# Model GP100
# GP100SI
# Gamma Detector

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## User's Manual

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# 1. Introduction

The Canberra GP100 detector is a wide range 10 μR/h to 10,000 R/h gamma detector.

The Canberra GP100SI detector is a Dose Equivalent Sv (Sievert) response wide range 0.1 μSv/h to 100 Sv/h gamma detector.

A pair of rugged halogen-quenched GM tubes serves as the basic detection elements in the GP100 series detectors. A lead foil wrap is used for correction of the energy response of the tubes. The GM tubes operate using the unique and patented Canberra Time-to-Count technique which removes many of the limitations associated with the use of GM tubes operated in the conventional mode.

In addition, the GP100 series of detectors are "smart" probes, which retain probe information in non-volatile memory. When calibrated, data such as probe calibration constants and identifying information are stored and verified in EEPROM memory in the probe circuitry. This arrangement allows the Canberra detectors to be interchangeable, and require no operator adjustments at time of use.

The GP100 series detectors can be used with the Canberra model ADM606, ADM606M, ADM616, or ADM300 Digital Ratemeters. The ratemeter provides low voltage power and signals to the probe, and interprets and displays count rate data from the probe. High voltages necessary for tube operation are produced via circuitry inside the GP100 series detector allowing use of low voltage cabling.

# 2. Installation

## 2.1 Unpacking

Visually inspect the detector for damage during shipment due to irregular handling. Report any missing or damaged items to the carrier and to Canberra as soon as possible.

## 2.2 Mounting

The GP100 series detector can be supplied with optional wall mount, M200. This detector mounting bracket provides a slot in which the detectors are placed.

Use Figure 1 on page 3 as a general guideline when attaching the mounting bracket to the desired location.

## 2.3 Connections

The GP100 series of detectors are connected to the Ratemeter via a detector cable to the appropriate connector on the Ratemeter. Please consult the Ratemeter manual for specific information.

Connection to the GP100 series detector is made by the MS3110E14 -12P type connector. Pin designations are as follows:

Pin A - +5 V dc
Pin B - GND
Pin C - EE Clock
Pin D - /LO Enable
Pin E - /HI Enable
Pin F - EE Enable
Pin G - /Event

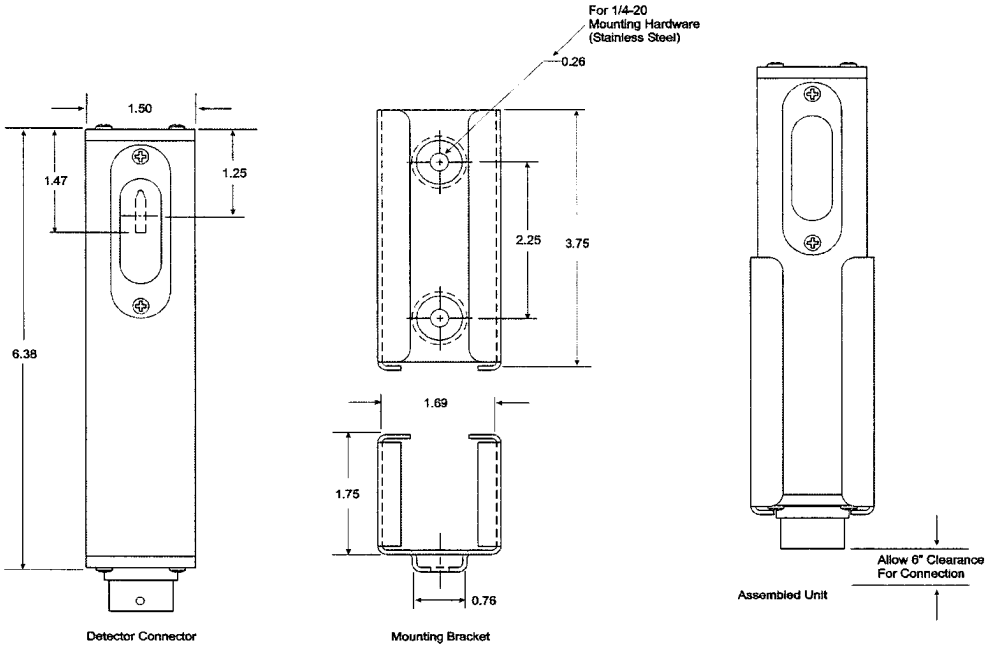


Figure 1 Mounting the Detector

## 2.4 Operation

Because the GP100 series contains all operation and calibration values stored in its internal EEPROM, the detector is simple to put into service. The ratemeter should be *off* when making or breaking cable connections to prevent possible damage to the detector. Calibration should be conducted at least annually following the procedure in Chapter 4, Maintenance.

# 3. Theory of Operation

Conventionally, a GM tube is operated with a fixed dc voltage continuously applied. Readings of rate are a function of the number of pulses (counts) produced by the tube per unit time. This type of operation is characterized by increasing non-linearity as the field intensity increases. This effect, due to the inherent "dead time" of the tube, limits its range of usefulness. The problems associated with the conventional dc mode of operation are best understood by examining the "Stever Pattern" produced by the tube in response to a radiation field. See Figure 2 for a typical Stever Pattern[1].

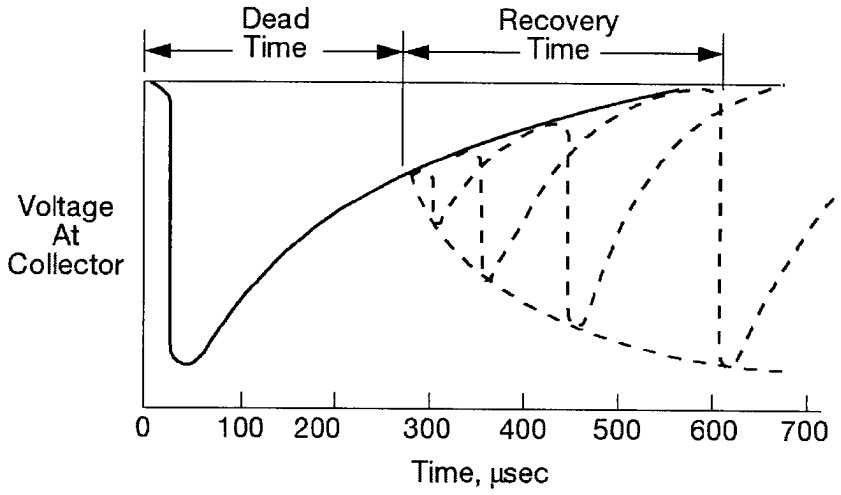


Figure 2 Typical Stever Pattern Representation of Dead Time in a GM Tube

Assume the GM tube is energized and the first pulse is produced by the tube in response to an ionizing event. This initial pulse will be full-size and will typically follow the pattern shown. Following the initiation of this pulse is a recovery period during which the discharge mechanism is operating within the tube. During the recovery time, if another ionizing event occurs in the tube, it cannot be detected. This time is defined as the dead time. If an ionizing event occurs within the dead time, a small pulse, barely detectable, could be observed.

Dead time varies with the dimensions of the tube, the operating impedance, the mobility of the tube gases, and, to a lesser extent, the operating voltage. The dead time of the low range tube used in the GP100 series detector is

[1] From H.G. Stever, Physics Rev., 61:38 (1942)

about 150 microseconds; the high range tube dead time is about 15 microseconds.

If an ionizing event takes place later than the dead time, the pulse produced would be larger. Finally, a time will occur when the pulse formed is of full height; i.e., equal to the amplitude and shape of the initial pulse observed. This time is called the recovery time, and corresponds to the time when the positive ion sheath (formed during the discharge mechanism) is neutralized at the outer wall of the GM tube. The dead time, which characterizes all GM tubes, produces the non-linearity at higher fields and severely limits the range over which the tube is useable.

A second undesirable characteristic of GM tube operation in the conventional mode is saturation. It can be seen that as the field intensity is increased, more and more ionizing events will arrive in close proximity to the dead time. The pulses produced by the tube will become smaller and smaller and eventually will no longer trigger the input circuit of the instrument in which it is being used, causing the reading to drop to very low values or zero. Most GM tube instruments currently produced will display this hazardous condition.

In the Time-to-Count technique employed in the GP100 series detector, the dead time and saturation effects are eliminated.

The GM tube bias voltage is abruptly raised to 500 volts dc biasing the tube into its operating region. At the same time a crystal controlled, 1 megahertz oscillator (clock) is gated on which measures the time duration in 1 μsec increments until a GM tube pulse or gamma strike is obtained. At that point, time counting is stopped, the accumulated time is recorded and the anode voltage is reduced to the low bias level. The voltage on the anode is maintained at the low bias level for 1.5 to 2 milliseconds, a time period which is long compared to the dead time and recovery time of the tube.

After two milliseconds, when the GM tube is fully recovered, the voltage is again applied to the anode. Only one GM tube pulse can occur in any one on-time. Since the tube is fully recovered between on-times, the pulses produced by the tube are full size. The process is repeated many times to obtain a statistically reliable average time-to-count. In this fashion, dead time losses are eliminated and saturation cannot occur.

It can be shown that the radiation field intensity is proportional to the reciprocal of the average time-to-count. Consider the probability equation:

$$P \quad 1 \quad e^{\,nRt} \qquad (1)$$

where

P = Probability of a GM count

n = GM tube sensitivity (in cp/mR/hr)

R = Field intensity (in mR/hr)

t = Observation time (seconds)

Since the detector requires a sufficient time to produce a GM count, a constant value can be assigned to the probability term, independent of the radiation field intensity. The equation reduces to:

$$K_1 \quad 1 \quad e^{\ nRt} \qquad (2)$$

Since n is a constant:

$$K_1 \quad 1 \quad e^{\ K_2 Rt} \qquad (3)$$

Since 2 of the 3 terms in Equation 3 are constants, then the third term must be a constant:

$$e^{\ K_2 Rt} = K_3 = \text{a constant} \qquad (4)$$

From Equation 4, it can be seen that if $e^{-nRt}$ is a constant, the exponent of e must also be a constant, therefore:

$$-K_2 Rt = K_4$$

Or, by defining a new constant:

$$K_5 = K_4 / -K_2$$

Finally:

$$Rt = K_5$$
$$R = K_5/t \qquad (5)$$

Thus, the radiation field intensity is proportional to the reciprocal of the time required to obtain a GM count. Looking at a single event of a random nature would be statistically unreliable. However, if this measurement is repetitively made over a defined period of time (for example: two seconds), and the average time to obtain a GM pulse is determined, we now have a statistically reliable measure of field strength. This precise microprocessor controlled relationship forms the design basis for the GP100 series detector and enables many decades of linear performance for the two GM tubes involved.

# 4. Maintenance

The GP100 series of detectors are "maintenance free" and require no routine servicing or preventative maintenance. Each detector should be calibrated on an annual basis to ensure operation within tolerance.

## 4.1 Calibration

The GP100 series of detectors are calibrated in a known, uniform field using the Canberra Digital Ratemeters. The ratemeters contain the necessary software for calibration and storage of calibration data in the GP100's EEPROM.

Refer to the appropriate ratemeter manual for specific operating instructions.

The general calibration procedure is as follows:

1. Using the appropriate cable, connect the GP100 series gamma detector to the ratemeter.

2. Place the detector in a known gamma low range radiation field with the major axis of the detector perpendicular to the beam. Figure 3 on page 8 for detector tube location and calibration geometry.

3. With the ratemeter in the KEYPAD position, enter Calibrate Mode by pressing SET and (↑) buttons simultaneously. Select low range and set the source strength for the known low range calibration field and start the calibration cycle.

4. Place the detector in a known gamma high range radiation field with the major axis of the detector perpendicular to the beam. See Figure 3 on page 8 for detector tube location and calibration geometry.

5. Select the High Range and set the field strength for the high range known calibration field and start the calibration cycle.

6. At the end of the calibration cycle, the ratemeter will have acquired sufficient data for an accurate determination of the calibration scale factor. This will be indicated by an audible beep tone series. The ratemeter will display the average accumulated dose rate seen and will flash "DONE."

7. At "DONE," remove the source radiation field. The bottom line of the display will indicate the old and new scale factors and message "To enter scale, Push MODE and SET." Press MODE and SET buttons simultaneously. The ratemeter will install the new scale factor in the probe's non-volatile EEPROM memory.

   It is not necessary to turn off the ADM606 series or ADM616 series ratemeter for the scale factors to be installed in the detector's non-volatile memory.

8. Verify that the low range reading is within ± 10% of the expected value.

9. Verify that the high range reading is within ± 10% of the expected value.

### 4.1.1 Calibration Source Strength

It is recommended that the low range and high range GM tubes be calibrated at 100 mR/hr (1 mSv/h) and 100 R/hr (1 Sv/h), respectively. These fields are chosen because they provide good statistical data in the default calibration time of approximately two minutes. However, due to the excellent linearity and accuracy of the Time-to-Count technique, calibrations can be done using a license free source (10 μCi $^{137}$Cs) generating approximately 1 mR/hr (10 μSv/h) at the detector locations. A calibration time of 10 minutes should be used with the lower fields to acquire good statistical data. The ADM units will automatically adjust the required calibration time.

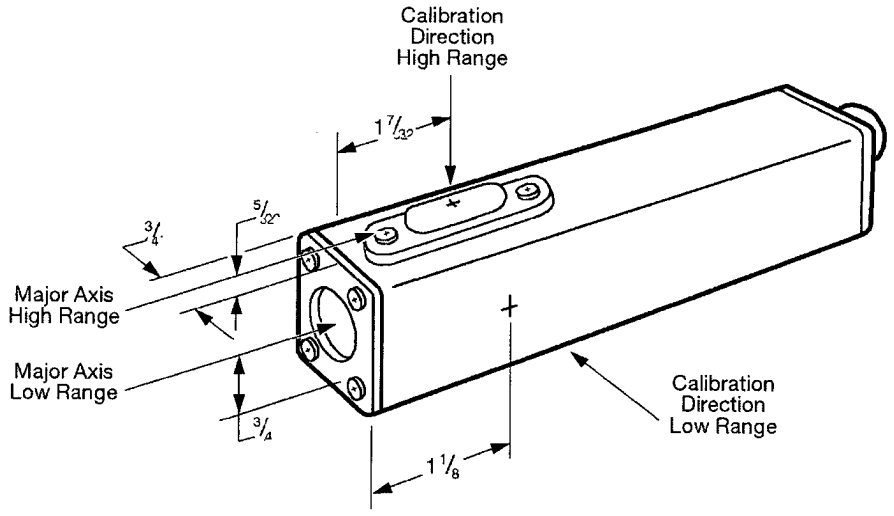


Figure 3 GP100 Series Detector Tube Location and Calibration Geometry

# A. Specifications

## A.1 General Specifications

DETECTOR TYPE – (2 ea) Halogen Quenched GM Tubes.

RESOLVING TIME, TIME-TO-COUNT – 1 µs.

PLATEAU SLOPE – 4% per 100 V max.

OPERATING VOLTAGE – 450 to 550 V dc.

DYNAMIC RANGE – 9 decades.

BACKGROUND – less than 5 CPM.

ENERGY RANGE – 80 keV to 3.0 MeV.

ENERGY RESPONSE – See Energy Response Curve, Figure 4, below.

- Responsive to energy above 50 keV.
- ±20% uniform from 80 keV to 3 MeV (tested up to $^{60}$Co energy of 1.25 MeV).

LINEARITY – ±5%.

RESPONSE TIME – 2 to 5 s.

OPERATING TEMPERATURE RANGE – From –30 °C to +50 °C (–22 °F to +122 °F).

OPERATING HUMIDITY – 0 to 95% non-condensing.

POWER – +5 V dc.

HV SUPPLY, INTERNALLY GENERATED – ±250 V.

OUTPUT, PULSE TRAIN – +5 V and ground.

HOUSING – Moisture Proof Aluminum.

WEIGHT – 0.45 kg (1 lb).

SIZE – 38 x 48 x 175 mm (1.5 x 1.9 x 6.9 in.).

CONNECTOR – MS3110E14 -12P.

TYPICAL APPLICATION – Area Monitor.

## A.2 GP100 Detector

DETECTOR SENSITIVITES, LOW RANGE – 1800 CPM/mR/h.

DETECTOR SENSITIVITES, HIGH RANGE – 4.2 CPM/mR/h.

DETECTOR DYNAMIC RANGE LOW LIMIT, LOW RANGE – 10 μR/h.

DETECTOR DYNAMIC RANGE LOW LIMIT, HIGH RANGE – 10 000 R/h.

## A.3 GP100SI Detector

DETECTOR SENSITIVITES, LOW RANGE – 3 CPS/μSv/h.

DETECTOR SENSITIVITES, HIGH RANGE – 0.007 CPS/μSv/h.

DETECTOR DYNAMIC RANGE LOW LIMIT, LOW RANGE – 0.1 μSv/h.

DETECTOR DYNAMIC RANGE LOW LIMIT, HIGH RANGE – 100 Sv/h.

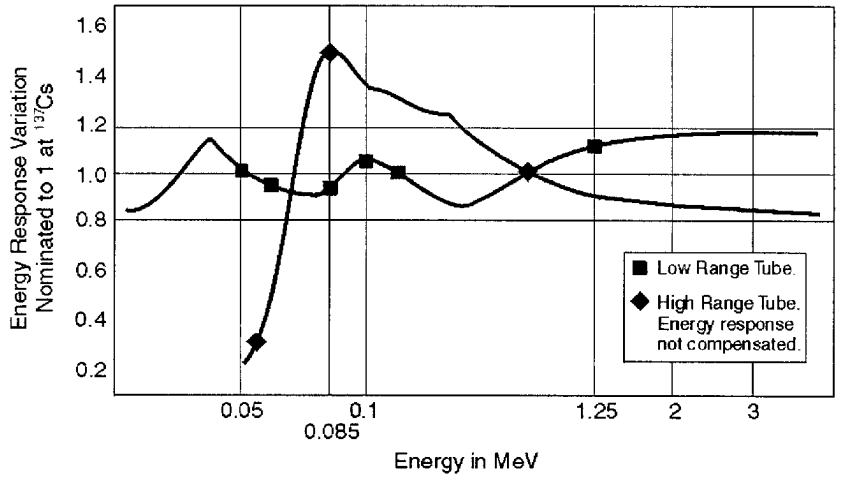


Figure 4 Energy Response Curve

# B. Installation Considerations

This unit complies with all applicable European Union requirements.

During the design and assembly of the module, reasonable precautions were taken by the manufacturer to minimize the effects of RFI and EMC on the system. However, care should be taken to maintain full compliance. These considerations include:

- Single point external cable access in metal conduit.
- Compliant grounding and safety precautions for any power distribution.
- The use of CE compliant accessories such as ratemeters, preamplifiers, fans, UPS, etc.

Any repairs or maintenance should be performed by a qualified Canberra service representative. Failure to use exact replacement components, or failure to reassemble the unit as delivered, may affect the unit's compliance with the specified EU requirements.

**Preventive Maintenance**

Preventive maintenance is not required for this unit.

When needed, the enclosure of the unit may be cleaned. Remove power from the unit before, cleaning. Use only a soft cloth dampened with warm water and make sure unit is fully dry before restoring power.

# Notes

# Warranty

Canberra (we, us, our) warrants to the customer (you, your) that for a period of ninety (90) days from the date of shipment, software provided by us in connection with equipment manufactured by us shall operate in accordance with applicable specifications when used with equipment manufactured by us and that the media on which the software is provided shall be free from defects. We also warrant that (A) equipment manufactured by us shall be free from defects in materials and workmanship for a period of one (1) year from the date of shipment of such equipment, and (B) services performed by us in connection with such equipment, such as site supervision and installation services relating to the equipment, shall be free from defects for a period of one (1) year from the date of performance of such services.

If defects in materials or workmanship are discovered within the applicable warranty period as set forth above, we shall, at our option and cost, (A) in the case of defective software or equipment, either repair or replace the software or equipment, or (B) in the case of defective services, reperform such services.

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Our warranty does not cover damage to equipment which has been altered or modified without our written permission or damage which has been caused by abuse, misuse, accident, neglect or unusual physical or electrical stress, as determined by our Service Personnel.

We are under no obligation to provide warranty service if adjustment or repair is required because of damage caused by other than ordinary use or if the equipment is serviced or repaired, or if an attempt is made to service or repair the equipment, by other than our Service Personnel without our prior approval.

Our warranty does not cover detector damage due to neutrons or heavy charged particles. Failure of beryllium, carbon composite, or polymer windows, or of windowless detectors caused by physical or chemical damage from the environment is not covered by warranty.

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