LUDLUM MODEL 2242
SURVEY METER

October 2023

Serial Number 219764 and Succeeding

Serial Numbers

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STATEMENT OF WARRANTY

Ludlum Measurements, Inc. warrants the products covered in this manual to be free of defects due to workmanship, material, and design for a period of twelve months from the date of delivery. The calibration of a product is warranted to be within its specified accuracy limits at the time of shipment. In the event of instrument failure, notify Ludlum Measurements to determine if repair, recalibration, or replacement is required.

This warranty excludes the replacement of photomultiplier tubes, G-M and proportional tubes, and scintillation crystals which are broken due to excessive physical abuse or used for purposes other than intended.

There are no warranties, express or implied, including without limitation any implied warranty of merchantability or fitness, which extend beyond the description of the face there of. If the product does not perform as warranted herein, purchaser's sole remedy shall be repair or replacement, at the option of Ludlum Measurements. In no event will Ludlum Measurements be liable for damages, lost revenue, lost wages, or any other incidental or consequential damages, arising from the purchase, use, or inability to use product.

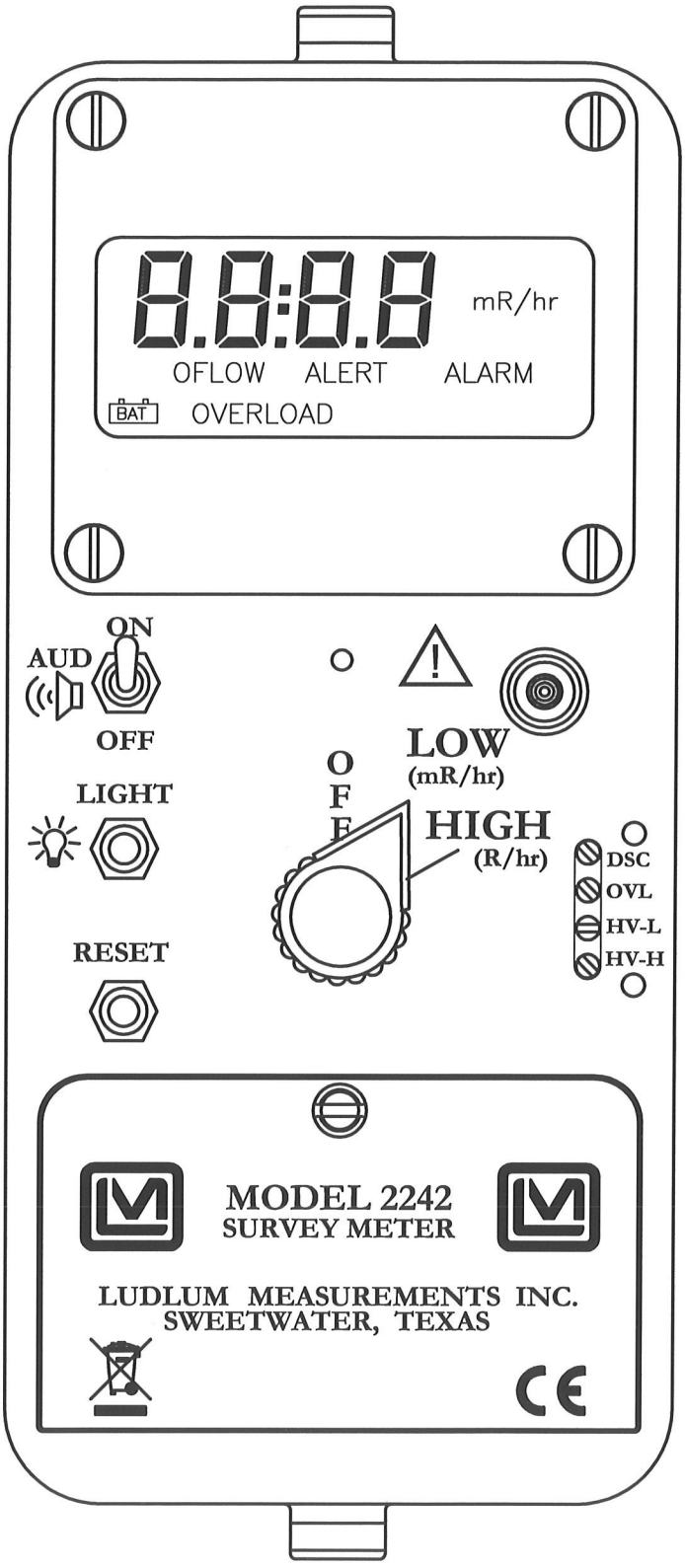
RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair or calibration, please send to the address below. All shipments should include documentation containing return shipping address, customer name, telephone number, description of service requested, and all other necessary information. Your cooperation will expedite the return of your equipment.

LUDLUM MEASUREMENTS, INC.
ATTN: REPAIR DEPARTMENT
501 OAK STREET
SWEETWATER, TX 79556

800-622-0828 325-235-5494
FAX 325-235-4672

REV #	ALTERATIONS	DATE	BY
1	VALID	4-7-04	PW
2	ECF# 2016	9-23-05	CMC
3	ADDED DO NOT DISCARD SYMBOL	6-1-06	CMC



CHG	NO.		DWN	CHK	APP
DWN	DATE	CHK	DATE	APP	DATE
CMC	6-1-06				7 Jun 07

TOL: SHOP STD ☐ OTHER

SCALE: FULL ☐ OTHER

TITLE MODEL 2242

LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES 408

SHEET 214

Table of Contents

Section 1

Introduction

The Model 2242 is a portable microprocessor-based digital Ratemeter designed for detection and measurement of ionizing radiation. The data is presented on a four-digit Liquid Crystal Display (LCD). A three-position switch labeled "OFF/LOW (mR/h)/HIGH (R/hr)" selects the desired operating range for the instrument. The internal detectors are energy-compensated GM (Geiger-Mueller) tubes capable of measuring fields from 0.01 mR/hr to 999.9 R/hr.

This instrument incorporates independent adjustable alarms for each range. The first-level alarm is indicated by ALERT on the LCD. Display of ALARM on the LCD, a continuous audible tone and an illuminated alarm LED (red) indicate the second-level alarm. Both audible alarms can be silenced (acknowledged) by depressing the RESET switch.

Other features include Dead Time Correction (DTC) to compensate for detector dead time; audible click-per-event with programmable 1, 10, 100, and 1000 divide-by; LCD backlight with programmable ON time; programmable fixed or variable response time; and count overflow visual alarm indicating that the counting circuitry is nearing the maximum counting capability.

All of the features described above may be programmed manually, using the internal switch board, or by computer through the RS-232 port. The switch board can be removed after entering or changing parameters to prevent undesired altering of setup parameters.

A regulated high-voltage power supply, dual set points adjustable from 400 to 2500 volts, with detector overload detection add versatility to the instrument. A single adjustable discrimination setting applies to both internal detectors. All calibration controls are covered to prevent any inadvertent altering of the detector operating parameters.

The instrument operates on two ″D″ cell batteries. The unit body is made of cast-and-drawn aluminum and is covered in beige powder-coating to aid in surface decontamination.

Section 2

Getting Started

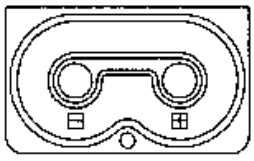
Unpacking and Repacking

Remove the calibration certificate and place it in a secure location. Remove the instrument and accessories (batteries, cables, etc.) and ensure that all of the items listed on the packing list are in the carton. Check individual item serial numbers and ensure calibration certificates match. The Model 2242 serial number is located on the front panel below the battery compartment.

To return an instrument for repair or calibration, provide sufficient packing material to prevent damage during shipment. Also provide appropriate warning labels to ensure careful handling. Include detector(s) and related cable(s) for calibration.

Every returned instrument must be accompanied by an Instrument Return Form, which can be downloaded from the Ludlum website at www.ludlums.com. Find the form by clicking the "Support" tab and selecting "Service Centert" from the drop-down menu. Then choose the appropriate Service division where you will find a link to the form.

Battery Installation



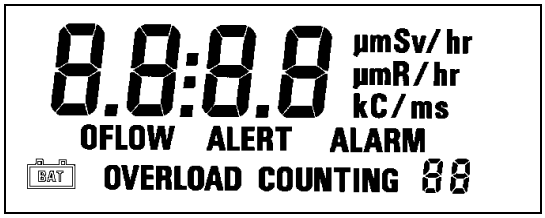
Ensure that the range selector switch is in the "OFF" position. Open the battery lid by pushing down and turning the quarter-turn thumbscrew counterclockwise ¼ turn. Install two "D" size batteries in the compartment.

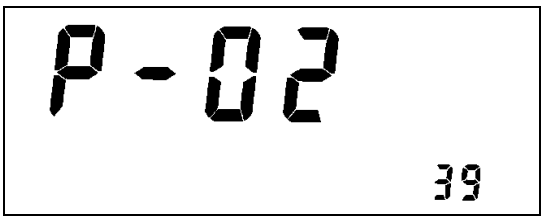
Note the (+) and (-) marks inside the battery door. Match the battery polarity to these marks. Close the battery box lid, push down and turn the quarter-turn thumb screw clockwise ¼ turn.

Note:

Center post of a flashlight battery is positive. The batteries are placed in the battery compartment in opposite directions.

Operating the Instrument





Turn the OFF/LOW(mR/hr)/HIGH(R/hr) switch to the LOW(mR/hr) position. The display goes through an initialization sequence. The display will show all "8"s with decimal points. Check to make sure all segments are on, as illustrated to the left.

The LCD then shows the firmware number in the format "P-XX YY." The "XX" is the firmware number, and the "YY" is the firmware version. (The figure to the left is for example only, to illustrate location of display.)

Select the desired AUD ON/OFF parameter and proceed to use instrument. Switch up to the R/hr range *only* if the OFLOW and/or OVERLOAD symbols are displayed, or if the display shows 999 mR/hr.

Principle of Operation

The Model 2242 utilizes microprocessor-based technology, providing an extensive range of operating features. Two independent detector parameters can be stored in memory (with the exception of a single discrimination parameter).

The Model 2242 incorporates a detachable switch board used to program detector and operating parameters into non-volatile memory (retains the data even after the power is removed). The switch board may be removed so that the operating parameters cannot be altered. If multiple units are to be used at one location, fewer Switch Boards may be purchased in order to program all instruments. A 16-position rotary switch (FUNCTION) selects each of the 16 operating/detector parameters. Three pushbutton switches on the Switch Board provide the means to change and save the variables for each of the parameters.

An RS-232 port is also available via the switch board for computer connection. An optional can with the RS-232 connector mounted externally is also available. Communication baud rate may be set with the FUNCTION switch to correspond to the computer baud. The computer can adjust the detector parameters and retrieve data.

An LCD provides the readout for the ratemeter data with the programmed units and multipliers, as well as ALERT, ALARM, OVERLOAD and OVERFLOW annunciators, "low battery" icon, and scaler counting mode indication (COUNTING – not used). The four 0.5-inch digits are used for the ratemeter data. The LCD also displays the variables during the manual programming sequence. (See figure above.) A front-panel alarm LED (red) illuminates during an alarm condition.

Section

3

Specifications

POWER: two standard "D" size batteries; current drain approx. 35 mA (backlight off); minimum battery voltage 2.2 ± 0.1 Vdc

BATTERY DEPENDENCE: instrument calibration change less than 3% to battery endpoint

BATTERY LIFE: approximately 200 hours with alkaline batteries

WARM-UP TIME: Unit may be used immediately after the LCD initialization sequence is completed, approximately 5 seconds after turn-on.

DISPLAY: four-digit LCD with 1.3 cm (0.5 in.) character height; 2 additional 0.5 cm (0.2 in.) digits are used for the exponential powers (parameter setup)

Backlight "ON" Time: 5, 15, 30, 60, 90, 120, or 240 ± 1 second

MEASURED RANGES:

mR/hr – 0.01 to 999.9
R/hr – 0.01 to 999.9

DISPLAY LINEARITY: within ± 10% of the true value with connected detector

RESPONSE TIME: Normally the time constant (TC) varies from 1 to 10 seconds.

The TC is defined as a one-time constant, which equals 63% of the final reading. To convert to the 10-90% of final reading definition, the TC value will have to be multiplied by 2.25. The readout updates every 2 seconds; therefore, response time measurements will be rounded to 2-second intervals; example: fixed TC = 2 seconds × 2.25 = 4.5 seconds for 90% of final reading. It will take 6 seconds before the display (3 each of 2-second intervals) will reach the 90% of final reading value.

ALERT/ALARM: separate visual and audible adjustable alarm points for both the mR/hr and R/hr ranges

INPUT SENSITIVITY: adjustable from 2-100 mV; negative pulse response. It is normally set at approximately 90 mV for the internal detectors.

HIGH VOLTAGE: externally adjustable from 400 to 2500 volts; regulated within 0.2% at 1000 Vdc; maximum load: 50 μA at 1000 Vdc. It is normally set at approximately 550 V for the internal detectors.

CALIBRATION CONSTANT: 0.001 to 280 × 10^{9} counts/unit

DETECTOR DEAD TIME COMPENSATION (DTC): adjustable from 0 to 9999 microseconds

RS-232 PORT: internal 9-pin ″D″ type connector with programmable baud rate from 150 to 19,200 bps. Optional external connector mounted on can is available.

SIZE: 16.5 x 8.9 x 21.6 cm (6.5 x 3.5 x 8.5 in.), including handle

WEIGHT: 1.6 kg (3.5 lb), including batteries

FINISH: drawn-and-cast aluminum, with computer-beige powder-coating and silk-screened nomenclature

Section 4

Description of Controls and Functions

Operator Controls

OFF / LOW (mR/hr) / HIGH (R/hr) Switch: A 3-position rotary switch which applies power to the instrument and selects mR/hr or R/hr counting modes.

AUD ON/OFF Switch: Front-panel toggle switch which silences or enables the clicks-per-event audio. The audible alarm is independent of the AUD ON/OFF switch and will override the audible click-per-event. An audible alarm can only be silenced by depressing the RESET button.

LIGHT (LCD Backlight): When depressed, this pushbutton illuminates the LCD for a pre-programmed time. The backlight ON time can be selected between 5 and 240 seconds during parameter setup.

RESET Pushbutton: In the non-alarm condition, depressing RESET resets the ratemeter display to the minimum display readout. In an alarm condition (ratemeter or scaler), depressing RESET will silence the audible alarm. Depressing RESET a second time will reset the ratemeter alarm and/or alert condition. Depressing the scaler count switch located in the end of the Model 2242 handle resets the scaler alarm only.

Remove the front-panel CAL cover to access the following controls:

DISC (Discriminator): A multi-turn potentiometer (approximately 20 revolutions) used to vary the detector pulse counting threshold from 2 to 100 millivolts. A Ludlum Model 500 Pulser or equivalent should be used in checking or adjusting the pulse discrimination parameter.

OVL (Detector Overload): A multi-turn potentiometer (approximately 20 revolutions) which adjusts the detector current level that must be exceeded to initiate an OVERLOAD alarm. This control adjusts the current level discrimination point from 0.5 and 40 microamperes, corresponding to the specific detector saturation point.

Note:

Measure the HV at the detector connector with a Ludlum Model 500 Pulser or a high-impedance voltmeter with a high-voltage probe. The impedance of the voltmeter must be 1000 megohms or greater.

HV1 and HV2: Multi-turn potentiometers (approximately 20 revolutions) used to vary the detector voltage from 400 to 2500 volts. The maximum HV output is adjusted by the HV LIMIT potentiometer located on the internal main board. The normal factory settings are 550 Vdc.

Internal Controls

MAIN BOARD

To access the internal circuit boards, unlatch the latches at each end of the Model 2242. Carefully separate the top chassis from the bottom cover (referred to as a "can"). The can has the audio speaker (unimorph) with a two-conductor cable attached to the main board. The audio plug may be disconnected during the internal control adjustments.

HV LIMIT (R027): A multi-turn potentiometer (approximately 20 revolutions) which sets the maximum high voltage limit with the front panel HV control adjusted to the maximum clockwise position. High voltage is adjustable from 1250 to 2500 Vdc.

VOLUME (R002): A multi-turn potentiometer (approximately 20 revolutions) which varies audible click-per-event and alarm audio. Adjust the control to the maximum clockwise position for maximum volume.

Note:

If the VOLUME control is adjusted to the maximum counterclockwise position the click-per-event or the audible alarm(s) will not be audible when active.

SWITCH BOARD

The switch board utilizes a 16-position rotary switch ("FUNCTION") to select the 16 setup parameters. (Refer to schematics and component layout drawing near the end of the manual.) All setup parameters are stored in the non-volatile EEPROM, which will retain data even after the Model 2242 batteries are removed. After parameters are entered, the switch board can be removed and the Model 2242 will operate from the programmed information for the specific detector setup entered prior to the removal of the board.

Description of and instructions for switch board setup parameters are detailed in another section of this manual – Initial Instrument Setup.

Display

DISPLAY: A four-digit LCD readout located in the lower right corner of the display indicates exponential power when in the parameter setup mode. The upper right of the LCD exhibits units and multiplier(s) - R/hr, mR/hr, or μR/hr; Sv/h, mSv/h or μSv/h; C/m, kC/m, C/s or kC/s. The bottom portion of the readout displays ALARM, ALERT, OFLOW, and OVERLOAD annunciators as well as the "low battery" icon.

DISPLAY STATUS DEFINITIONS

ALARM - Ratemeter or scaler count has increased above the preset alarm threshold. An audible continuous tone will accompany the "latching" ALARM condition. Depressing RESET acknowledges the audible ratemeter alarm. Depressing RESET a second time will reset the ratemeter reading and ratemeter alarm.

ALERT - Ratemeter count has increased above the preset alert threshold. To reset an ALERT condition, depress RESET once if in a non-alarm condition and twice if in an alarm condition. (The first depression in the alarm condition acknowledges the audible alarm.) The ratemeter will reset to the minimum displayable reading each time the alert is reset.

OFLOW (Overflow) - Indicates that the incoming count exceeds the capability to display stable or reliable readings corresponding to the radiation level being measured. The overflow symbol will appear when the ratemeter exceeds 100 kcps or if the dead time correction is greater than 75%.

OVERLOAD - Indicates that the detector is being exposed to radiation intensities greater than the detector maximum operating limit. The overload alarm point is set by adjusting the OVL control located underneath the CAL cover.

"low battery" icon - Indicates that the batteries have decreased to the minimum operating voltage of 2.2 ±0.1 Vdc.

Section

5

Safety & Maintenance Considerations

Environmental Conditions for Normal Use

Indoor or outdoor use

No maximum altitude

Temperature range of -30 to 50 °C (-22 to 122 °F)

Maximum relative humidity of less then 95% (non-condensing)

Pollution Degree 3 (as defined by IEC 664) (Occurs when conductive pollution or dry nonconductive pollution becomes conductive due to condensation. This is typical of industrial or construction sites.)

Cleaning Instructions and Precautions

The Model 2242 Scaler/Ratemeter may be cleaned externally with a damp cloth, using only water as the wetting agent. Do not immerse the instrument in any liquid. Observe the following precautions when cleaning:

1. Turn the instrument range selector switch to the OFF position and remove the batteries.

2. Allow the instrument to sit for one minute before cleaning.

Warning Markings and Symbols

Caution!

The operator or responsible body is cautioned that the protection provided by the equipment may be impaired if the equipment is used in a manner not specified by Ludlum Measurements, Inc. This includes guarding against severe impacts to the instrument housing (can), which could cause damage to the internal detectors.

The Model 2242 Survey Meter is marked with the following symbols:

CAUTION (per ISO 3864, No. B.3.1) – designates hazardous live voltage and risk of electric shock. During normal use, internal components are hazardous live. This instrument must be isolated or disconnected from the hazardous live voltage before accessing the internal components. This symbol appears on the front panel. **Note the following precautions:**

Warning!

The operator is strongly cautioned to take the following precautions to avoid contact with internal hazardous live parts that are accessible using a tool:

1. Turn the instrument power OFF and remove the batteries
2. Allow the instrument to sit for one minute before accessing internal components.

The "CE" mark is used to identify this instrument as being acceptable for use within the European Union. It is located on the battery lid.

The "**crossed-out wheelie bin**" symbol notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding; each material must be separated. The symbol is placed on the battery lid. See section 9, "Recycling for further information.

Maintenance

Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and the calibration. An instrument operational check should be performed prior to each use by exposing the detector to a known source and confirming the proper reading on each scale.

The Model 2242 instrument may be cleaned with a damp cloth (using only water as the wetting agent). Do not immerse instrument in any liquid. Observe the following precautions when cleaning:

1. Turn the instrument OFF and remove the batteries.
2. Allow the instrument to sit for one minute before accessing internal components.

RECALIBRATION

Recalibration should be accomplished after maintenance or adjustments have been performed on the instrument. Recalibration is not normally required following instrument cleaning, or battery replacement.

Note:

Ludlum Measurements, Inc. recommends recalibration at intervals no greater than one year. Check the appropriate regulations to determine required recalibration intervals.

Ludlum Measurements offers a full-service repair and calibration department. We not only repair and calibrate our own instruments, but most other manufacturer's instruments as well. Calibration procedures are available upon request for customers who choose to calibrate their own instruments.

BATTERIES

The batteries should be removed any time the instrument is placed into storage. Battery leakage may cause corrosion on the battery contacts, which must be scraped off and/or washed using a paste solution made from baking soda and water. Use a spanner wrench to unscrew the battery contact insulators, exposing the internal contacts and battery springs. Removal of the handle will facilitate access to these contacts.

Note:

Never store the instrument over 30 days without removing the batteries. Although this instrument will operate at very high ambient temperatures, battery seal failure may occur at temperatures as low as 37 °C (100 °F).

Section

6

Setup and Calibration

Entering or Changing Switch Board Parameters

THE FUNCTION SWITCH

A 16-position rotary switch labeled ″0-9″ and ″A-F″. This switch selects a parameter setup mode for the Model 2242. If the board is not installed, the normal operation mode (counting mode) is selected. If the switch board is installed, the selector switch must be set to the ″0″ position for normal operation. The following may be changed using this board:

- detector parameters
- RS-232 communication baud rate
- RS-232 data dump mode
- RS-232 detector parameters set/read mode

The switch board utilizes this16-position rotary switch (FUNCTION) to select the 16 setup parameters. (Refer to schematics and component layout drawing near the end of the manual.) All setup parameters are stored in the non-volatile EEPROM, which will retain data even after the Model 2242 batteries are removed. After the parameters are entered, the switch board can be removed, and the Model 2242 will operate from the programmed information for the specific detector setup prior to the removal of the board.

- Select the desired parameter to enter or change selecting the corresponding FUNCTION switch position. Depress ENTER and a character will start to flash. The flashing character indicates that the program is in the parameter change mode.

- To change the character, increment the UP switch to the desired variable. To shift to another character, increment the LEFT switch, which enables the operator to sequence through all the characters on the LCD associated with that particular parameter.

- Once the desired data is entered, depress ENTER. The LCD stops flashing and the new parameter data is displayed.

Note:

The OFF/LOW/HIGH switch allows the Model 2242 to have 2 sets of operating parameters.

FUNCTION SWITCH POSITION DESCRIPTIONS AND VARIABLES

POSITION 0: NORMAL OPERATION, places the Model 2242 in the normal operating mode.

POSITION 1: DEAD TIME (µs), allows changing the detector dead time correction for the current detector setup. Setting this parameter to ″0″ disables dead time correction. The dead time adjusts from 0 to 9999 microseconds (µs). The incoming counts are adjusted for dead time using the following formula:

$$n = \frac{m}{1 - m\tau}$$

where,

n = corrected counts per second
m = incoming count per second
τ = system dead time

POSITION 2: CALIBRATION CONSTANT, allows changing the calibration constant for the current detector setup. The calibration constant (CC) adjusts from 0.001 to 280 × 109. The calibration constant converts counts/time base to units/time base.

POSITION 3: NOT USED

POSITION 4: NOT USED

POSITION 5: AUDIO DIVIDE-BY, selects the audible clicks-per-event division rate for the current detector setup. If the audio ON/OFF switch is off, then no audio clicks will be heard. This parameter ranges from:

0 =Divide By 1
1 =Divide By 10
2 =Divide By 100
3 =Divide By 1000

POSITION 6: RESPONSE TIME, allows changing the time constant (TC) for the current detector setup. If the response is set to "0" the Model 2242 automatically calculates (for variable mode), the time constant based on the incoming cps. If a variable of 1-199 is entered for TC, the response time becomes fixed.

Variable Response - Response time is varied in proportion to the incoming count rate. The variable mode varies the TC from 1-5 seconds.

Fixed Response - The response is programmable from 1-199 seconds. For MDA-type measurements, the fixed response time mode is recommended.

Note

Refer to the Response Time specification on Page 3-1 for a detailed explanation of "time constant" (TC).

POSITION 7: RATEMETER ALARM/ALERT, allows changing the ratemeter alarm for the current detector setup. The units of this alarm are the same as the units for the ratemeter display units. The fifth push of the left button allows the decimal point to be moved. The ratemeter alarm adjusts from 1μ to 999 R/hr (Sv/h).

POSITION 8: NOT USED

POSITION 9: NOT USED

POSITION A: NOT USED

POSITION B: LCD backlight ON time is the amount of time that the LCD backlight will stay on after pressing the front panel switch to the BKLITE position. This value is stored in EEPROM. Available values are:

5	seconds
30	seconds
60, 90	seconds
180, 240	seconds.

POSITION C: NOT USED

POSITION D: NOT USED

POSITION E: NOT USED

POSITION F: NOT USED

Calibration

The Model 2242 calibration routine consists of entering detector parameters into memory by way of the Cal/Switch board and adjusting the analog controls (HV, DISC and OVERLOAD) for the specific detector operating requirements.

Initial subsection contains a general overview for determining various detector operating voltages (HV) and adjustment of counter input sensitivity (DISC). Exposure rate calibration is covered in the following subsection. The detector Calibration Constant (CC) and Dead Time Compensation (DTC) are the two primary parameters used in the exposure rate (or dose-equivalent rate) calibrations. These two constants are alternately varied to achieve linearity at the detector non-linear operating regions. Detector overload calibration is covered in the final subsection

GENERAL DETECTOR SETUP INFORMATION

The operating point for an instrument detector is established by setting the detector voltage and instrument sensitivity (HV and DISC). The two energy-compensated Geiger-Mueller (GM) detectors operate at a HV of 550 Vdc and 460 Vdc, and instrument sensitivity (DISC) of 90 mV.

EXPOSURE RATE CALIBRATION

To calibrate the Model 2242 to exposure rate after setting the HV and DISC potentiometers, start with the following values for DT (Dead Time, Switch Position 1) and CC (Calibration Constant, Switch Position 2).

For exposure rates:

mR/hr: DT = 75×10^{-6}, CC = 645×10^{5}
or (75 e-06 and 645 e+05)

R/hr: DT = 75×10^{-6}, CC = 420×10^{2}
or (75 e-06 and 420 e+02)

For exposure rate calibrations, use a calibrated ^{137}Cs source, and set the Model 2242 to ″mR/hr″. Place the detector at the following points:

mR/hr	**µR/hr**
2	2
8* adjust CC	8* adjust CC
20	20
80	80
200	200* adjust DT
800* adjust DT	800

DETECTOR OVERLOAD (OVL) CALIBRATION

Note:

The detector operating voltage (HV) must be determined and adjusted before the OVERLOAD adjustment is performed. If the HV is varied or another detector is substituted, OVERLOAD must be readjusted. If the OVERLOAD feature is not used, adjust the control to the maximum counterclockwise position.

The detector overload circuit senses current flow through the detector. As the radiation intensity is increased, the detector may start to saturate (decrease pulse production), and the readout may decrease or read zero. But as the pulse output continues to decrease in the saturated field, the detector current drain continues to increase. This increase in current is detected by a comparator circuit which triggers the OVERLOAD annunciation on the LCD by way of the microprocessor.

For G-M detectors, the OVERLOAD trip point is adjusted to the point to where the readout no longer increases with increasing radiation intensity. In the event that the overload point cannot be determined due to radiation field limitations, adjust the overload point from 5 to 10 times the upper operating range of the detector.

Adjust the OVERLOAD control to the maximum counterclockwise position.

Place the detector in an increasing radiation field in which the readout no longer increases. Adjust the OVERLOAD control until the OVERLOAD alarm appears. Position the detector between the upper operating limit and the overload set point and ensure the overload alarm is defeated. Adjust the OVERLOAD control accordingly.

Loading Default Parameters

To load the default parameters for all detector setups, hold down the UP pushbutton on the switch board until DEF is displayed on the LCD. The following table shows the default values.

Model 2242	**mR/hr**	**R/Hr**
	Setup 01	**Setup 02**
Dead Time	90 uSec	100 uSec
Cal Const	645e+5	300e+2
Rate Alarm	500 mR/hr	500 R/hr
Scaler Alarm	85000	85000
Count Time	12 Secs	12 Secs
Time Base	Mins	Secs
Units	R/hr	R/Hr
Audio Divide By	1	1
Response	0	0
Check Source	0	0
Percent CS	0	0
Rate Alert	450 mR/hr	450 R/hr
Min Display	00.0 uR/hr	00.0 uR/hr
Baud Rate	9600	
LCD Time Off	5 Secs	
Detector	0	

Section 7

Troubleshooting

Occasionally, you may encounter problems with your LMI instrument or detector that may be repaired or resolved in the field, saving turnaround time and expense in returning the instrument to us for repair. Toward that end, LMI electronics technicians offer the following tips for troubleshooting the most common problems. Where several steps are given, perform them in order until the problem is corrected. Keep in mind that the most common problems encountered with this particular instrument are: (1) detector cables, (2) sticky meters, (3) battery contacts.

Note that the first troubleshooting tip is for determining whether the problem is with the electronics or with the detector. A Ludlum Model 500 Pulser can be invaluable at this point, because of its ability to simultaneously check high voltage, input sensitivity or threshold, and the electronics for proper counting.

We hope these tips will prove to be helpful. As always, please call if you encounter difficulty in resolving a problem or if you have any questions.

Troubleshooting Electronics which utilize Geiger-Mueller (GM) Type Detectors

SYMPTOM	POSSIBLE SOLUTION
No power, or low battery icon displays	1. Check batteries and replace if weak. 2. Check polarity (see marks inside battery lid). Are the batteries installed backwards?

SYMPTOM	POSSIBLE SOLUTION
No power, or low battery icon displays (continued)	3. Check battery contacts. Clean them with rough sandpaper or use an engraver to clean the tips. 4. Check for loose or broken wires, especially between the main board and the calibration board.
Nonlinear Readings	1. Check the high voltage (HV) by using a Ludlum Model 500 Pulser (or equivalent). If a multimeter is used to check the HV, ensure that one with high impedance is used, as a standard multimeter could be damaged in this process.
Display reads full scale	1. Check the HV, and if possible, the input threshold for proper setting. 2. Open the instrument "can" and check for loose wires. 3. Ensure that the instrument's "can" is properly attached. When attached properly, the speaker will be located on the left side of the instrument. If the can is on backwards, interference between the speaker and the input preamplifier may cause noise.
No Response to Radiation	1. Substitute a "known good" detector. 2. Has the correct operating voltage been set? Refer to the calibration certificate for correct operating voltage.

SYMPTOM	POSSIBLE SOLUTION
No Audio	1. Ensure the AUD ON/OFF switch is in the ON position. 2. Remove the instrument housing and check the connection between the circuit board and the speaker. Plug in the 2-pin connector if necessary.

Section 8

Technical Principle of Operation

Refer to the Main Board Schematic, Drawing 408 × 223 for the following:

Detector Input/ Amplifier

Negative-going detector pulses are coupled from the detector through C021 to Amplifier U021. R024 and CR021 protect the input of U021 from inadvertent shorts. Self-biased amplifier U021 provides gain in proportion to R022, divided by R025. Transistor pins 4, 5, and 6 of U021, provide amplification. Pins 10-15 of U021 are coupled as a constant current source to pin 6 of U021. The output self-bias to 2Vbe (approximately 1.4 volts) at pin 7 of U021. This provides just enough bias current through pin 6 of U021 to conduct all of the current from the constant current source. Positive pulses from pin 7 of U021 are coupled to the discriminator (U011) through R031 and C012.

Discriminator

Positive pulses from amplifier U021 are coupled to pin 2 of U011 comparator. The discrimination level is set by the DISC control connected to pin 3 of U011. As the positive pulses at pin 2 of U011 increase above DISC reference at pin 3, pin 1 goes low, producing a low pulse. Pin 1 of U011 is normally held high (+5V) by R014.

The low pulse from pin 1 of U021 is coupled to univibrator U001. U001 shapes and fixes the pulse-width to approximately 10 μs. The Univibrator is configured in the non-retriggerable mode. Negative pulses from pin 9 of U001 are coupled to the μP for counting.

Low Voltage Supply

Battery voltage is coupled to DC-DC convertor U231. U231 and related components provide +5V to power the μP, op-amps, and logic circuitry. R135 and R136 provide voltage division for "low battery" detection. Pin 6 of

U231 provides a low signal when the battery voltage decreases to +2.2 ±0.1Vdc. U121 provides the +2.5Vdc reference for the HV and DISC control references.

High Voltage Supply

High Voltage is developed by blocking oscillator Q241, T141, and C244 and rectified by voltage multiplier CR041-CR043, C041-C043, and C141. High voltage increases as current through R241 increases, with maximum output voltage with Q241 saturated.

High voltage is coupled back through R034 to op-amp pin 2 of U131. Resistor network R027, R132 completes the HV division circuit to ground. R027 provides HV limit from 1250-2500 when the HV control on the calibration board is at maximum. The regulated HV output is controlled by the HV1 and HV2 potentiometers located under the CAL cover on the front panel. This control provides the reference for comparator pin 3, U131. During stable operation, the voltage at pin 2 of U131 will equal the voltage at pin 3 of U131. Pin 1 of U131 will cause conduction of Q141 to increase or decrease until the HV finds a level of stability.

Detector Overload

A voltage drop is developed across R031 and sensed by comparator pins 5, 6 and 7 of U131 as detector current increases. When the voltage at pin 5 of U012 goes below pin 6, pin 7 goes low, signaling U111 (μP) to send the OVERLOAD alarm to the LCD. The OVL control (underneath CAL cover) control provides adjustment for the overload set point.

Microprocessor (μP)

U111 controls all of the data, control inputs, and display information. The clock frequency is crystal-controlled by Y221 and related components at 6.144 MHz. The μP incorporates internal memory (ROM), storing the program information. C102 resets the μP at power-up to initiate the start of the program routine. During the program loop, the μP looks at all the input switches for initiation or status changes and responds accordingly.

U122 is a 256 × 8 bit EEPROM used to store the setup parameters. The information is transferred serially from the μP. The EEPROM is non-volatile: retains memory even after power is removed.

Audio

Click/event, divide-by, and alarm audio pulse frequency is generated by the μP and coupled to Q101. Q101 then inverts the pulses and drives the bottom of T101. Bias voltage is provided by the volume control (R002) to the top of T101.

Refer to the Switch Board Schematic, Drawing 408 × 45 for the following:

Switch Board

"S1" ("FUNCTION") is a 16-position binary rotary switch which selects the programmable parameters for the Model 2241-2I. The switch selects the parameters using the hexadecimal numbering system via buss lines "SW1-SW4."

"S2-S4" are pushbutton switches which enter/change the variables for each of the 16 parameters.

U1 is a +5V powered RS-232 driver/receiver used to interface the Model 2241-2I to a computer.

Refer to the Display Board Schematic, Drawing 408 × 79 for the following:

LCD Drive

U111 and U211 are serial input 32-bit LCD drivers. The data is loaded serially into the 32-bit shift registers (internal) via the "D" IN input. The LOAD input instructs the shift register to receive data while the CLOCK input shifts the data through the 32-bit registers. After all the data is loaded, the LOAD line is pulsed by the μP, instructing the registers to transfer the data to the LCD drivers.

The backplane (BP) signal from U211 provides the reference signal (approximately 125 Hz at 5Vdc) to the LCD (DSP1) BP connection. When a segment is illuminated, the signal to that segment will be out-of-phase with the BP signal. If the segment is OFF, the signal will be in-phase with the BP signal.

Backlight Drive

Depressing the LIGHT switch instructs the μP to set the BACKLIGHT line, pin 31 on μP, "low" for the predetermined backlight ON time. (Refer to main board schematic for details.) A "low" condition on pin 31 causes Q212 to conduct sending +3V to P8-3 on display board. With +3V at P8-3 (refer to display board schematic), backlight oscillator Q011, T011, and related components starts to oscillate, producing a 2.5 kHz, sine wave signal. The signal is amplified by T011 to 150 volts peak-to-peak to drive the backlight.

Section

9

Recycling

Ludlum Measurements, Inc. supports the recycling of the electronics products it produces for the purpose of protecting the environment and to comply with all regional, national and international agencies that promote economically and environmentally sustainable recycling systems. To this end, Ludlum Measurements, Inc. strives to supply the consumer of its goods with information regarding reuse and recycling of the many different types of materials used in its products. With many different agencies, public and private, involved in this pursuit it becomes evident that a myriad of methods can be used in the process of recycling. Therefore, Ludlum Measurements, Inc. does not suggest one particular method over another, but simply desires to inform its consumers of the range of recyclable materials present in its products, so that the user will have flexibility in following all local and federal laws.

The following types of recyclable materials are present in Ludlum Measurements, Inc. electronics products, and should be recycled separately. The list is not all-inclusive, nor does it suggest that all materials are present in each piece of equipment:

Batteries	Glass	Aluminum and Stainless Steel
Circuit Boards	Plastics	Liquid Crystal Display (LCD)

Ludlum Measurements, Inc. products that have been placed on the market after August 13, 2005, have been labeled with a symbol recognized internationally as the "crossed-out wheelie bin." This notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding; each material must be separated. The symbol will be placed near the AC receptacle, except for portable equipment where it will be placed on the battery lid.

The symbol appears as such: 

Section

10

Parts List

	Reference	Description	Part Number
Model 2242 Survey Meter	UNIT	Completely Assembled Model 2242 Survey Meter	48-3437
Main Board, Drawing 480 × 223	BOARD	Completely Assembled Main Board	5408-223
CRYSTAL	Y221	MICRO X-TAL-6.144 MHZ	01-5262
CAPACITORS	C1	0.1uF, 50V	04-5663
	C3	0.1uF, 50V	04-5663
	C001-C002	47pF, 50V	04-5660
	C011	0.001uF, 100V	04-5659
	C012	0.1uF, 50V	04-5663
	C021	100pF, 3KV	04-5532
	C031	0.0047uF, 3KV	04-5547
	C032	100pF, 3KV	04-5532
	C033	0.0047uF, 3KV	04-5547
	C041-C043	0.0047uF, 3KV	04-5547
	C101	47uF, 10V	04-5666
	C121	47uF, 10V	04-5666
	C122-C123	27pF, 100V	04-5658
	C131	0.0047uF, 3KV	04-5547
	C132-C133	0.1uF, 50V	04-5663
	C134	0.01uF, 50V	04-5664
	C135	47uF, 10V	04-5666
	C136	0.01uF, 50V	04-5664
	C137	47uF, 10V	04-5666
	C138	100pF, 100V	04-5661
	C139	0.001uF, 100V	04-5659
	C141	0.0047uF, 3KV	04-5547
	C241	1uF, 35V	04-5656
	C242	68uF, 10V	04-5654

	Reference	Description	Part Number
	C243	0.1uF, 50V	04-5663
	C251	68uF, 10V	04-5654
TRANSISTORS	Q101	2N7002L	05-5840
	Q141	MMBT3904T	05-5841
	Q211	2N7002L	05-5840
	Q212	MMBT4403LT	05-5842
	Q241	MJD210	05-5843
INTEGRATED CIRCUITS	U1	MAX810	06-6424
	U001	CD74HC4538M	06-6297
	U011	TLC372ID	06-6290
	U021	CA3096M	06-6288
	U111	AT89C51RC2	06-6893
	U121	LM285MX-2.5	06-6291
	U122	X24C02S8T5	06-6299
	U131	LM358D	06-6312
	U231	LT1073CS8-5	05-5852
	*	SOCKET-44PIN	06-6613
DIODES	CR021	MMBD7000LT1	07-6355
	CR031	GI250-2	07-6266
	CR041-CR044	GI250-2	07-6266
	CR231	CXSH-4 EB33	07-6358
	CR241	MMBD914L	07-6353
	CR242	CXSH-4 EB33	07-6358
POTENTIOMETERS	R002	10K, VOLUME	09-6921
	R027	1M, HV LIMIT	09-6906
RESISTORS	R001	100K, 1/4W, 1%	12-7834
	R011-R012	10K, 1/4W, 1%	12-7839
	R013	1K, 1/4W, 1%	12-7832
	R014	10K, 1/4W, 1%	12-7839
	R015	100K, 1/4W, 1%	12-7834
	R021	1M	10-7028
	R022	392K, 1/8W, 1%	12-7841
	R023	10K, 1/4W, 1%	12-7839
	R024-R025	4.75K, 1/4W, 1%	12-7858
	R026	8.25K, 1/8W, 1%	12-7838
	R031	1M	10-7028
	R032	1M	10-7028

	Reference	Description	Part Number
	R033-R034	1G	12-7686
	R111-R113	22.1K, 1/4W, 1%	12-7843
	R121	100 Ohm, 1/8W, 1%	12-7840
	R122	6.81K, 1/4W, 1%	12-7857
	R131-R132	1 M, 1/4W, 1%	12-7844
	R133	750K, 1/4W, 1%	12-7882
	R134	1 M, 1/4W, 1%	12-7844
	R135	82.5K, 1/8W, 1%	12-7849
	R136	10K, 1/4W, 1%	12-7839
	R141	22.1K, 1/8W, 1%	12-7843
	R211	2.21K, 1/4W, 1%	12-7835
	R231	100 Ohm, 1/4W, 1%	12-7840
	R241	2.21K, 1/4W, 1%	12-7835
	R242	200 Ohm, 1/8W, 1%	12-7846
INDUCTOR	L231	CTX100-2	21-9740
TRANSFORMERS	T101	AUDIO	4275-083
	T141	L8050	40-0902
CONNECTORS	P1	CONN-1-640456-2 MTA100	13-8061
	P2	CONN-1-640456-3 MTA100	13-8100
	P3	CONN-640456-6 MTA100	13-8095
	P4	CONN-640456-2 MTA100	13-8073
	P5	CONN-1-640456-2 MTA100	13-8061
Calibration Board, Drawing 408 × 229	BOARD	Completely Assembled Calibration Board	5408-229
POTENTIOMETERS	R1	1M 64W105, INT HV SET	09-6814
	R4	1M 64W105, EXT HV SET	09-6814
	R5	1M 64W105, OVERLOAD	09-6814
	R8	100K 64W104, DISC	09-6813
RESISTORS	R2	1.5M, 1/4W, 1%	10-7038
	R3	1M, 1/3W, 1%	12-7751
	R6	1M, 1/3W, 1%	12-7751
	R7	10K, 1/3W, 1%	12-7748
	R9	1K, 1/3W, 1%	12-7750
CONNECTOR	P7	640456-7	13-8115

	Reference	Description	Part Number
Display Board, Drawing 408 × 79	BOARD	Completely Assembled Display Board	5408-091
CAPACITORS	C012	27pF, 100V	04-5658
	C113	47pF, 100V	04-5660
INTEGRATED CIRCUITS	U111	AY0438-I/L	06-6358
	U114	SP4422N	06-6399
	U211	AY0438-I/L	06-6358
RESISTORS	R001	10K, 1/8W, 1%	12-7839
	R003-R004	10K, 1/8W, 1%	12-7839
	R121	10K, 1/8W, 1%	12-7839
INDUCTORS	L001-L002	20mH, 70 OHM	21-9792
	L011-L012	20mH, 70 OHM	21-9792
MISCELLANEOUS	P8	CONN-640456-8 MTA100	13-8039
	DS111	Backlight-EL QUANTEX	07-6382
	DSP1	LCD-8246-365-4E1	07-6383
Switch Board, Drawing 408 × 46	BOARD	Completely Assembled Switch Board	5408-052
CAPACITORS	C1-C2	4.7uF, 10V	04-5578
	C3-C4	10uF, 20V	04-5592
	C5	4.7uF, 10V	04-5578
	C6	100uF, 10V	04-5576
INTEGRATED CIRCUITS	U1	MAX220EPE	06-6359
SWITCHES	S1	350134GSK	08-6721
	S2-S4	3CTH9 PB	08-6716
RESISTORS	R1-R2	22K, 1/4W, 5%	10-7070
MISCELLANEOUS	P6	CONN-1-640456-3 MTA100	13-8100
	P10	CONN-208006-2	13-8451

	Reference	Description	Part Number
Wiring Diagram, Drawing 408 × 221			
SWITCHES	S1	30-1-PB GRAYHILL	08-6517
	S4	7101-SYZ-QE C&K	08-6511
	S5	30-1-PB GRAYHILL	08-6517
	S6	PA-600-210	08-6501
CONNECTORS	J2	1-640442-3 MTA100	13-8138
	J3	640442-6 MTA100	13-8171
	J4	640442-2 MTA100	13-8178
	J5	1-640442-2 MTA100	13-8407
	J6	1-640442-3 MTA100	13-8138
	J7	640442-7 MTA100	13-8172
	J8	640442-8 MTA100	13-8184
RESISTORS	R1	4.7 M, 1/4W, 5%	10-7030
	R2	3.3M, 1/4W, 5%	10-7044
	R3	56 Ohm, 1/4W, 5%	10-7096
AUDIO	DS1	UNIMORPH	21-9251
LED	DS2	Led Alarm Red	21-9169
BATTERY	B1-B2	"D" Duracell Battery	21-9313
MISCELLANEOUS	V1	GM Detector LND 71616	01-5298
	V2	GM Detector LND 71210	01-5295
	*	Model 2241 Switch Board Add On	4408-053
	*	Model 2241-2I Internal Detector Board	5408-160
	*	Model 2241-2I/2 Internal Detector Board	5408-162
	*	Model Digital Bezel Assembly	4408-051
	*	Bezel Back	7408-025
	*	Bezel Back Gasket	7408-026
	*	Portable Battery Contact Set	2001-042
	*	Model 2241-2 Main Harness	8408-220
	*	Portable Harness Can Wires	8363-462
	*	Switch Board Harness	8408-027
	*	Silkscreened Casting	9408-217
	*	Model 5 Can Assembly	4363-868
	*	Can Gasket	22-9773

Reference	Description	Part Number
*	Portable Knob	08-6613
*	Assembled Screened Battery Lid	9408-218
*	Portable Battery Gasket	7363-183
*	Portable Calibration Cover w/Screws	9363-200
*	Portable Handle Assembly	7363-139
*	(OPTIONAL) Check Source (1μCi Cs-137)	01-5196

Section

11

Drawings and Diagrams

Model 2242 SIDE VIEW, Drawing 408 × 219C

MAIN BOARD, Drawing 408 × 223 (3 sheets)

MAIN BOARD LAYOUT, Drawing 408 × 224 (2 sheets)

CALIBRATION BOARD, Drawing 408 × 229

CALIBRATION BOARD LAYOUT, Drawing 408 × 230 (2 Sheets)

DISPLAY BOARD, Drawing 408 × 79

DISPLAY BOARD COMPONENT LAYOUT, Drawing 408 × 80 (2 sheets)

SWITCH BOARD, Drawing 408 × 45

SWITCH BOARD LAYOUT, Drawing 408 × 46

WIRING DIAGRAM, Drawing 408 × 221

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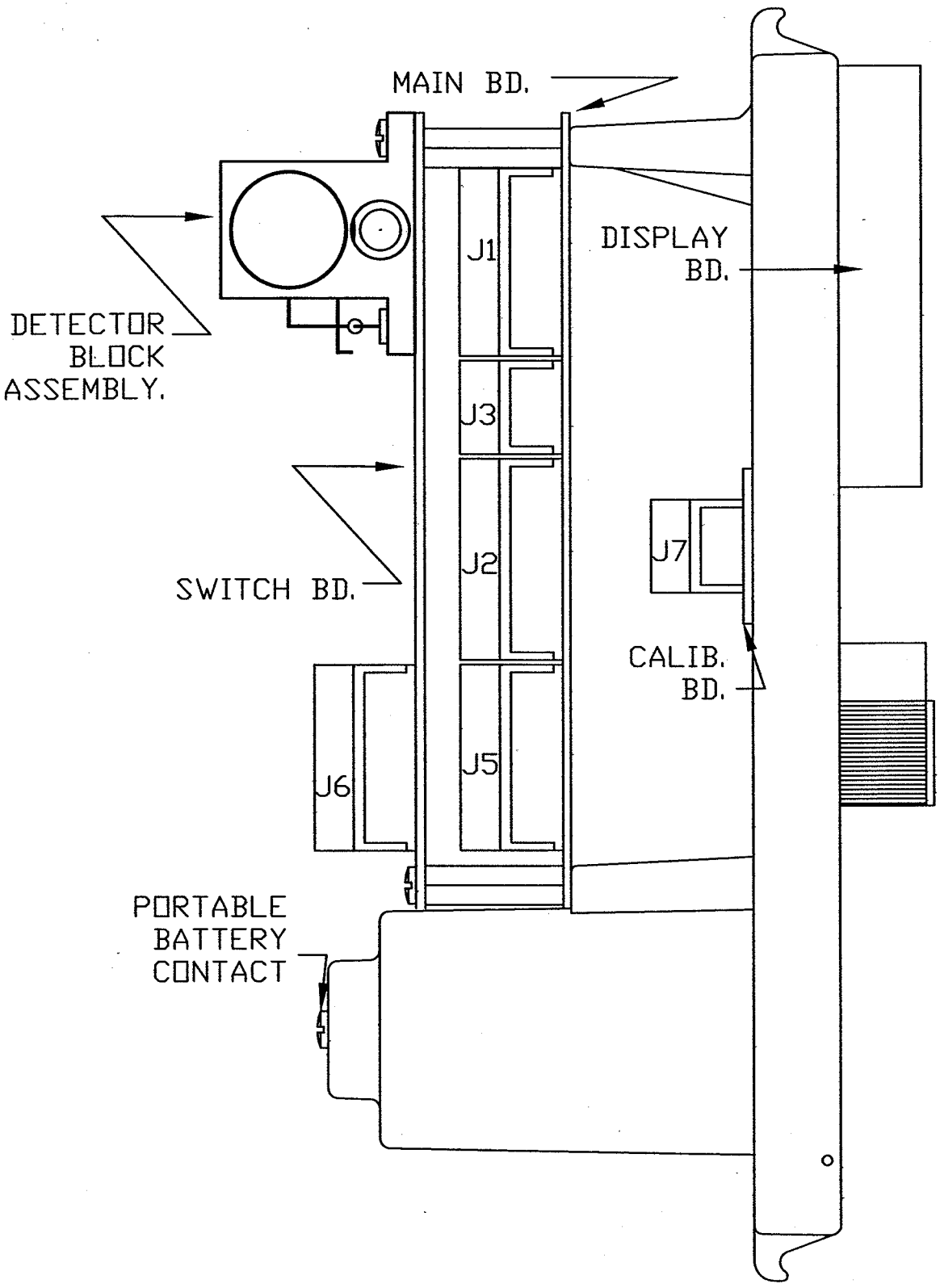

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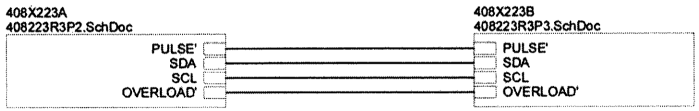

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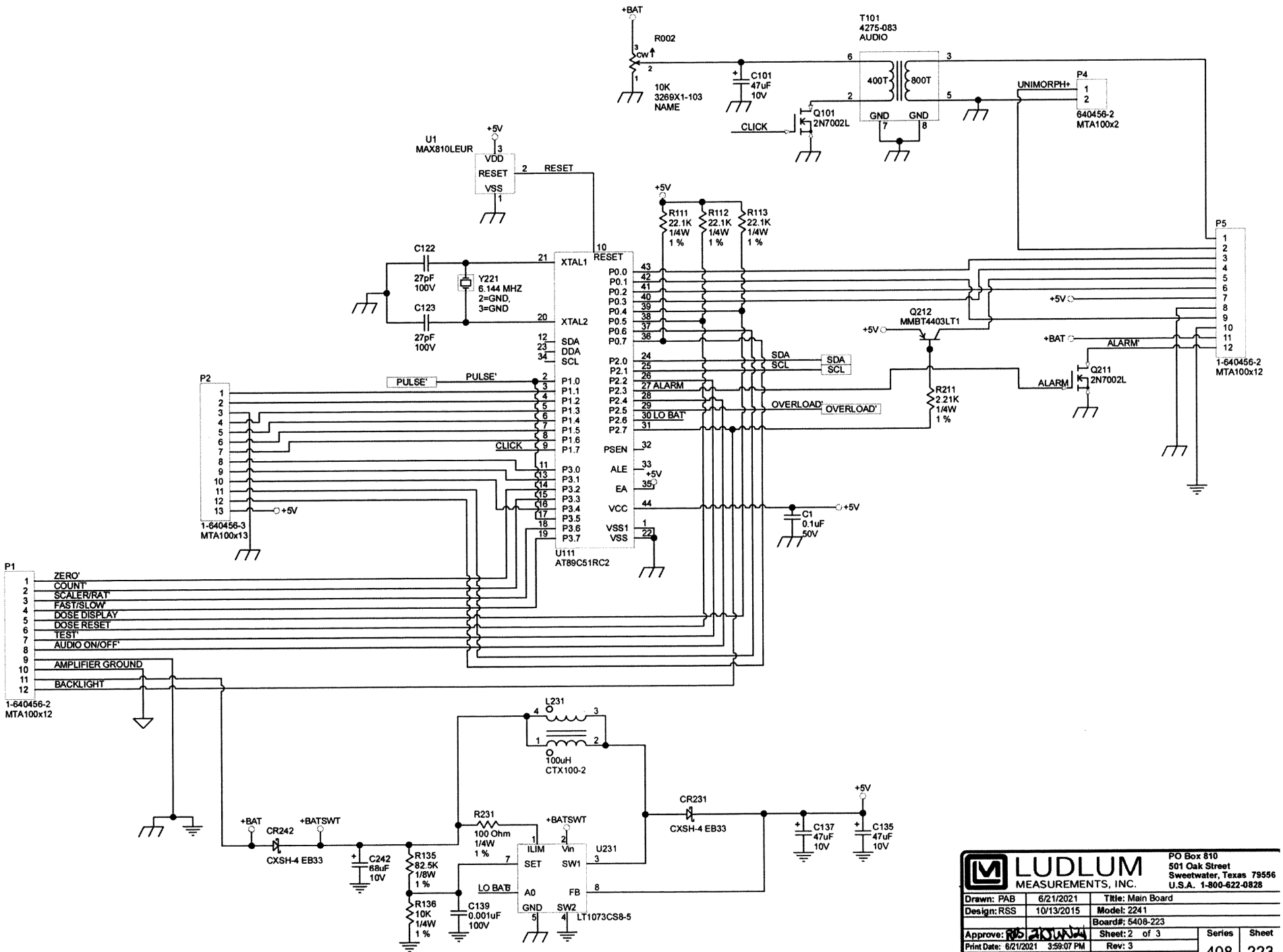

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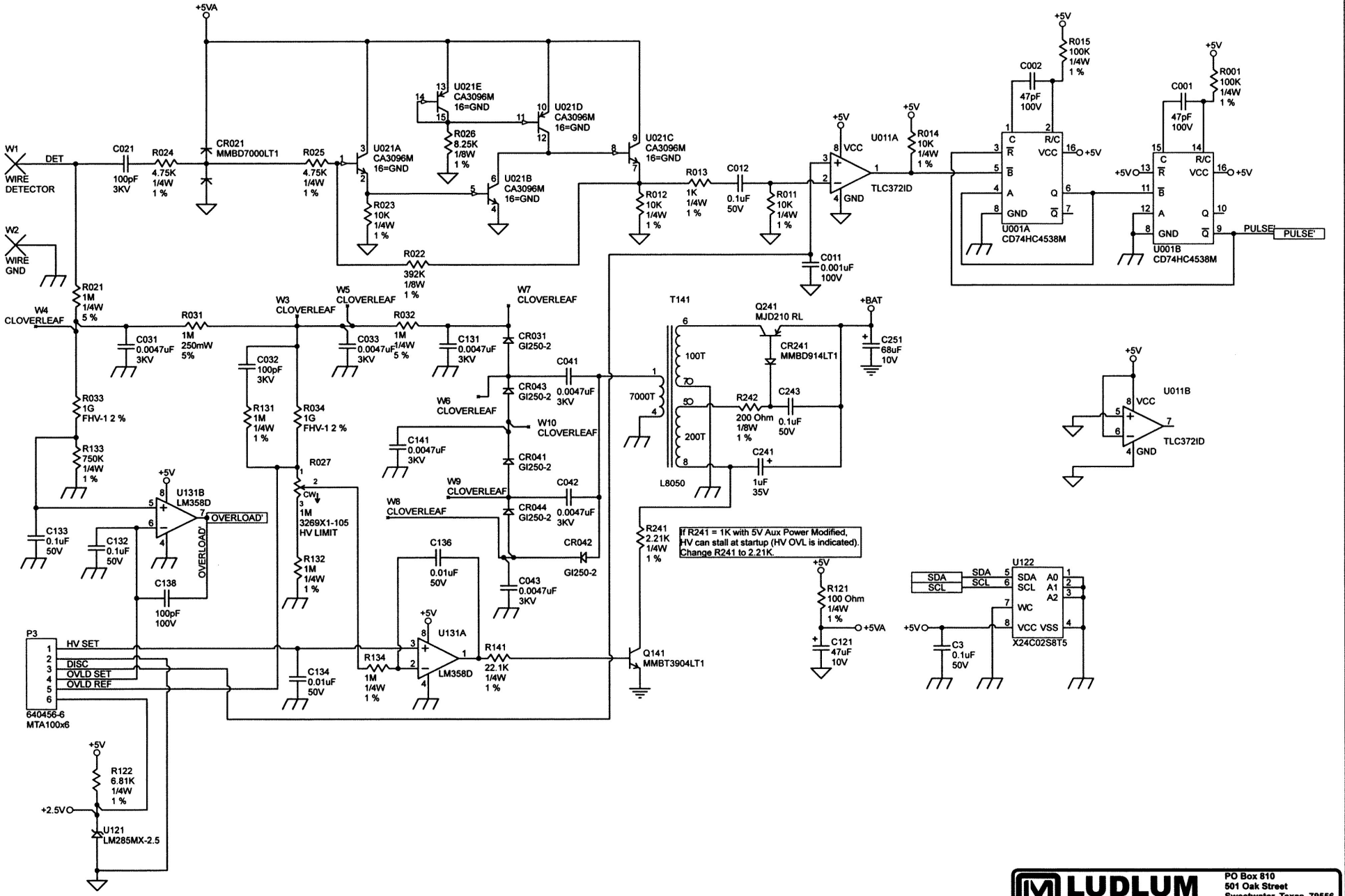

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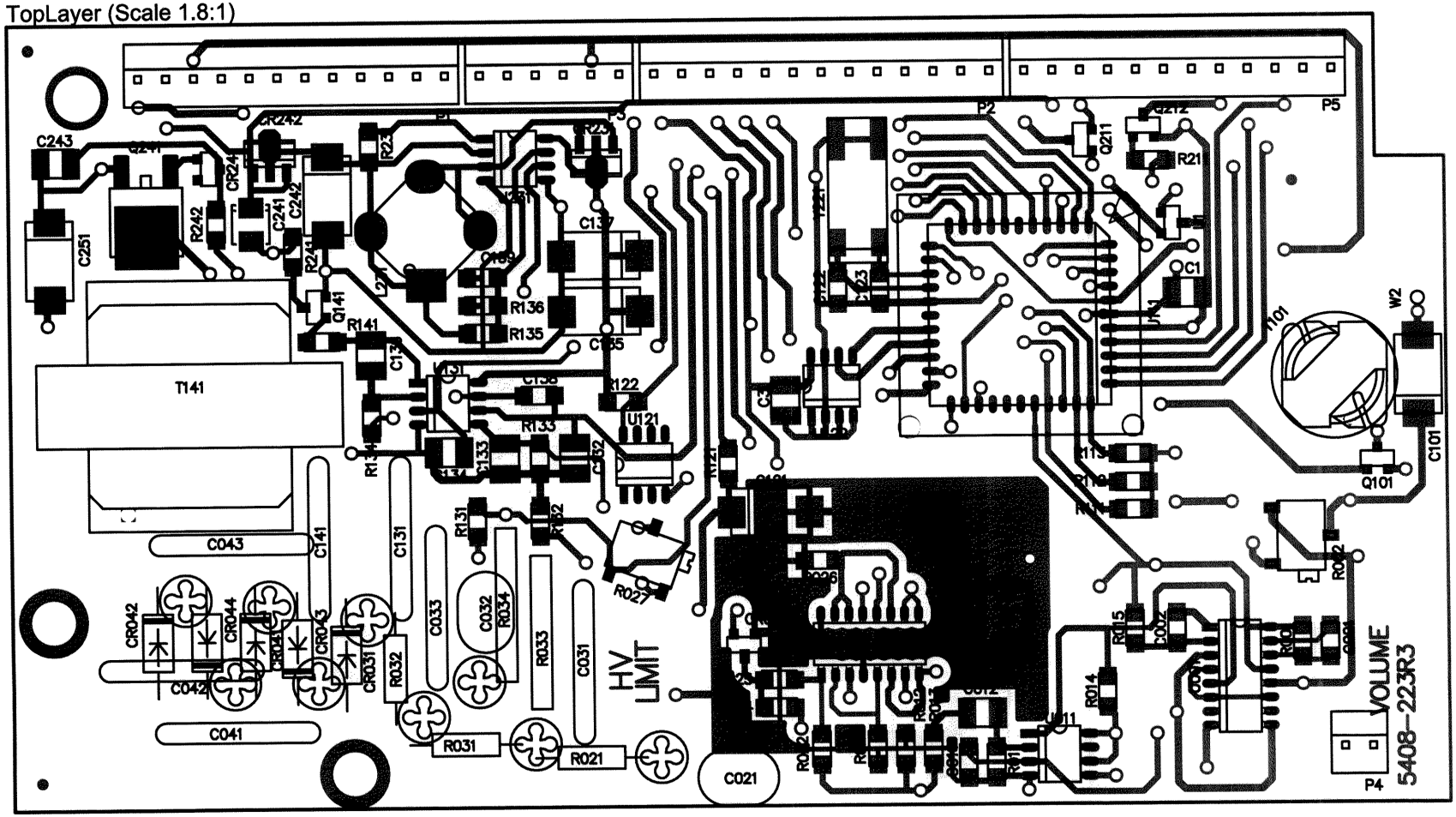

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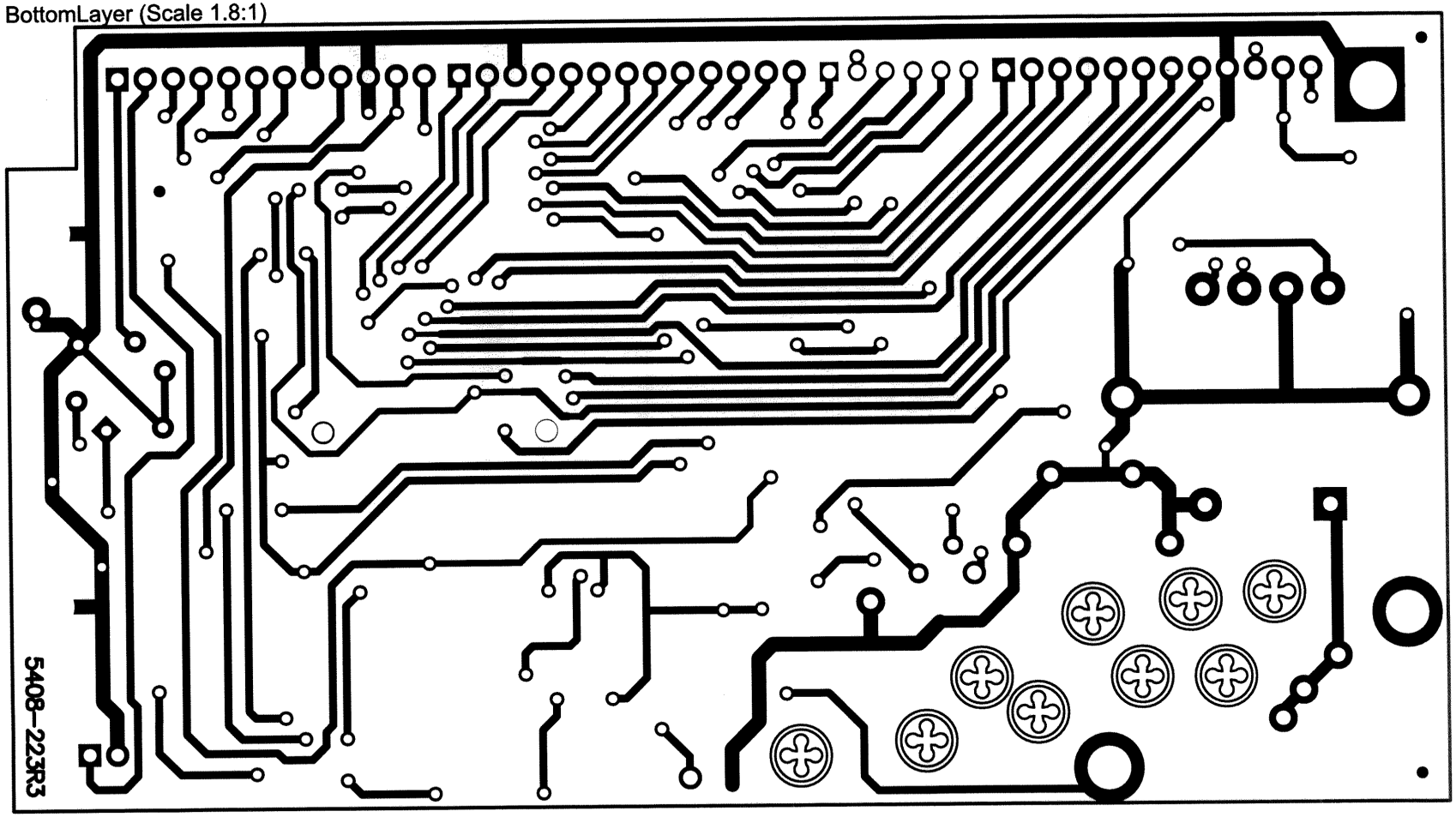

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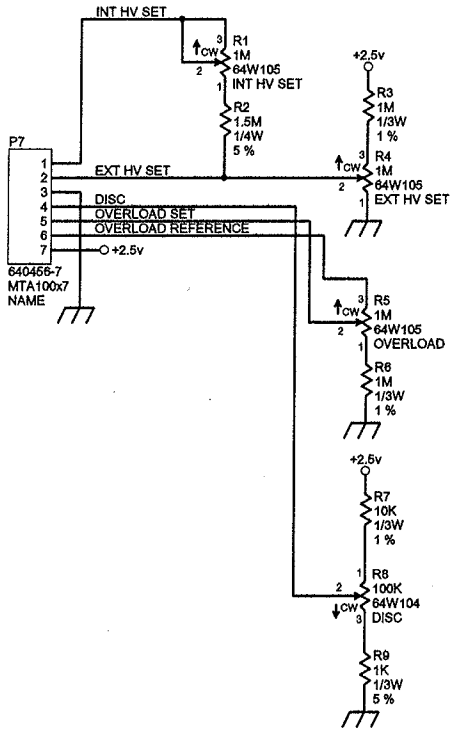

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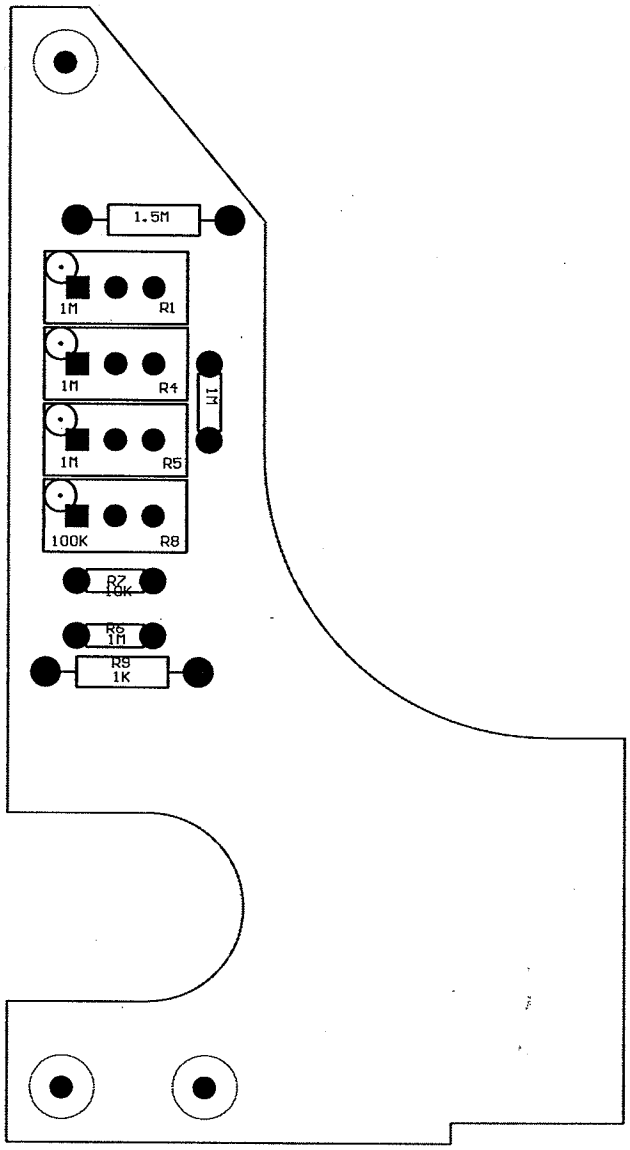

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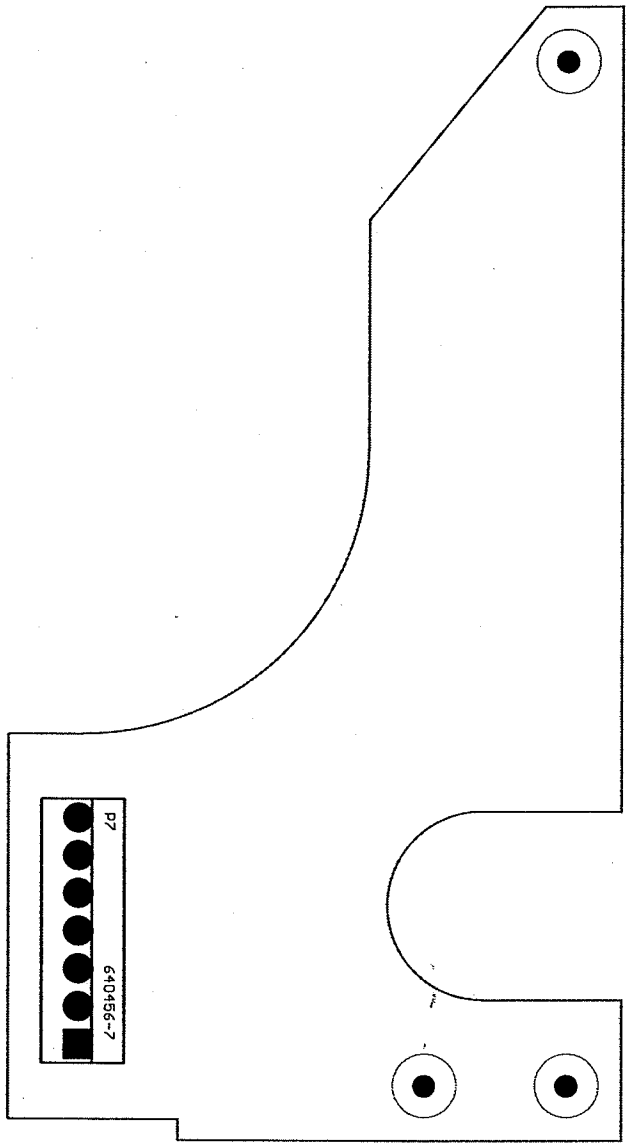

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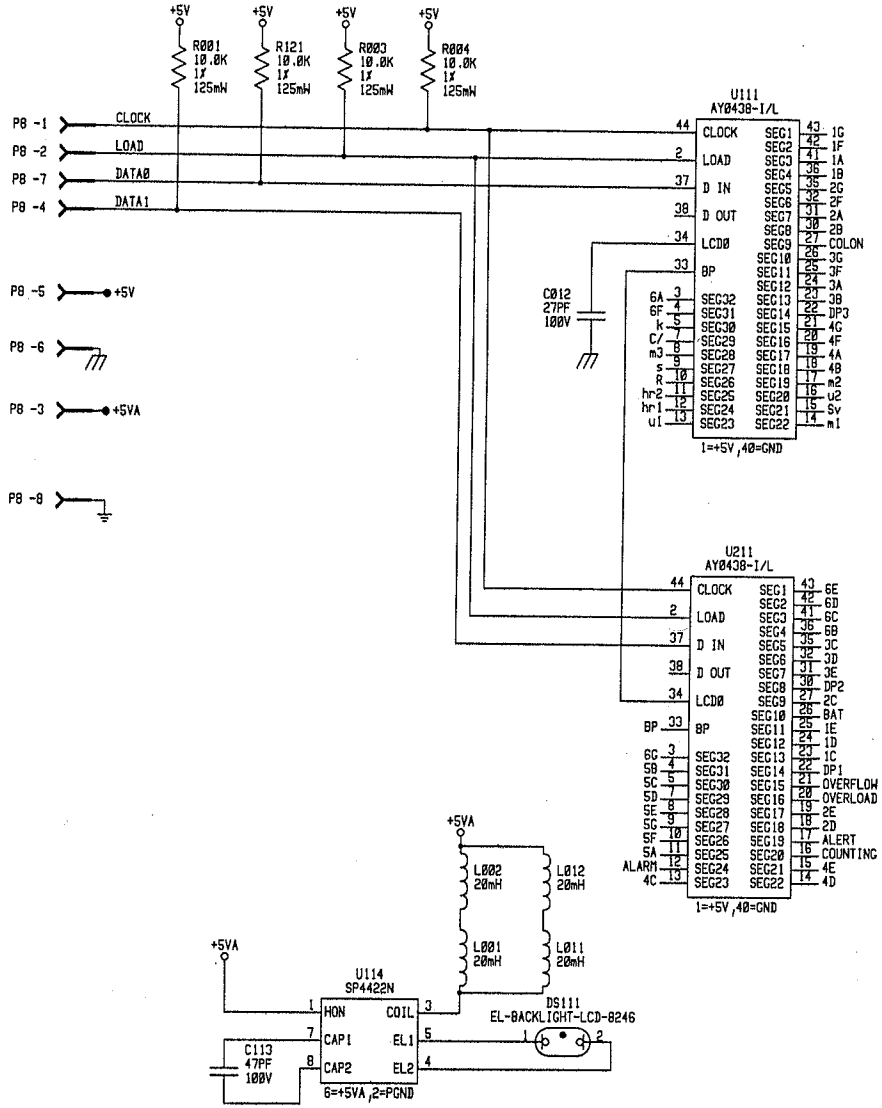
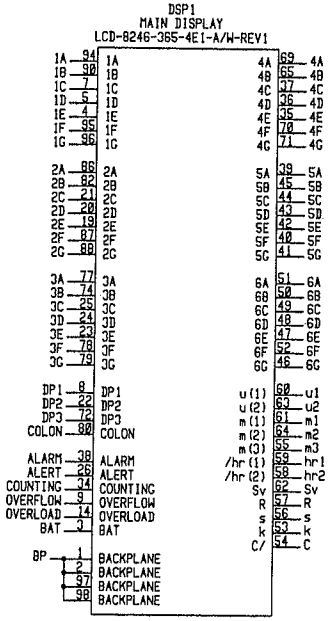
REVISIONS					
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED





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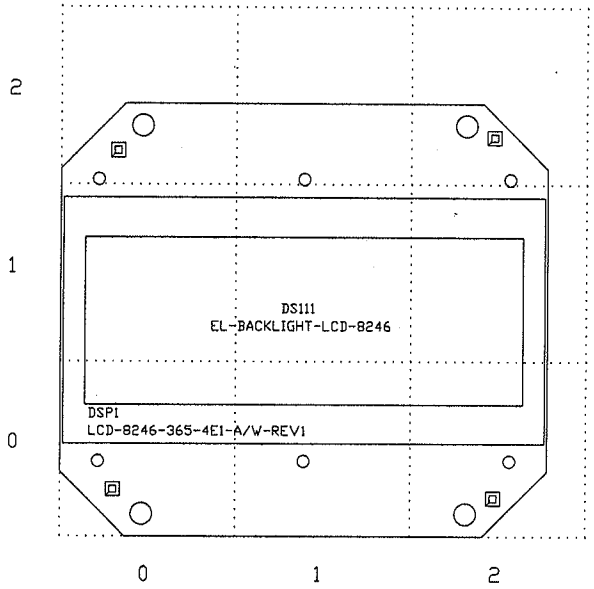
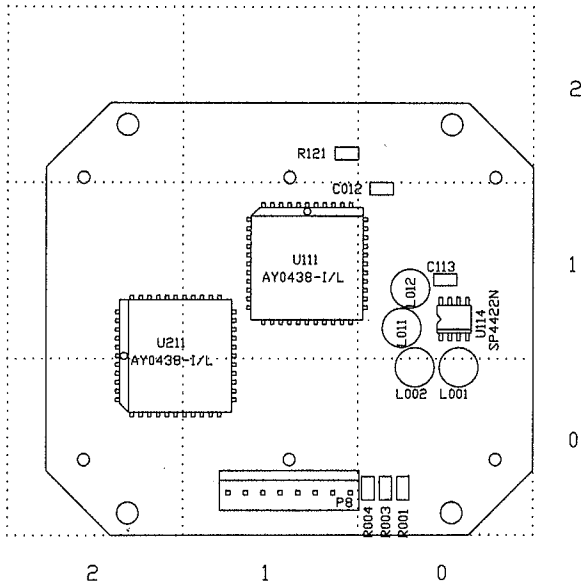
NEXT HIGHER ASSY.			
13:22:51	2-Jul-01	SB408091	SHEET 1 OF 1

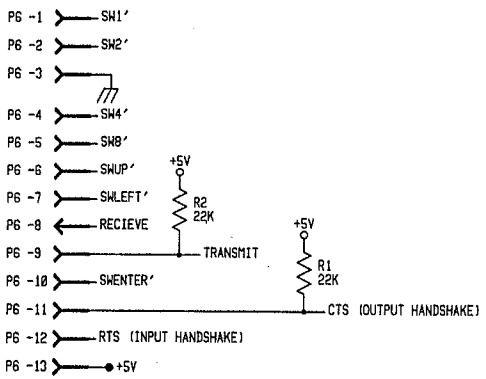


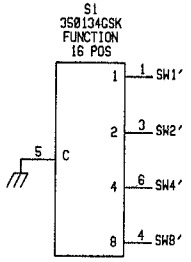
LUDLUM MEASUREMENTS INC. SWEETWATER, TX.					
DR CKB	06-MAR-97	TITLE: DISPLAY BOARD W/E.L.			
CHK R.C. July 2 01		BOARD: 5408-091			
DSGN RSS	12-JAN-96	MODEL: 2240/2241/78			
APP RSS 7-2-01		FILENAME: BS408091			
		13:23:38	2-Jul-01		
COMPONENT	SOLDER	REVISION	SERIES	SHEET	
		1.0	408	80	
OUTLINE					



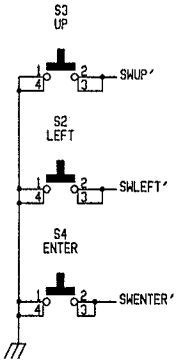
LUDLUM MEASUREMENTS INC. SWEETWATER, TX.					
DR CKB	06-MAR-97	TITLE: DISPLAY BOARD W/E.L.			
CHK R.C. July 2 01		BOARD: 5408-091			
DSGN RSS	12-JAN-96	MODEL: 2240/2241/78			
APP BSS 7-2-01		FILENAME: BS408091			
		13:23:38	2-Jul-01		
COMPONENT	SOLDER	REVISION	SERIES	SHEET	
		1.0	408	80	
	OUTLINE				

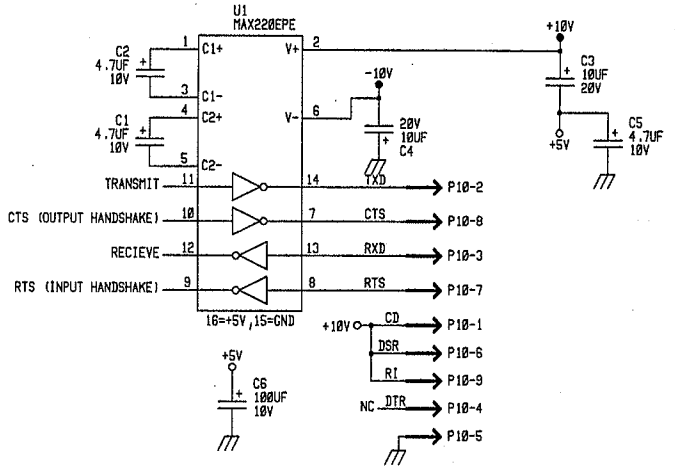
REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



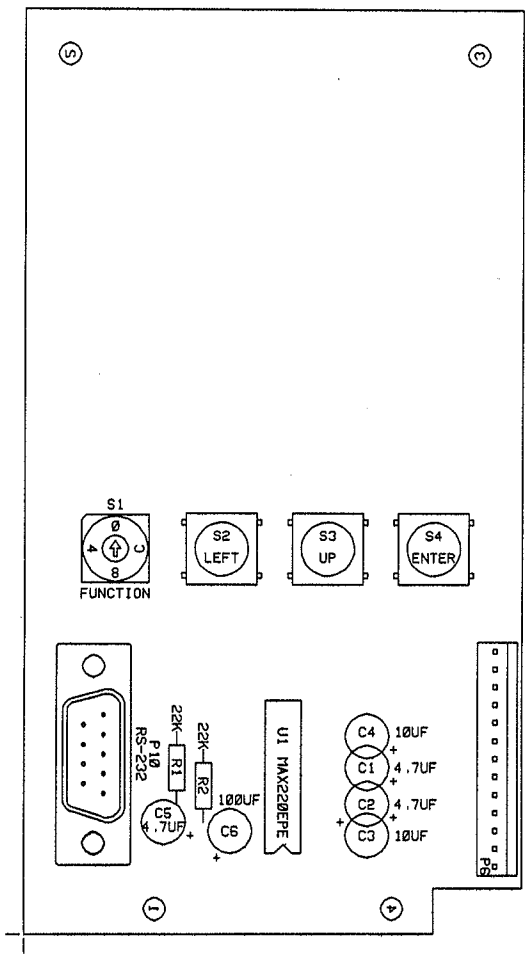


POS	FUNCTION
0	NORMAL OPERATION
1	DEAD TIME (us)
2	CALIBRATION CONSTANT
3	DISPLAY UNITS
4	TIMEBASE: CPS, CPM
5	AUDIO DIVIDE BY
6	RESPONSE TIME
7	RATEMETER ALARM / ALERT
8	SCALER ALARM / COUNT TIME
9	NOT USED
A	DETECTOR SETUP NUMBER
B	LCD BACKLIGHT ON TIME
C	SET MINIMUM DISPLAY
D	RS-232 DATA DUMP MODE
E	RS-232 DETECTOR SETUP MODE
F	RS-232 BAUD RATE

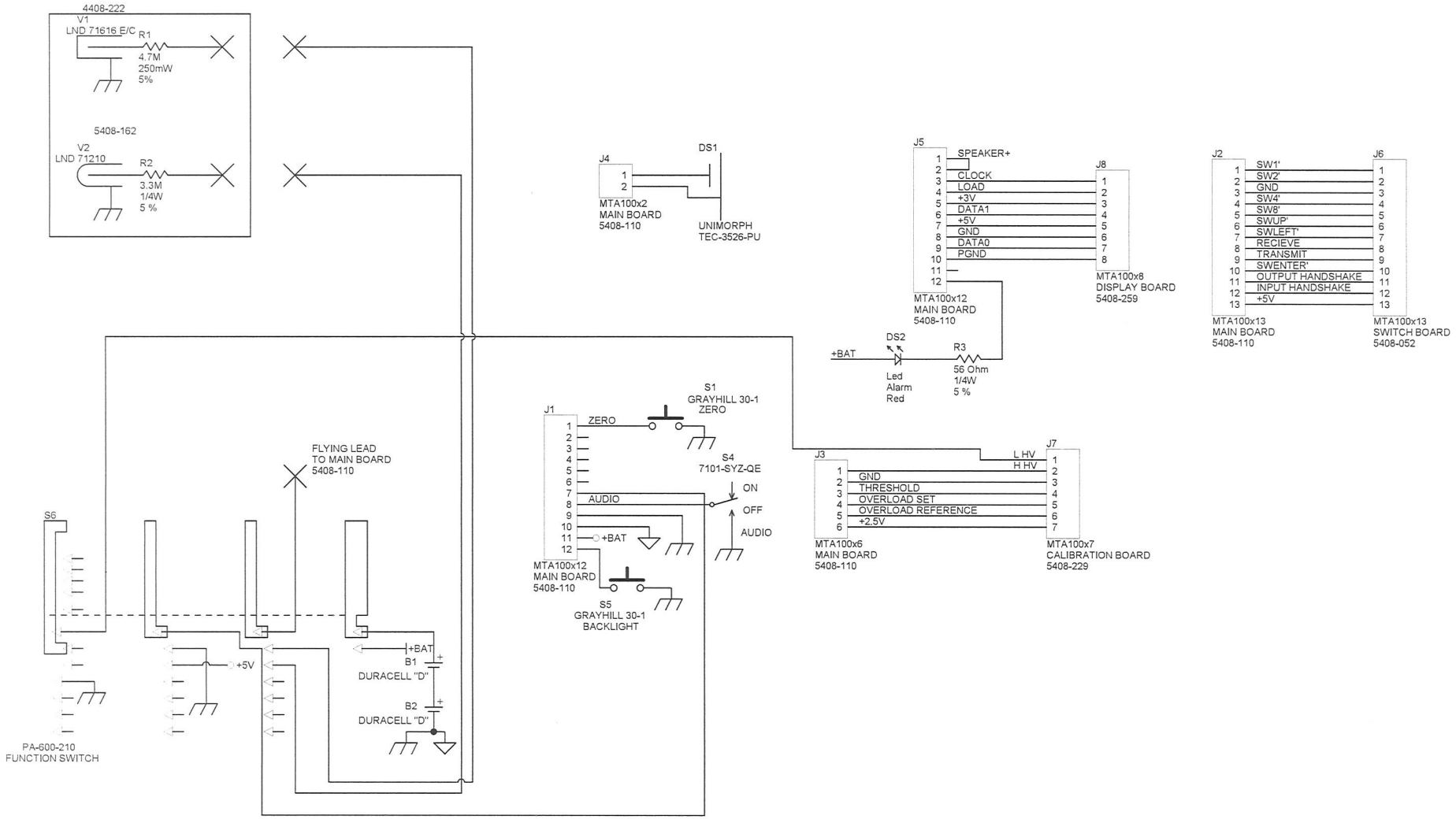




UPDATED CKB	21-DEC-00	LUDLUM MEASUREMENTS INC.
DR CKB	06/24/96	TITLE: SWITCH BOARD
CHK RDS	12-21-00	
DSGN LL	3/17/93	BOARD# 5408-052
APPD RDS	21Dec00	SIZE C · MODEL 2241 · SERIES 408 · SHEET 45
NEXT HIGHER ASSY.		
09:54:25	21-Dec-00	S0408052 · SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR CKB 06/24/96		TITLE: SWITCH BOARD	
CHK BS 12-Dec-00		BOARD: 5408-052	
DSGN LL 03/16/94		MODEL: 2241	
APP RDS 21 Dec 00		FILENAME: BS408052	
COMPONENT	SOLDER	09:52:54	21-Dec-00
		REVISION	SERIES / SHEET
OUTLINE	OUTLINE	1.0	408 / 46



LUDLUM MEASUREMENTS, INC.
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501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828

Drawn: SA	03/30/07	Title: WIRING DIAGRAM		
Design: RSS	20-APR-04	Model: 2242		
		Board#: 408-221		
Approve:	25Sep14	Sheet: 1 of 1	Series	Sheet
8:59:05 AM	9/25/2014	Rev: 2	408	221
408221R2.SchDoc				