# Determining Minimum Detectable Activity (MDA)

**BY BETH HALL AND ROLLIE CANTU**

Judging by the number of requests we receive at LMI for copies of past "From the Trenches" articles, the "hot" topic for many of our readers is that of determining Minimum Detectable Activity (MDA). In the interest of providing useful information to meet the needs of Ludlum customers, this column will feature reprints of a popular series of articles addressing MDA time constants. This three-part series, written by David Wyatt and published over 7 years ago, is updated to reflect changes in instrumentation and general thinking since then.

*Note: This is part 1 of a 3-part series covering MDA time constants. Part 1 addresses linear ratemeters controlled by conventional resistor-capacitor (RC) integration components. Part 2 encompasses logarithmic ratemeters. Part 3 addresses microprocessor-controlled ratemeters.*

### DETERMINING LINEAR ANALOG RATEMETERTIME CONSTANTS FOR MDA EQUATIONS

The following information applies to the MDA equation (95% confidence) for linear analog ratemeter instruments– such as portable friskers and hand-held contamination monitors.

The original of this article, from December 1994, included an equation for calculating MDA that was taken from reference 1 *(Gollnick, April 1994)*. In December 1998, we published a two-part series of articles titled "Detection Sensitivity and MDA", written by our guest contributor Paul Steinmeyer, Jr., which included a different version of the MDA equation *(reference 2)*. Since 1994, Dr. Gollnick has published a new edition of Basic Radiation Protection Technology *(reference 3)* which reflects a slightly different approach to the subject of calculating MDAs and minimum detectable concentrations (MDCs) from his 1994 book.

Since we published the Steinmeyer article, we have recommended use of what Steinmeyer calls "the best all-encompassing form of the MDA equation" *(reference 2 – equation 1)*. We continue to use it at Ludlum Measurements. It is written below in its original form *(equation A)* for a timed count.

**STEINMEYER (ORIGINAL) – EQUATION A**

$$MDA = \frac{2.71 + 3.29\sqrt{R_b t_s \left[1+\frac{t_s}{t_b}\right]}}{(t_s)(E)}$$

where MDA = minimum detectable activity in dpm

$R_b$ =background count rate in cpm

$t_s$ =sample counting time in minutes

$t_b$ =background counting time in minutes

E =detector efficiency in counts per disintegration

**It is written again in modified form as Equation B, for the case in which we want the MDA to be in terms of a specific area, such as surface measurements in which we want the MDA in terms of dpm per 100 cm². For this case, an additional factor is included in the denominator to adjust the MDA for the area of the detector being used.**

Equation B also addresses the use of a ratemeter as the counting instrument, in which there is no clear sample and background counting time. As acknowledged in reference 2, it has been accepted that in ratemeter applications, twice the instrument's time constant can be substituted for the sample and background counting times. Thus, "2T" has been substituted for both "$t_s$" and "$t_b$" (sample and background counting time) in the original equation.

**STEINMEYER (MODIFIED) – EQUATION B**

$$MDA\,(dpm/100\,cm^2) = \frac{2.71 + 4.65\sqrt{(R_b)(2T)}}{(2T)(E)\left(\frac{A}{100}\right)}$$

(may be simplified algebraically, if desired) where MDA= minimum detectable activity in dpm/100 cm²

$R_b$=background count rate in cpm

T =time constant of counting instrument in minutes

E =detector efficiency in counts per disintegration

A =probe area in cm²

So, how does one determine the time constant ("T")? First, some definitions:

- **RESPONSE TIME:** the time interval required for the instrument reading to change from 10% to 90% of the final reading (or vice versa) following a step change in the radiation field (i.e., signal) at the detector.[4]

**Note: All LMI specified response times are measured by injecting a fixed pulse rate from a pulse generator.*

- **TIME CONSTANT: the time involved in the charging or discharging of an inductor or capacitor. One time constant is the length of time required to reach 63 percent of the full charge or discharge.**

The specification related to time constant in the counter instruction manual is specified as response time – 10% to 90% of final reading. There are two methods of calculating the required "counter time constant" for the MDA as shown below in Method 1 and Method 2.

**Method 1:**

An approximate method used for conversion from the specified response time to the required time constant involves multiplying the response time data by 0.44.

**Example:** The Slow response position on a Ludlum Model 14C is specified at 22 seconds. Thus, 22 x 0.44 ≈ time constant of 9.7 seconds = 0.16 minutes for "T".

**Method 2:**

The integration RC time constant can be calculated by multiplying R x C. There are 3 components associated with this calculation.

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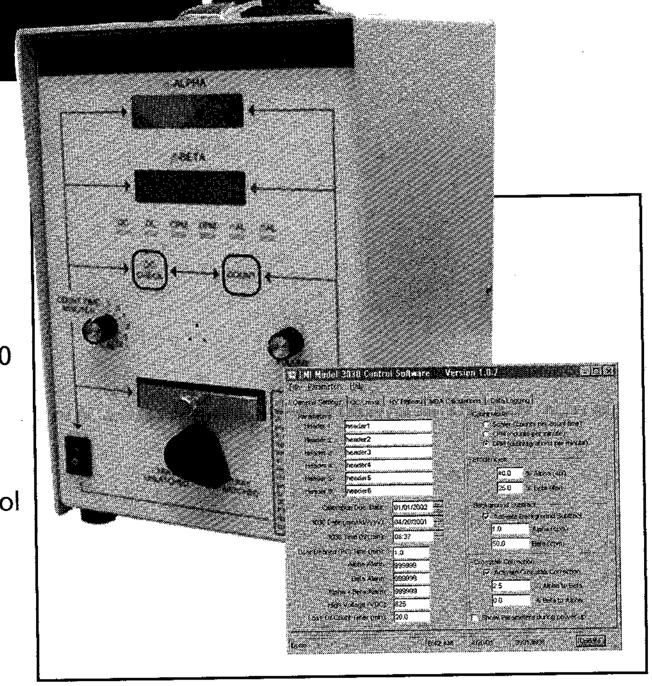
# Model 3030 Alpha/Beta Scaler





**INDICATED USE:** Simultaneous Alpha/Beta sample counting
**DETECTOR:** ZnS(Ag) adhered to plastic scintillation material
**TUBE:** 2" (5.1cm) diameter magnetically shielded photomultiplier
**WINDOW:** 0.4 mg/cm$^2$ aluminized mylar
**ACTIVE AND OPEN AREA:** 20.3 cm$^2$
**SAMPLE HOLDER:** Brass housing with Chrome plated Brass sample tray capable of holding 1" or 2" diameter samples
**EFFICIENCY (4PI GEOMETRY):**
**ALPHA:** 37%-Th-230; 39%-U-238; 37%-Pu-239
**BETA:** 8%-C-14; 27%-Tc-99;29%-Cs-137; 26%-Sr-90/Y-90
**CROSS TALK:** Alpha to Beta: 10% or less (10 μR/hr field)
Beta to Alpha: 1% or less
**BACKGROUND:** Alpha - 3 cpm or less
Beta-Gamma - Typically 50 cpm or less (10 μR/hr field)
**AUDIO:** Built in unimorph type speaker with volume control to provide a dual tone (1 for each channel ) click-per-event audio
**STATUS INDICATORS:** Backlit indicators for QC-Daily QC check needed; OL-Scintillation detector is in overload condition; CPM/DPM-Counting in CPM or DPM mode; ∝AL/βAL-Count has exceeded alarm set point
**SCALERS:** 2 ea. 6 digit LCD displays with back lights providing a range of 0 - 999999 counts (started by COUNT button)
**SCALER LINEARITY:** Reading within ±2% of true value
**COUNT TIMER:** Adjustable from 0.1 - 60 minutes (PC setting is user-defined via PC software)
**HIGH VOLTAGE:** Adjustable from 0 - 2500 volts
**THRESHOLD:** BETA - 4mV • ALPHA - 120mV
**BETA WINDOW:** 50mV
**DATA-OUTPUT:** 9 pin RS-232 port
**POWER:** 95 - 250 VAC, 50-60 Hz single phase (less than 100 mA) with battery backup
**CONSTRUCTION:** Aluminum housing with Gray polyurethane enamel paint and sub-surface printed front panel
**TEMPERATURE RANGE:** -4°F (-20°C) to 122°F (50°C); May be certified to operate from -40°F (-40°C) to 150°F (65°C)
**SIZE:** 9" (22.9 cm)H X 6" (15.2 cm)W X 9" (22.9 cm)D
**WEIGHT:** Approximately 40 lbs (18 kg)
**SOFTWARE:** PC based to perform setup and calibration routines including background subtract, crosstalk correction, cpm/dpm modes, daily QC check parameters, alarm levels, and automatic plateaus. All parameters are stored in the instrument in non-volatile memory. Logging of data is also available with software collecting and storing the following data:

| | | | |
|---|---|---|---|
| Sample Number | Sample Date | Sample Time | Alpha Count |
| Beta Count | Sample Type | Comments | |

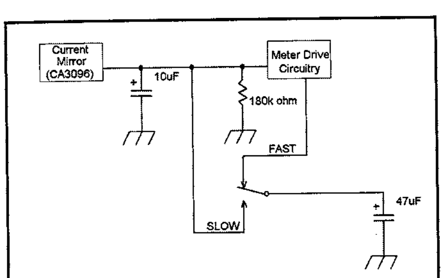
## DETERMINING MINIMUM DETECTABLE ACTIVITY

*(Continued from page 2)*

**Example:** The illustration shows the 3 components in a Model 14C circuit: 10 μF, 180k ohm, and 47 μF.

In the Fast response position, the RC time constant is 10 μF ($10 \times 10^{-6}$ F) x 180,000 ohms = 1.8 seconds or 0.03 minutes for "T". For the Slow position, the 47μF parallels with the 10μF = 57μF ($57 \times 10^{-6}$ F) x 180,000 ohms = 10.3 seconds or 0.17 minutes for "T".

Locate the integration RC components by tracing the Fast/Slow response switch or current mirror to the components or by referring to the appropriate circuit board schematic located in the instrument's Instruction Manual.




**References:**
[1]*Gollnick, D. A.; Basic Radiation Protection Technology, 3rd Edition. Altadena, CA: Racific Radiation Corporation; April, 1994.*

[2]*Steinmeyer, Paul Jr.; "From the Trenches", Ludlum Report, Ludlum Measurements, Inc., Volume 13, No. 1; December, 1998.*

[3]*Gollnick, D. A.; Basic Radiation Protection Technology, 4th Edition. Altadena, CA: Racific Radiation Corporation; May, 2000.*

[4]*American National Standard Performance Specifications for Health Physics Instrumentation - Portable Instrumentation For Use in Normal Environmental Conditions. New York: Institute of Electrical and Electronic Engineers; ANSI N42.17A-1989.*