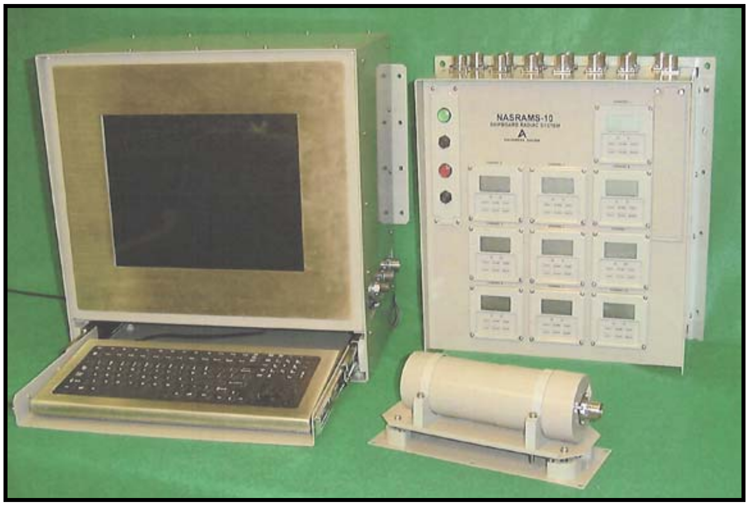
TRADEWAYS LTD

NASRAMS Naval Ship Radiation Monitoring System

NASRAMS provides continuous, real time radiological information collected from probes located throughout the ship. The system employs GM Detectors operating in the patented "Time-To-Count" operating mode; providing outstanding linearity over the entire dynamic range of the system (no saturation in gamma fields to 10^5 Gy/hr). NASRAMS detects and measures Prompt Dose (neutron and gamma) as well as Residual (fallout) Radiation. NASRAMS is EMI and EMP qualified and fully Mil. Spec. in accordance with MIL-STD-810.



DETECTORS: ULTRA LONG LIFE WITH CALIBRATION STABILITY, UP TO 15 PER SYSTEM AVAILABLE IN 3 CONFIGURATIONS:

Local Readout Detector

Gamma detection with local readout suitable for use below or above deck where it is considered advantageous to provide a local readout of radiation at that location. Unit has a display but no controls.

Mast Mount Detector

No readout, designed for mast mount or otherwise inaccessible location.

Underwater Detector

For measurement of sea water radioactivity. Capable of being immersed to a depth of 150m.

Central Readout and Control Center (CRCC):

- All radiation detectors distributed throughout the ship continually report to the CRCC over a RS-485 data bus.
- CRCC is direct reading and continually displays dose rate, detector operability status and alarm status for each detector in use.
- CRCC display provides total dose exposures for each channel by operator action (push button).
- CRCC features individual pre-settable alarms for both dose rate and total dose for each detector.
- Alarms identified and indicated by specific channel and general alarm indicators (both visual and audible).
- CRCC features a 12 hr of backup battery to power the system in case of a power outage.
- Fiber Optic detector cables are available as an option for increased immunity to EMP.
- Channel Displays are backlit for night use.
- CRCC withstands shock per MIL-S-901 and vibration per MIL-STD-167 (shipboard vibration requirements).

Communication to Ship's Computer: The information collected by the Central Readout and Control Center can be sent to the shipboard computer/command and control system for further processing.

Training Simulation:

NASRAMS features a training simulation mode, allowing conduct of training exercises on the installed NASRAMS system. The programmable exercises include time variable simulated radiation levels (including statistical fluctuation) to accurately depict a real life radiation environment. Start/finish time, as well as the radiation readings as a function of time, are pre-selected by the Training Officer to simulate the desired event scenario. Training can be conducted locally, aboard an individual ship or on a broader scope within the Fleet.

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Specifications

Central Readout and Control Center:

- NASRAMS – 5, up to 5 channels
- NASRAMS – 10, up to 10 channels
- NASRAMS – 15, up to 15 channels
- Direct reading liquid crystal display backlit for night operation, three significant digits, floating decimal point, unit and alarm status indicators, large digits readable at 80 in. (2 m).
- System: Power ON/OFF
- Alarm selection On/Off/Audible/Visual/Aud/Vis.
- Audible Alarm – 100db at 40 in. (1 m).
- Visual Alarm – bright flashing light**.**
- Alarm identified to specific channel.
- Channels (each): RATE, DOSE, CLR/TEST.
- Detectors connected via RS-485 data bus.
- Individual pre-settable alarms for dose and dose rate.
- Settable over entire dynamic range, auxiliary contacts provided for remote alarms.
- Power – 110 V ac ± 20%, 50 to 60 Hz 1A, or 12 to 24 V dc, 2 amperes.
- Back-up rechargeable battery capable of 12 hr operation in event of line failure.
- CRCC will communicate with onboard computer.
- Gasketed aluminum cabinet with rear panel wall mount. All cabling by connectors through top of cabinet.
- CRCC: 394 X 206 X 412 mm (15.5 X 8.2 X 16.25 cm) (W x D x H)
- CRCC: 18.2 kg (40 lb)
- Operating Temperature: -40 ºC to 50 ºC (-40 ºF to 122 ºF)
- Storage Temperature: -50 ºC to 70 ºC (-58 ºF to 158 ºF)
- Humidity: 98% RH and 50 ºC (122 ºF) continuous.
- Salt Environment: Meets MIL-STD-810E for shipboard use.
- Shock and Vibrations: Meets MIL-S-901 shipboard shock vibration, MIL-STD-167 shipboard vibration.

Detectors:

- Accuracy - ± 15% of true dose and dose rate over entire dynamic range.
- Gamma Dose Rate (Residual) 0.01 µGy/hr to 10 µGy/hr.
- Gamma Dose (Residual) 0.001 µGy/hr to 10 µGy/hr.
- Gamma Dose (Prompt) 5 cGy to 10 cGy.
- Neutron Dose (Prompt) 5 cGy to 10 cGy.
- Sieverts units available.
- Gamma Energy Response - ± 15% from 80 keV to 3 MeV.
- Residual fields, two GM tubes operating in "Time-to-Count" mode.
- Prompt Radiation: Gamma – PMOS-FET device. Neutron – PIN DIODE.
- Will not saturate up to 10^5 cGy/hr.
- Response Time: Within 10% of final reading in 4 s at 0.01 cGy/hr, returns to background within 4 s.
- Meets EMI requirements of MIL-STD-461, fiber optic cable compatible.
- Meets requirements of USANCA criteria for nuclear survivability.
- Temperature: Operating -40 ºC to 50ºC (-40 ºF to 122 ºF).
- Temperature: Storage -60 ºC to 70 ºC (-76 ºF to 158 ºF).
- Humidity: Withstands constant humidity at 98% RH and 50 ºC (122 ºF).
- Immersion: Watertight and splash tight per MIL-STD-810E.
- Underwater Detector: Watertight to 150 m depth (continuous).
- Salt Environment: Continuous exposure per MIL-STD-810E.
- Shock and Vibration: Shipboard shock per MIL-S-901 and shipboard vibration per MIL-STD-167.
- RS-485 operating bus.
- Sealed PVC case and aluminum liner for EMP and EMI immunity. Underwater detector stainless steel cylinder.
- Local Readout and Mast Mount Detector Dimensions:
  Cylindrical: 304 x 75 mm (10 x 3 in.) (L x dia.).
- Underwater Detector Dimensions:
  Cylindrical: 304 x 75 mm (12 x 2.5 in.) (L x dia.).
- Local Readout and Mast Mount Detector Weight: 2.25 kg (5 lb.).
- Underwater Detector Weight: 1.8 kg (4 lb.).

TIME-TO-COUNT TECHNIQUE

NRC GM tube detectors are operated using a unique technique, which removes many of the limitations associated with the use of G-M tubes operated in the conventional mode.

Conventionally, a G-M 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.

Assume the G-M 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 be properly counted. 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 immediately following 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 NRC GM tube detectors is about 150 microseconds; the high range tube dead time is about 15 microseconds. If an ionizing event takes place a trifle 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 G-M tube. The dead time, which characterizes all G-M tubes, produces the non-linearity at higher fields and severely limits the range over which the tube is usable.

A second undesirable characteristic of G-M 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 G-M tube instruments currently produced will display this hazardous condition. In the TIME-TO-COUNT technique employed in NRC GM tube detectors, the dead time and saturation effects are eliminated.

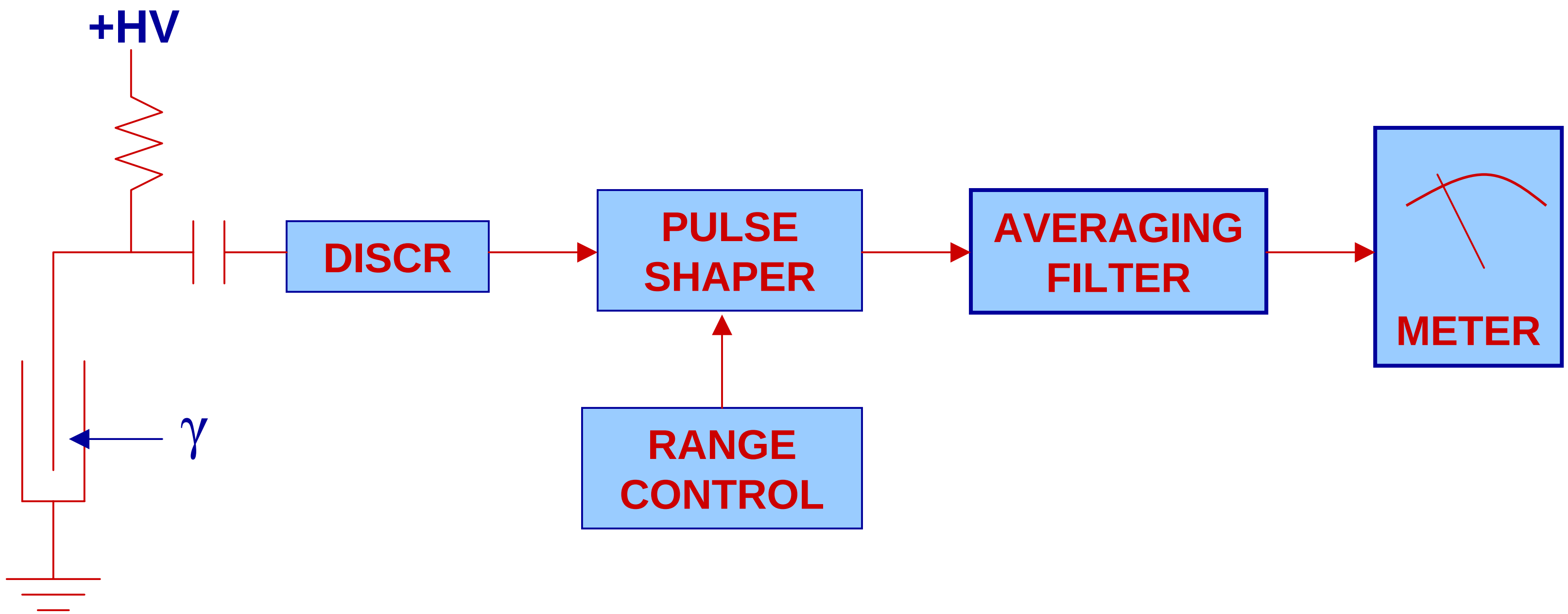
A low DC bias voltage is abruptly raised to 500 volts DC carrying the tube into its operating region. The rise time of this voltage is less than 0.2 microseconds. At the same time, this rapid increase in voltage is applied, a crystal controlled, 1 megacycle oscillator (clock) is gated on and time, in the form of 1 microsecond cycles, starts being counted. Time counting continues until a G-M tube pulse is obtained. At that point, time counting is stopped and the accumulated time is recorded. At the same time, the anode voltage is reduced into the low bias level. The voltage on the anode is maintained at the low bias level for 1.5 to two milliseconds, a time period which is long compared to the dead time and recovery time of the tube.

After two milliseconds, when the G-M tube is fully recovered, the voltage is again applied to the anode. Only one G-M 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.

Thus, the radiation field intensity is proportional to the reciprocal of the time required to obtain a G-M 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: 2 seconds), and the average time to obtain a G-M pulse is determined, we now have a statistically reliable measure of field strength. This precise microprocessor controlled relationship forms the design basis for NRC GM tube detectors and enables many decades of linear performance for the two G-M tubes involved.

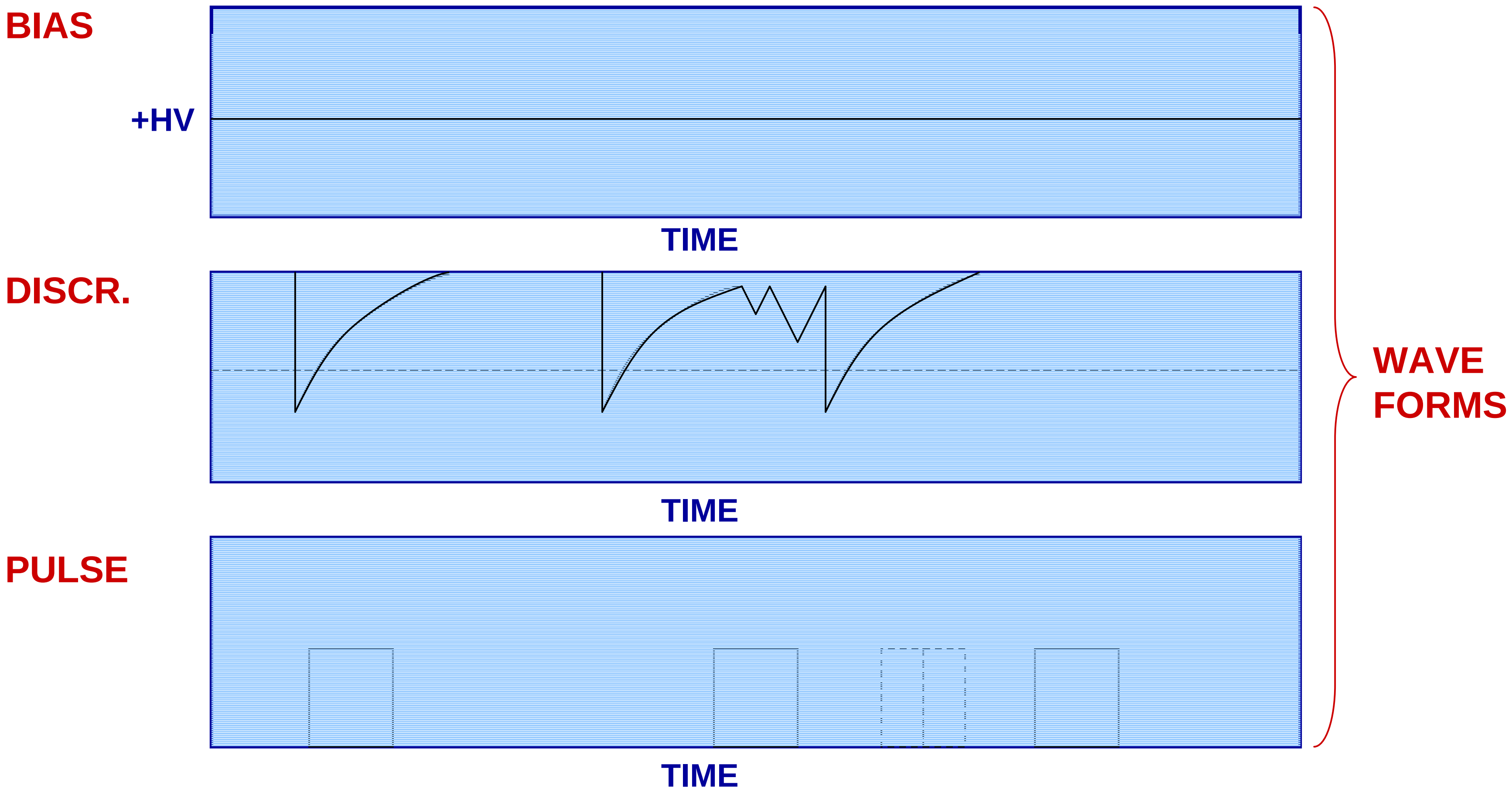
OPERATING PRINCIPLES – OPERATIONAL KIT

Typical GM Tube Instrument



OPERATING PRINCIPLES – OPERATIONAL KIT

Conventional GM Tube Instrument Operation



OPERATING PRINCIPLES – OPERATIONAL KIT

GEIGER-MÜLLER (GM) TUBES

ADVANTAGES

- WORKHORSE
- HIGH GAIN
- SIMPLE ELECTRONICS

DISADVANTAGES

- DEAD TIME NON-LINEARITY
- SATURATION / FOLDOVER
- LIMITED LIFE (10^8 TO 10^{10} COUNTS)

OPERATING PRINCIPLES – OPERATIONAL KIT

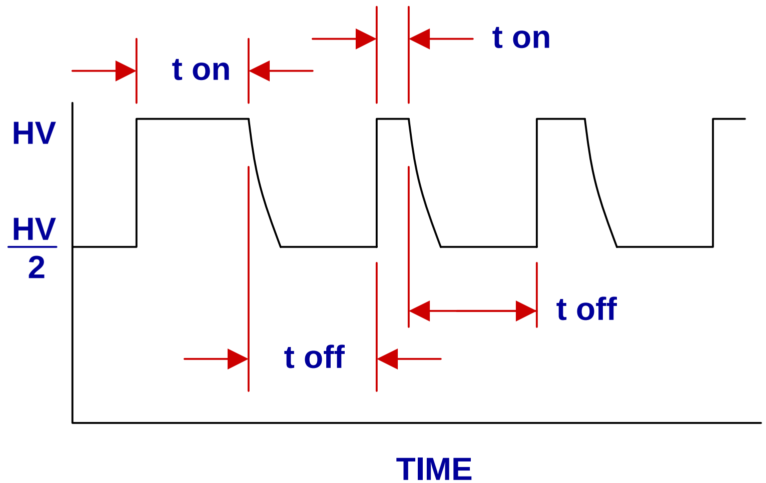
"Time to Count" Operation

Canberra Dover has eliminated the inherent disadvantages of GM Tubes with the development of "Time to Count".

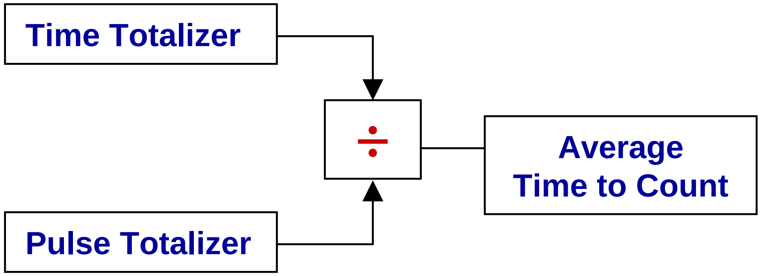
- **GATED HIGH VOLTAGE TO GM TUBE**
- **GUARANTEED FULL RECOVERY**
- **NO DEAD-TIME NON-LINEARITIES → SINGLE POINT CALIBRATION**
- **NO DEAD-TIME INDUCED SATURATION OR PARALYSIS**
- **LONG LIFE (MAXIMUM COUNTRATE 500/SECOND)**

OPERATING PRINCIPLES – OPERATIONAL KIT

“Time to Count” Operation



GM TUBE WAVEFORMS

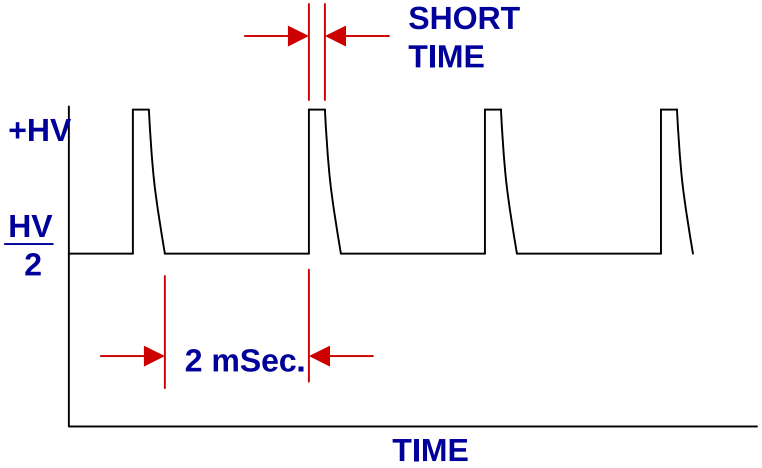


$$\text{RATE} = \frac{K}{\text{TIME TO COUNT}}$$

OPERATING PRINCIPLES – OPERATIONAL KIT

“Time to Count” Operation

HIGH
FIELD



LOW
FIELD