

MODEL 101-H-DC-3 MULTI-CHANNEL RADIATION DETECTOR

Rev. J

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The model 101-H-DC-3 from Carroll / Ramsey Associates is a radiation detector system intended for radiochemical synthesis and process monitoring applications in laboratory hot cells.

TECHNICAL DESCRIPTION

The system comprises a set of up to three miniature detector probes, plus a three-channel transresistance (current-to-voltage converter) amplifier.

The maximum gain of the transresistance amplifier in each detector channel is nominally 5×10^9 ohms, that is, a detector current of one nano-ampere can produce a voltage at the output of the amplifier of five volts. A multi-turn trim potentiometer on the output of each amplifier chain allows the user to adjust the overall transresistance gain of the system over a range of approximately 10:1.

Probe

The active element in the detector probe is a silicon PIN diode which is enclosed in Cu foil and coated with an opaque plastic resin to shield it against light and stray electromagnetic fields. The sensitive area is designated by a dot near the tip of the probe.

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

Four sizes of probe are available; 1 mm², 7.6 mm² (standard), 25 mm², and 100 mm². The diode substrate thickness is 300 microns, and produces ~1 pico-ampere per mm² per rad / hr (Si).

Mechanical

The probes are mechanically robust and are not damaged by normal handling. However, the probe and its connecting cable will 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.

DC-Amplifiers

A small positive or negative DC offset -- equivalent to ~ 5 pico-amperes or less (0.25% referred to full-scale), in the absence of radiation -- is normally present.

Measurements at very low gamma 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.

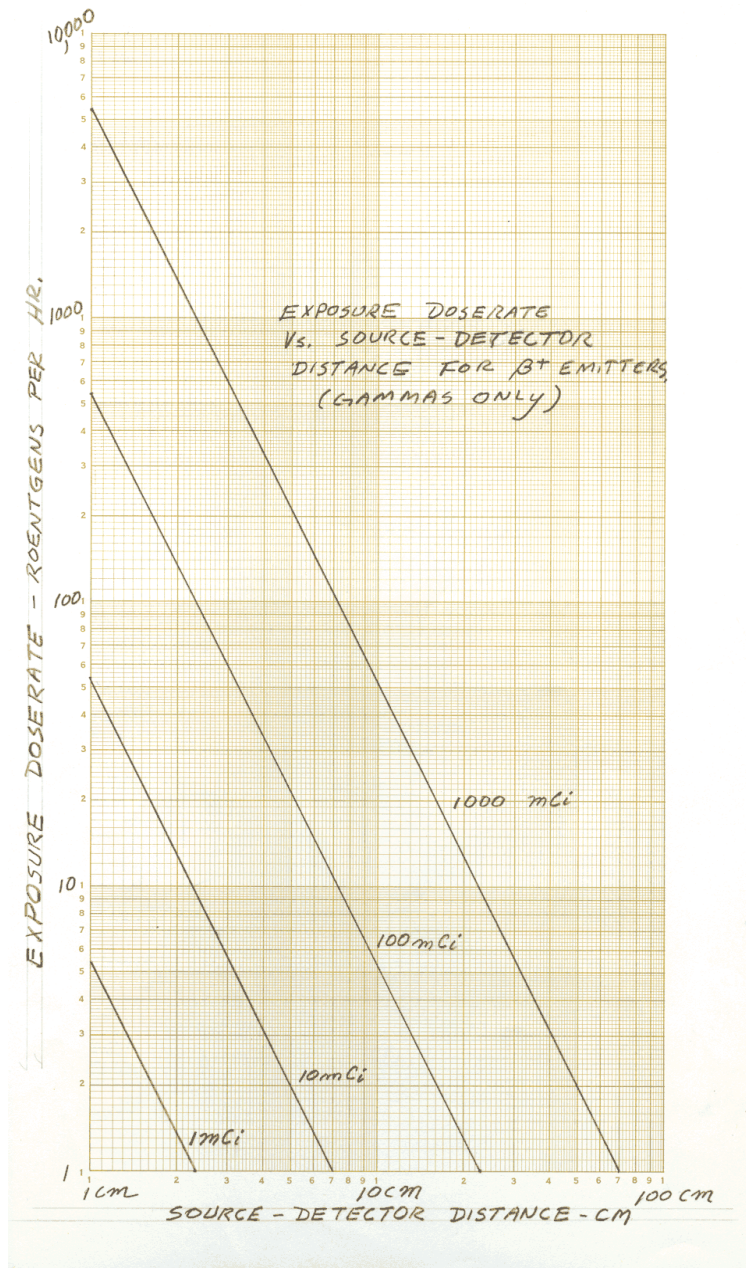
Display

The 3 1/2 digit auto-ranging numerical display on the Model 110A Remote Console reads from 0 - 1.500 volts, on the low-range setting, and 0 - 10 volts on the high-range setting.

Source-Detector distance

See the attached graph to determine exposure doserate 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 doserate. 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 doserate (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 1000 roentgens / hr at a distance ~ 2.4 cm from the source. A "low-sensitivity" probe produces ~ 1 nanoampere at this exposure doserate, yielding a reading on the voltmeter display of "5.0" at full sensitivity; once the source-detector mounting position is fixed, the amplifier gain control potentiometer may be adjusted so as to set the scale reading to "1.0".

INSTALLATION AND OPERATING ENVIRONMENT

The 3-channel amplifier box may be placed where radiation is present, but preferably away--or shielded-- from intense sources of radiation.

The operating voltage for the 3-channel amplifier box is +12 to +15 VDC, well-filtered. Mating connectors are supplied with the system.

The sensitive element in each detector probe is near the tip, designated by a dot. The detector probes are connected to BNC coaxial receptacles in the 3-channel amplifier box marked **Ch. 1**, **Ch. 2**, **Ch. 3**, respectively.

The cable connecting the 3-channel amplifier box to the remote display unit should be a 4-conductor, shielded type, with wires distinctly color-coded. One wire is used for +12VDC; 3 wires are used for the respective signal connections. The shield is used as the signal common and power return. The 9-pin "D" connectors are wired as follows:

Channel 1 out	1	+12VDC	6
Channel 2 out	2	Shield / ground	9
Channel 3 out	3		

The connecting cables may be any length up to ~100 ft.

The gain for each channel may be adjusted by means of multi-turn, screwdriver-adjust, potentiometers which are accessible from the rear of the display unit. The signal levels, which are proportional to dose-rate, may also be monitored by a digital voltmeter, high-impedance chart recorder or computer data acquisition system (1 megohm or more input impedance) which can be connected in parallel to the display console by means of the 9-pin D-Subminiature connectors on the rear of the chassis just below the connectors from the preamplifiers.

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.

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 (100 megohms or more) to the amplifier BNC input (negative polarity). For convenience and ease of maintenance, an adjustable current source (0-1500 picoamperes) is available as an accessory from Carroll / Ramsey Associates.

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 90 days from date of shipment. Carroll / Ramsey Associates' (CRA) sole obligation for products that prove to be defective will be repair or replacement. In no event shall CRA's obligation exceed the buyer's purchase price. CRA specifically disclaims any implied warranties or merchantability or fitness for a specific purpose, nor will CRA 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 Associates are not intended for use as critical components in medical devices or life-support devices or systems.

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