of the counter is transferred to an output buffer and the counter reset to zero. The total number of pulses accumulated by the counter in any counting period represents the true average of the signal during that counting period; if the accumulated pulses from a number of counting periods are added and normalised then a true average over a longer period is obtained.

The input to the ADC can be either from the amplifier, or another, auxiliary source, selected by depressing the aux button.

The input to the ADC is offset giving the unit a small negative range. This ensures that negative going noise peaks, occurring in near zero signals, are correctly averaged while retaining most of the available resolution for positive signals.

Furthermore, the ADC provides information to the computer indicating that a transient overload has occurred during the conversion period, caused, for example, by Cherenkov radiation.

The limit of low light level detection is often imposed by the ability of the measuring system to distinguish between the signal to be measured and the associated electrical noise. In most cases, where the noise is truly random, the signal to noise ratio can be improved by averaging. For a signal accompanied by random noise the signal to noise ratio will increase in proportion to $\sqrt{T}$ where T is the averaging period.

The ADC therefore behaves as a digital averager with the averaging period programmable in 100ms increments.

Software schemes may be employed to determine the averaging period based on the sensitivity range of the amplifier so that averaging period increases as the sensitivity required increases.

Mechanical
The 487 module is fitted via the front of the Bentham 417(T) bin, and secured with four M2.5 screws.

Electrical
The 487 module is fitted with a Molex connector to adapt to the 417(T) mother board, with six pins connected. This should be fitted to the nearest available location; only one orientation of the connector is physically possible.

The input to the amplifier is via BNC; connection should be made from the inner of the input socket directly to the anode in the case of PMTs and to the cathode in the case of photodiodes. A load resistor should not be employed.

It is important to ensure, in the case of PMTs, that the dynode chain should be arranged for negative high voltage operation with the anode at ground.

Manual Operation
The amplifier may be controlled manually from the front panel. For manual control the green led marked REM must be off. If this led is ON, meaning that the unit is in remote mode, you may Return To Local mode by pressing the button marked RTL.

To decrease sensitivity by one range press the button marked (uparrow) once, to increase sensitivity by one range press the button marked (downarrow) once.

In manual or remote mode the selected sensitivity range is indicated by an orange led.

To change input press the IP1/IP2 button once. The input in use is indicated by a green led.

Overload
A red led lights when the 487 output exceeds +10V or -10V.

The overload circuit in the 487 has a special feature to deal with transient overloads typically produced by Cherenkov events in photomultiplier tubes. When such an event occurs a large but short lived pulse of current is produced by the pmt. The 487 senses the overload produced by this pulse but instead of producing a momentary flash of the overload led the led is kept on for 2 seconds. During this period the overload condition can be sensed via the USB. Use of this feature allows measurements where Cherenkov events have occurred to be rejected.

Use with detectors
The 487 is primarily intended for use with current source detectors such as photomultipliers and photodiodes.

When used with these devices connection should be made from the inner of the input socket directly to the anode in the case of pmts and to the cathode in the case of photodiodes.

Do not use a load resistor.

In the case of pmts the dynode chain should be arranged for negative high voltage operation with the anode at ground.

The required circuits are as follows; both of these circuits will give rise to a positive going voltage output from the 487.

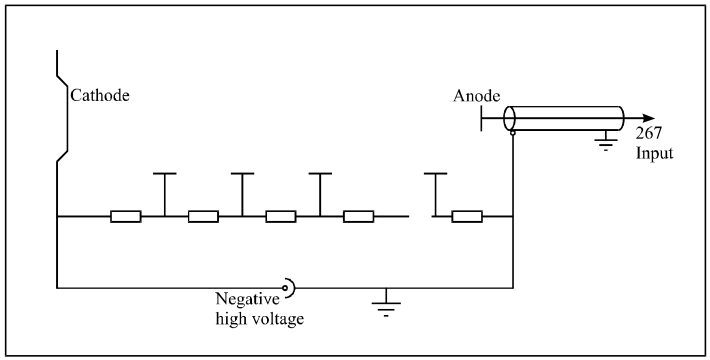

Fig 1 Photomultiplier

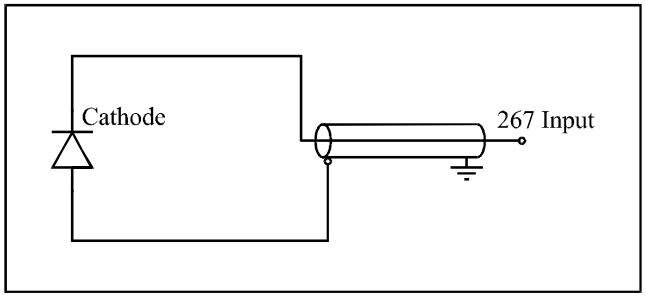

Fig 2 Photodiode

Specifications

Transconductance	1E5 V/A to 1E10 V/A.
Bandwidth	dc to 30Hz on all ranges.
Range to range gain accuracy	0.3%

Block Diagram

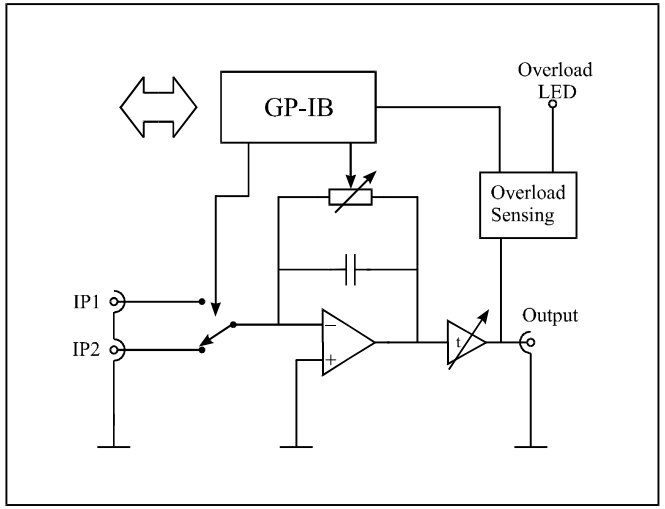

Fig 3 Block Diagram of 267 Amplifier

Applications
The 487 is useful in any application where a precise measurement of the current from a photomultiplier or photodiode is required. The unit is found in systems ranging from simple photometers using a single photodiode to sophisticated spectroradiometers with dual detector.

The following diagram shows a typical spectroradiometer using a photomultiplier and indium gallium arsenide photodiode to cover the wavelength range from 200nm to 1700nm

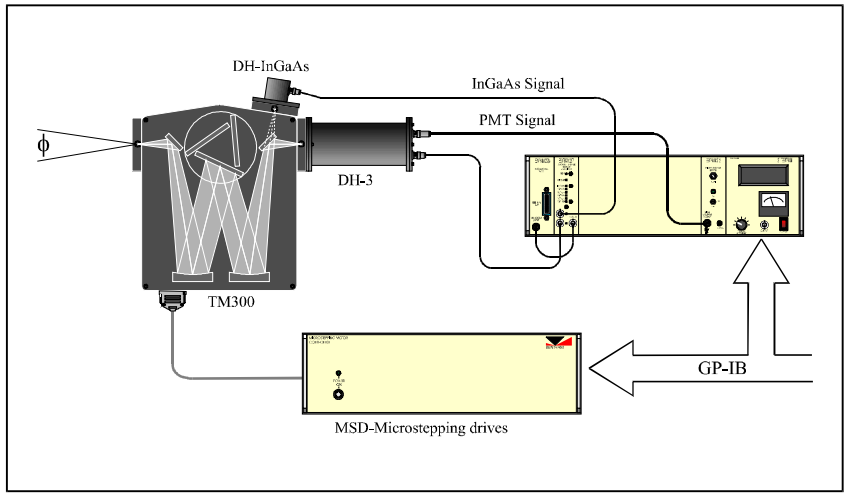

Fig 4 Schematic of Spectroradiometer

SYMPTOM	POSSIBLE CAUSES
The 487 does not respond to USB	The 487 is set to the wrong address/ not connected to USB/ I2C
No leds are illuminated on the 487 front panel.	The power connector form the 487 is not connected to the 417 mother board
Signal is expected from the detector but there is little or no output from the 487.	Wrong input has been selected If the detector is a photomultiplier, the high voltage is switched off - see 215 manual 2.1.
The 417 display indicates that the output of the487 is in mid-range but the overload led is illuminated.	The signal is pulsed. Although the average signal as displayed by the 487 is in mid-range, the peaks are breaking through the overload level. Reduce sensitivity/contact Bentham.
An offset, which cannot be attributed to dark current or signal, appears at the output and increases with increasing sensitivity.	Detector has low shunt resistance

WEEE statement

Bentham are fully WEEE compliant, registration number is WEE/CB0003ZR. Should you need to dispose of our equipment please telephone 0113 385 4352 or 4356, quoting account number 135419.

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