

MODEL 101SDC-P SINGLE-CHANNEL RADIATION DETECTOR

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The model 101S-DC-P from Carroll & Ramsey Associates is a radiation detector system intended for radio-chemical synthesis and process monitoring applications in nuclear medicine laboratories, hot cells, etc.



TECHNICAL DESCRIPTION

The system comprises a miniature detector probe, plus a trans-resistance (current-to-voltage converter) amplifier.

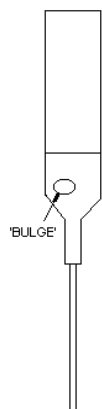
The maximum gain of the transresistance amplifier is nominally 5×10^9 ohms, that is, a detector current of one nano-ampere (negative polarity) can produce a voltage at the output of the amplifier of +5 volts. A multi-turn trim potentiometer on the output of the amplifier allows the user to adjust the overall trans-resistance gain of the system over a range of approximately 20:1.

Probe

The active element in the detector probe is a silicon PIN diode which is enclosed in a thin brass capsule to shield it against light and stray electromagnetic fields. The sensitive element is parallel to the face of the probe.

The probe is connected to its amplifier unit through a length of small-diameter coaxial cable. The detector probe operates in "DC" mode and is intended to be used in close proximity to concentrated sources of gamma-emitting radio-nuclides.

Three sizes of Si diode probe are available; 7.6 mm² (standard), 25 mm², and 3 x 30 mm. The diode substrate thickness is 300 microns, and produces approximately 1 pico-ampere per mm² per rad / hr (Si). Also available are high-sensitivity scintillation probes with 1 cu cm or 10 cu cm CsI(Tl) crystals coupled to 1 sq cm Si photo-diodes .



The probes are not necessarily symmetrical front-to-back; One face is somewhat more sensitive than the other – especially when the source of activity is intimately coupled, as in a flow-cell application. On the smaller (2.7 x 2.7 mm and 5 x 5 mm probes) the more sensitive face is recognized by a small ‘bulge’ formed by a solder connection under the shrink-tubing . ***On the 3 x 30 mm probe, the more sensitive face is the ‘smooth’ (no-bulge) face of the probe.***

Mechanical

The probes are mechanically robust and are not damaged by normal handling. However, the probe and its connecting cable may generate spurious signals ("microphonics") if moved or flexed during use. When making a measurement, the probe and its cable should be held in place and padded if necessary to minimize coupling to sources of vibration such as fans, pumps, motors, etc.

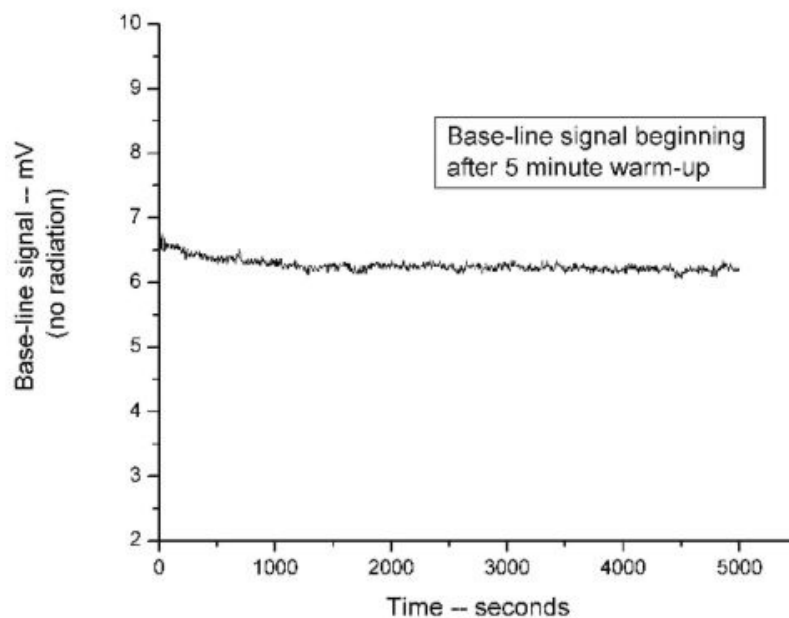
The amplifier is built into a small aluminum case approximately 6" long x 3" wide x 1.5" high (exclusive of cable connectors).

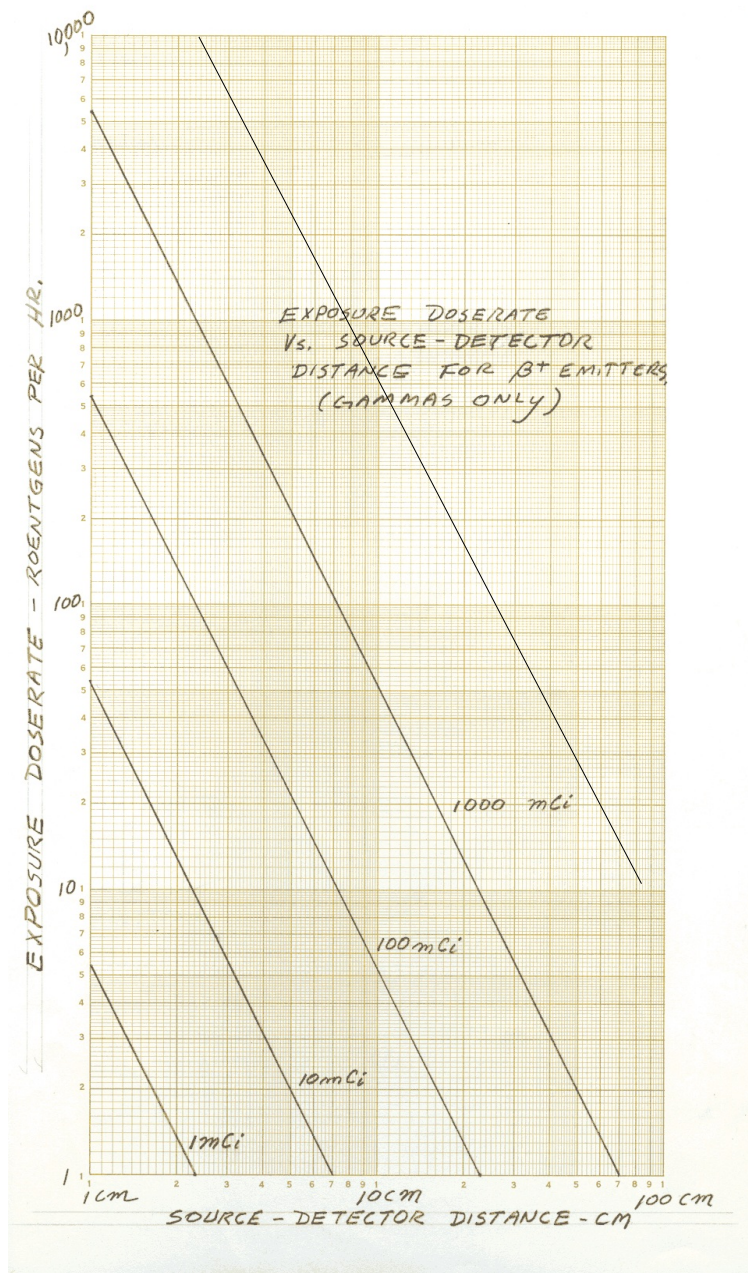
DC-Amplifiers

A small positive DC offset -- equivalent to approximately 5 pico-amperes or less (~0.5% referred to full-scale), in the absence of radiation -- is normally present. Measurements at very low radiation exposure dose levels are confounded to some degree due to this offset, and by slow changes in offset -- referred to as "drift" -- which are indistinguishable from changes in radiation intensity. Other sources of error are detector diode leakage and "dark" currents--all of which, in turn, are strongly influenced by

ambient temperature. Offset drift is minimized by utilizing high-quality operational amplifiers with very low initial offset. Leakage current is minimized by operating the diode at zero bias into a low-impedance ("virtual ground") transresistance amplifier input.

However, the diode's dark current is still of the order of a few pico-amperes at 25° C, and increases by a factor of 2 for every 5° C rise in temperature. Thus, since the basic probe sensitivity is of the order of ~ 1 pA per sq. mm per rad / hr (Si), this detector system is best suited for applications involving gamma radiation fields of several roentgens per hour or greater exposure dose-rate, for example, in close proximity to concentrated sources of gamma activity of 1 mCi or more for the smallest probes, or several 10's of microcuries (at least) for the larger probes.





Source-Detector distance

See the attached graph to determine exposure dose rate as a function of distance from a concentrated ("point") source of β^+ (i.e., 511 KeV gamma in this example) activity. For very close coupling to a point source of activity, the inverse-square law has a potent effect on detector response. This can be of some advantage in reducing the amount of shielding required against ambient activity away from the source relative to activity at the source.

However, if one is monitoring the amount of activity trapped in a column, for example, the exact place within the column where the activity is trapped can affect the observed dose rate. Moving the detector a short distance away will mitigate this effect. The user should experiment with source-detector placement to find the best compromise between repeatability and minimum shielding.

Scale factor

Since observed dose rate (and, consequently, detector current) is a function of source-detector distance, one may place the detector at a particular distance from the source so as to provide a convenient scale reading. For example, (refer to graph) a 1 curie β^+ source produces a field of 200 roentgens / hr at a distance ~ 5 cm from the source. A "standard" probe produces ~ 1.5 nanoampere at this exposure dose rate, yielding an output signal of 15.0 volts at full gain setting; once the source-detector mounting position is fixed, the amplifier gain control potentiometer may be adjusted so as to set the scale reading to "10" to correspond (for example) to "1.0 curie".

INSTALLATION AND OPERATING ENVIRONMENT

The amplifier box may be placed where radiation is present, but preferably away– or shielded from – *intense* sources of radiation.

In North America, the operating voltage for the amplifier box is 110 VAC, 50 / 60 Hz. In Europe the operating voltage is 230 VAC, 50 Hz. A 0.125 ampere “Pico fuse” is soldered to the circuit board adjacent to the power supply.

Caution! High Voltage

Servicing the fuse should be done only by qualified personnel.

Do not open the amplifier chassis box before unplugging the system from the AC mains.

The detector probe should be connected to the BNC coaxial receptacle labeled “Probe in” on the front of the amplifier box. The output signal is taken through a BNC coaxial receptacle on the rear of the box, adjacent to the power cord. The signal level, which is proportional to dose-rate, may be monitored by a read-out device such as a digital voltmeter, high-impedance chart recorder or computer data acquisition system (1 megohm or more input impedance).

The cable connecting the amplifier to the readout device should be a good-quality coaxial cable such as RG-174, RG-58AU, or equivalent, and may be any length up to ~100 ft.

The amplifier gain may be adjusted by means of a multi-turn, screwdriver-adjusted potentiometer which is accessible by removing the top of the amplifier box. Turning the adjustment screw clockwise increases gain, and vice-versa. The potentiometer is set at the factory at approximately mid-value. *Note: The internal circuitry is sensitive to ambient light and/or electromagnetic interference, which may cause an excessive baseline offset when the cover is left off. Gain adjustments should be made in steps, closing the cover after each increment / decrement until the desired operating point is found.*

Caution! High Voltage

Do not open the amplifier chassis box before unplugging the system from the AC mains. Do not attempt to adjust any other components inside the amplifier box.

Environment

The system is intended for indoor use. Components have not been characterized for operation outside the range 0°C - 55°C. The system components and system wiring must not be in close proximity to any flame, heating element, or exposed electrical terminals. The system components have not been characterized for operation in extreme neutron / gamma radiation fields such as encountered in close proximity to accelerator targets during irradiation. The system and its components should be protected from contact with solvents or volatile or corrosive reagents.

EMI susceptibility Nuclear particle accelerators are used for the production of short-lived radio-isotopes. Such accelerators usually employ high-powered radio-frequency (RF) systems which have the potential to ‘leak’ RF energy into the environment.

The Model 101-SDC-P radiation detector system is widely -- and successfully -- used in PET / Radio-chemistry laboratories, which are almost always situated close to a cyclotron or similar type of ‘RF continuous wave’ nuclear particle accelerator.

However, the system detects and amplifies very low-level input signals. Thus, there is a possibility that power surges, transient bursts, or RF interference – either radiated or conducted through power or signal wiring – may occasionally cause spurious or false outputs. This may occur as a result of fast electrical transients or modulated RF signals -- for example -- from nearby digital cellular telephones or from electrically ‘noisy’ devices such as on / off (make-and-break) relay contacts, or from small ‘universal’ (AC/DC) motors often used in small electrical appliances.

For best results, RF devices such as cellular telephones and electrically ‘noisy’ equipment should not be operated in the near vicinity of sensitive radiation detection equipment (or -- for that matter – near any sensitive electronic instrumentation).

TEST AND MAINTENANCE

Sensitivity

Sensitivity scale factor (numerical display reading) should be verified periodically against a known standard.

Analog Gain

Amplifier system gain may be verified by connecting a current source comprising a 1.5 VDC battery in series with a high-ohm resistor (1000 megohms or more) to the amplifier BNC input (negative polarity)

Probe

The detector probe may be tested in a gross manner as an ordinary diode using a good-quality ohmmeter with a "diode-test" setting; if it appears that a probe is not working properly, check for a short- or open-circuit condition. A substantial increase in reverse leakage current due to radiation damage manifests as an equivalent drop in reverse resistance, which may, in turn, cause a noticeable increase in observed offset. However, the reverse resistance of a properly-working detector probe is of the order of a few hundreds to thousands of megohms, and cannot, in general, be read on a standard ohm-meter.

When in doubt, compare a suspected probe against another unit which is known to be sound.

WARRANTY

Systems are warranted against defects in materials and workmanship for a period of 1 year from date of shipment. Carroll & Ramsey's (CRI) sole obligation for products that prove to be defective will be repair or replacement. In no event shall CRI's obligation exceed the buyer's purchase price. CRI specifically disclaims any implied warranties or merchantability or fitness for a specific purpose, nor will CRI be liable for any indirect, incidental, or consequential damages.

This warranty does not apply to products which have been subject to mis-use such as accident, severe mechanical shock and distress, over-voltage, immersion, exposure to volatile or corrosive agents, etc. The warranty does not apply to defects due to unauthorized modification, or which have been altered in such a way as to not be capable of undergoing functional test.

Performance specifications, physical dimensions, etc. are subject to change without notice.

Products sold by Carroll & Ramsey Instruments are not intended for use as critical components in medical devices or life-support devices or systems.

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