LUDLUM MODEL 78 AND 78-1
DIGITAL ANALOG STRETCH SCOPE

March 2021

Serial Number 299335 and Succeeding

Serial Numbers

LUDLUM MODEL 78 AND 78-1
DIGITAL ANALOG STRETCH SCOPE

March 2021

Serial Number 299335 and Succeeding

Serial Numbers

LUDLUM MEASUREMENTS, INC
501 OAK STREET, P.O. BOX 810
SWEETWATER, TEXAS 79556
325-235-5494, FAX: 325-235-4672

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.

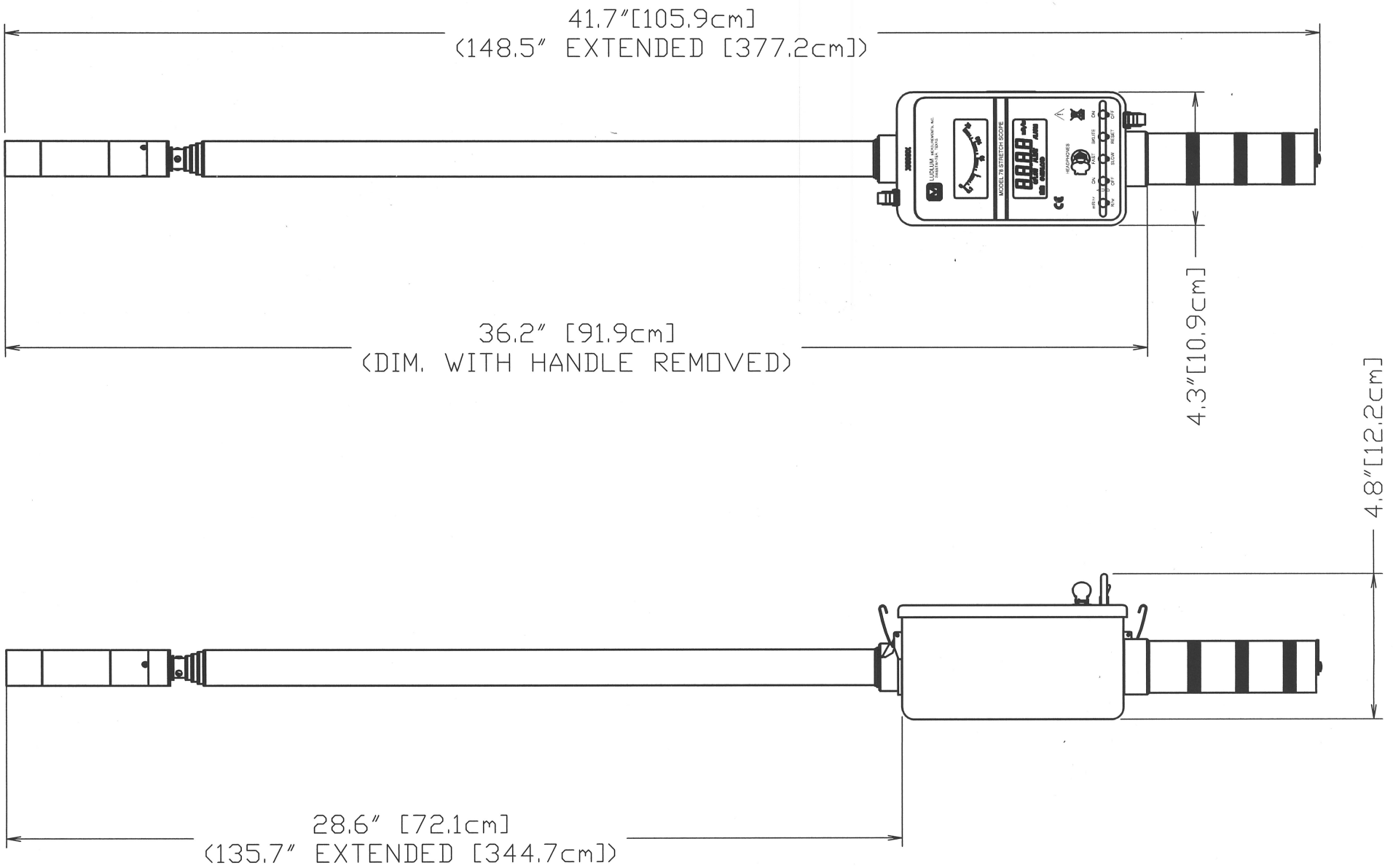
RETURN OF GOODS TO MANUFACTURER

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	9/26/01	DSW
2	ADDED SWITCH GUARD	7/1/13	JLW



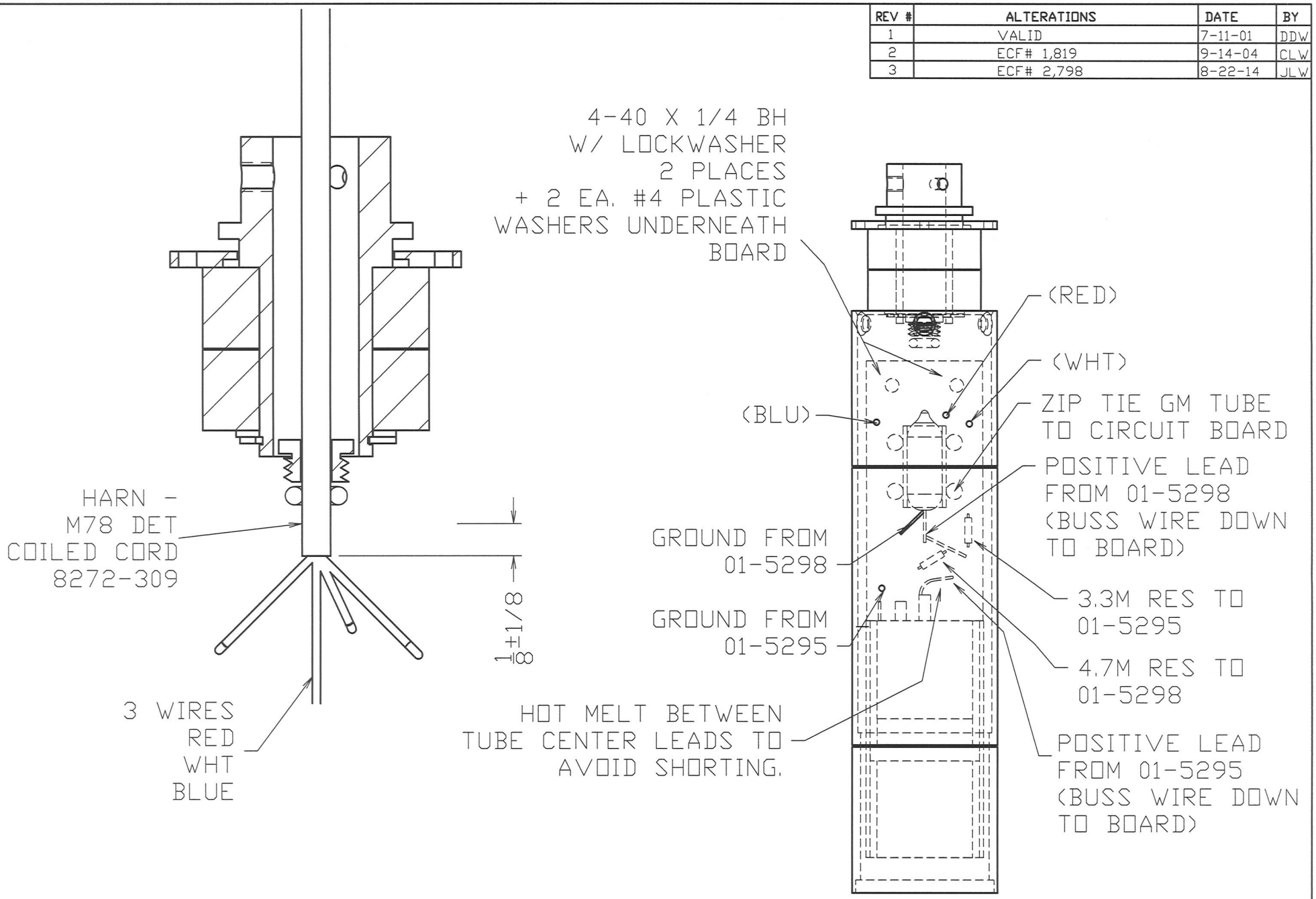
DWN	DATE	CHECKED	APPROVED
JLW	7/1/13		JGW 7-1-13

TITLE: M 78 OVERALL

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

SERIES	SHEET
272	336

REV #	ALTERATIONS	DATE	BY
1	VALID	7-11-01	DDW
2	ECF# 1,819	9-14-04	CLW
3	ECF# 2,798	8-22-14	JLW



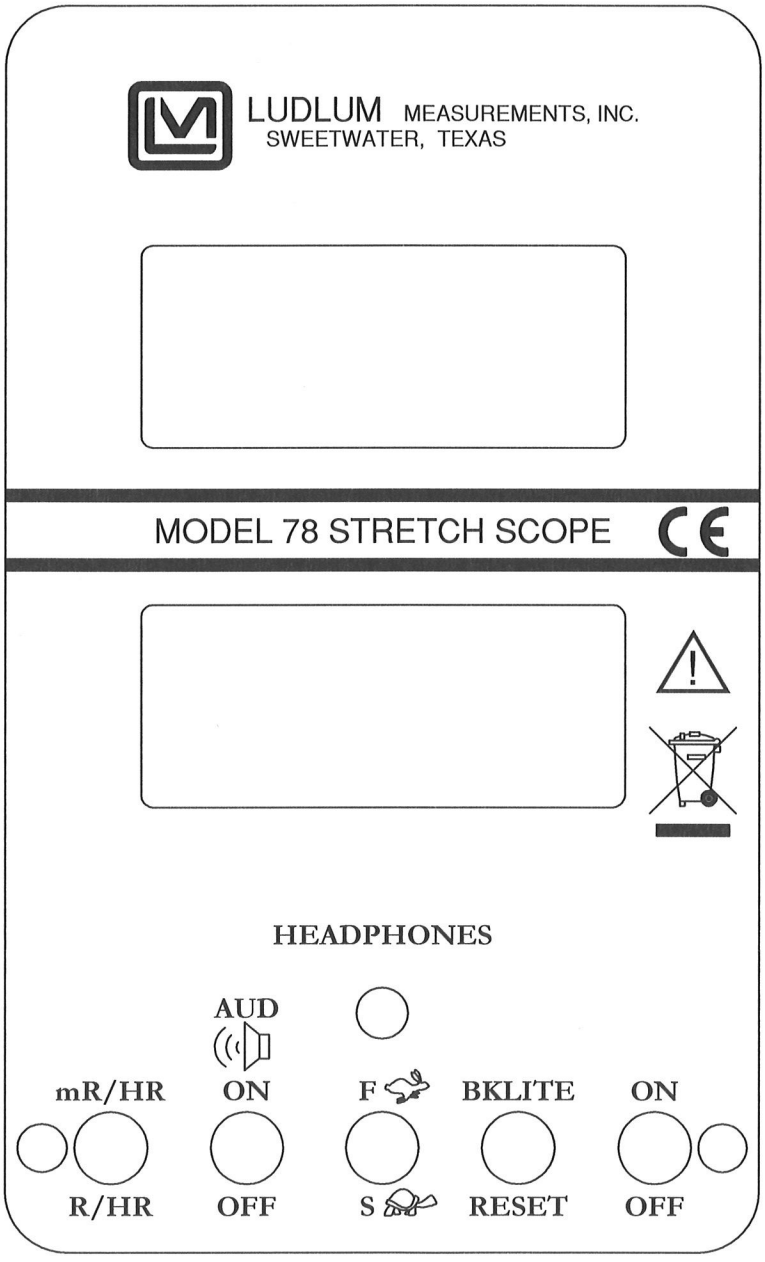
DWN	DATE	CHECKED	APPROVED
WJM	3/25/15		2/5/15

TITLE: M 78 TUBE BOARD WIREUP

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

SERIES	SHEET
272	284C

REV #	ALTERATIONS	DATE	BY
1	VALID	11-21-02	TJR
2	MADE PURCHASED PART	9-17-02	JGW
3	ADDED SYMBOLS	10-15-09	JGW
4	REDESIGN	11-7-12	CMC
5	ECF# 3580	7/21/15	WJM

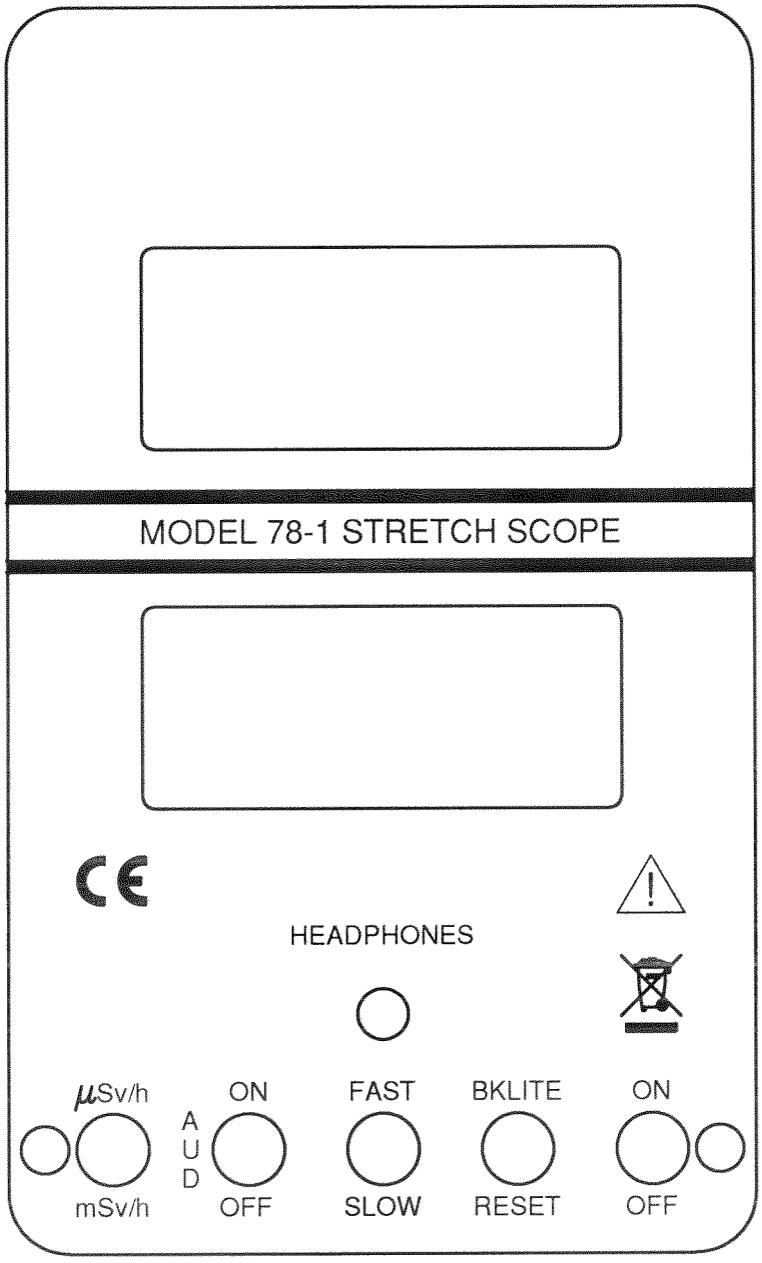


DWN	DATE	CHK	DATE	APP	DATE
WJM	7/21/15			MGW	7-21-15

DWG NUM: 9272-339	SCALE: FULL ☒ OTHER
TITLE M 78 FRONT PANEL	

LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556	SERIES 272	SHEET 339A

REV #	ALTERATIONS	DATE	BY
1	VALID	11-21-02	TJR
2	CHANGED M/N AND SWITCH LABEL	10-15-09	JGW
3	ADDED HANDLE HOLES, ECF #3580	2/25/21	WJM



SEE SHEETS 272 X 339B, C (A) FOR DIMENSIONS

DWN	DATE	CHK	DATE	APP	DATE
WJM	2/25/21			WJM	2-25-21

DWG NUM: 3272-359 SCALE: FULL ☒ OTHER

TITLE M 78-1 FRONT PANEL

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

SERIES 272 SHEET 359A

Table of Contents

Section 1 Introduction

The Ludlum Model 78 and 78-1 Digital/Analog Stretch Scope features two radiation radiation detectors mounted on a 3.7 m (12 ft) extendable pole. The two energy-compensated, Geiger-Mueller (GM) detectors measure gamma radiation from 0.1 mR/hr mR/hr to 1000 R/hr (1μSv/h – 10,000mSv/h). The Model 78 measures in R (Roentgen) (Roentgen) units while the 78-1 measures in Sieverts.

Both an analog meter and a backlit 4-digit LCD (liquid crystal display) are utilized for display. The 4-decade logarithmic meter face spans from 0.1 to 1000. The digital readout displays the level of radiation in either mR/hr or R/hr (μSv/h), depending upon the detector selected. The LCD also has indicators for low battery, alert, alarm, overflow, and detector overload.

Other instrument 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 a count overflow visual alarm.

Warning

There is a reduced response in pulsed fields due to the detector dead time.

The Model 78 incorporates independent adjustable alarms for both detectors. There are two alarm indications. The first-level alarm is indicated by display of ALERT on the LCD. The second-level alarm is indicated by display of ALARM and a continuous audible tone. The audible alarm can be silenced (acknowledged) by depressing the RESET switch.

The electronics front panel is equipped with switches for control of detector selection, audio on/off, fast or slow response times, LCD backlight, display reset, and power on/off. A headphone jack is also available. Two "D" cells located in the handle provide power to the electronics. Battery life is approximately 250 hours.

The stretch scope is made of stainless steel tubing that retracts to an overall length of 105.9 cm (41.7 in.). The handle can be removed for storage, reducing the length to 92 cm (36.2 in.). The electronics are housed in an aluminum body with a beige powder-coat finish and subsurface-printed Lexan front panel. Front-panel switches are sealed with rubber "boots" for resistance to moisture.

Section 2 Getting Started

Unpacking and Repacking

Remove the calibration certificates and place them in a secure location. Remove the instrument, detectors, and accessories (batteries, cable, 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 78 serial number is located on the front panel above the analog meter face. Most Ludlum Measurements, Inc. detectors have a label on the base or body of the detector for model and serial number identification.

Important!

If multiple shipments are received, ensure that the detectors and instruments are not interchanged. Each instrument is calibrated to a specific detector(s), and is therefore not interchangeable.

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 "Repair and Calibration" from the drop-down menu. Then choose the appropriate Repair and Calibration division where you will find a link to the form.

Battery Installation

Ensure the Model 78 ON/OFF switch is in the OFF position. Remove the handle by rotating the handle counterclockwise. Install two "D" size batteries in the compartment with the posts pointing toward the instrument. Re-install the handle, rotating clockwise.

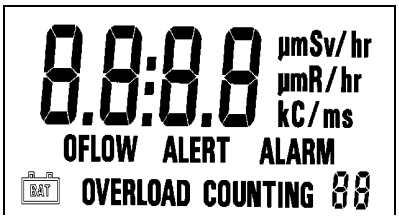
Note:

The center post of the battery is positive. Batteries are placed in the battery compartment with the posts pointing toward the instrument.

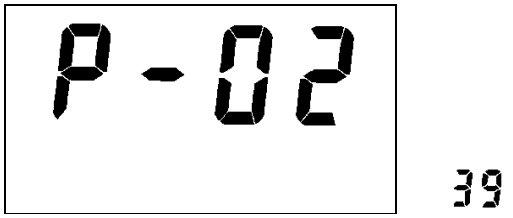
Operational Check

Turn the ON/OFF switch to the ON position.

The display goes through an initialization sequence showing all 8s with decimal points. Check on all segments to ensure they are on as illustrated:



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 following figure is for example only, to illustrate location of display.)



Note:

The Model 78 is not sensitive to neutron radiation.

Expose the detector to a check source if the background count is too low to generate a display reading. Place the AUD ON/OFF switch in the ON position and confirm the external unimorph produces an audible click for each event detected (audio divide by "1" parameter). The AUD ON/OFF switch will silence the clicks if in the OFF position.

Note:

It is recommended to use the SLOW response setting when measuring low radiation fields.

Increase the source activity or lower the alert and alarm points to initiate an ALERT and ALARM condition. (Refer to Section 8 for parameter change procedures.) Depress the RESET to acknowledge the audible alarm

Decrease the radiation activity below the ALERT and ALARM threshold and depress RESET to clear the alarm conditions. If an alarm condition is not present, depressing RESET the first time will reset the alert condition and zero the ratemeter.

Position a check source to produce a reading of 0.5 to 2.0 mR/hr (0.005 to 0.02 mSv/h) while observing the ratemeter fluctuations, select between the fast and slow response time (FAST/SLOW) positions to observe different variations in the display. The SLOW position should respond approximately five times slower (for fixed response mode) and three times slower (for the variable response mode) than the FAST position.

Note:

The slow response position is normally used when the Model 78 is displaying low numbers that require a more stable display. The fast response is used at high count levels.

Depress and release the BKLITE switch. The backlight located behind the LCD should illuminate for pre-programmed "ON" time.

Select the desired FAST/SLOW and AUD ON/OFF parameters and proceed to use the instrument.

Note:

The warm-up time on this instrument is less than 10 seconds on every range.

Section 3 Specifications

DISPLAY: 4-digit LCD with 1.3 cm (0.5 in.) character height

Model 78 RANGE: 0.1 to 999.9 mR/hr

Model 78-1 RANGE: 1 μSv/h to 9999 mSv/h

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

INPUT SENSITIVITY: adjustable from 2-100 mV; negative pulse response; normally set to 50 mV through coiled cable

ACCURACY: digital readout and analog logarithmic meter are accurate within 10% of true value

HIGH VOLTAGE: adjustable supply from 200 to 2500 V; regulated to within 0.2% at 1000 Vdc; maximum load of 50 μA at 1000 Vdc; two set-points normally set to 550 Vdc (HV1) and 550 Vdc (HV2)

RESPONSE TIME: variable or fixed ratemeter response (All stated times correspond to a range of 10% to 90% of the final reading). Factory default is ˝variable˝ so that the instrument will automatically adjust the response time to the best setting for the current count rate

> **Variable Response**: dependent on the number of counts present; typically 4 to 25 seconds for FAST and 4 to 60 seconds for SLOW
>
> **Fixed Response**: The FAST response position is programmable from 1-199 seconds. The SLOW response position is approximately five times slower than the FAST. For MDA-type measurements, the fixed response mode is recommended

ANGULAR RESPONSE: within 30% as detector is rotated from 0 to 90 degrees (calibration reference is with radiation field parallel to the long axis of the detector)

GEOTROPISM: referenced to the unit in horizontal position with display up. The indication will not vary more than 2% of the full-scale reading with the unit in any other orientation.

WARM-UP TIME: unit may be used immediately after the LCD initialization sequence is completed – approximately five seconds after turning on

ALERT/ALARM: visual and audible adjustable alarm points

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

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

Backlight "ON" Time: 5, 15, 30, 60, 90, 120, 180, or 240 ±1 second

HEADPHONE JACK: size 0.32 cm (1/8 inch)

POWER: two standard "D" size batteries housed in a sealed handle; current drain approximately 35 mA (backlight off); minimum battery voltage 2.2 ±0.1 Vdc

BATTERY DEPENDENCE: Meter readings vary by less than 3% from fully charged batteries until the battery symbol appears, indicating the need for recharge or replacement.

BATTERY LIFE: approximately 250 hours for alkaline batteries; battery failure indicated on display

SIZE: 12.2 x 10.9 x 105.9 cm retracted; 377.2 cm fully extended (4.8 x 4.3 x 41.7 in. retracted; 148.5 in. fully extended) (H x W x L, fully extended L)

WEIGHT: 2.9 kg (6.4 lb), including batteries

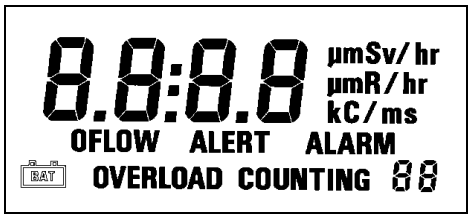
CONSTRUCTION: Main instrument housing is fabricated of aluminum with beige powder-coat finish and printed, membrane front panel. Detector housing consists of a polished stainless steel telescope assembly with brass fittings.

Section 4

Identification of Controls and Functions

Display

The Model 78 utilizes a four-digit LCD readout with a fixed decimal point. The two smaller digits located in the lower right corner of the display indicate 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. However, normally only units of R/hr, mR/hr or μR/hr are used. The bottom part of the readout displays ALARM, ALERT, OFLOW, and OVERLOAD enunciators as well as the low-battery icon.



Display Status Definitions

ALARM: ratemeter count has increased above the preset alarm threshold. An audible continuous tone will accompany the "latching" ALARM condition. Depressing RESET will acknowledge 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 the 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 (OFLOW) will appear when the ratemeter exceeds 100 kcps or if the dead time correction is greater than 75%.

OVERLOAD: indicates the detector is being exposed to radiation intensities greater than the detector maximum operating limit. The overload alarm point is set by adjusting the OVERLOAD control located on the CAL/SWITCH BOARD.

Low Battery Icon: indicates that the batteries have decreased to the minimum operating voltage of 2.2 ±0.1 Vdc

COUNTING: appears upon power-up, but not implemented

Front Panel Controls

ON/OFF Switch: a two-position toggle switch that applies power to the instrument.

AUD ON/OFF Switch: The clicks-per-event audio may be silenced or enabled via this front-panel toggle switch. The audible alarm is independent of the AUD ON/OFF switch and will override the audible clicks-per-event. An audible alarm can only be silenced by toggling the RESET switch.

mR/hr - R/hr Select Switch: a protected toggle switch that toggles between mR/hr and R/hr ranges

F/S (Fast/Slow) Response Switch: a two-position toggle switch that selects fast or slow counting response time

> **Variable Response**: dependant on the number of counts present; typically 4 to 25 seconds for FAST, and 4 to 60 seconds for SLOW
>
> **Fixed Response**: The FAST response position is programmable from 1-199 seconds. The SLOW response position is approximately five times slower than the FAST. For MDA-type measurements, the fixed response mode is recommended

BKLITE (LCD Backlight) /RESET: A momentary switch, which when pressed to the BKLITE, position illuminates the LCD for a pre-programmed time. The backlight "ON" time can be selected from between 5 and 240 seconds during parameter setup. In the non-alarm condition, pressing the momentary switch to RESET resets the ratemeter display to the minimum display readout. In an alarm condition, pressing RESET will silence the audible alarm. Pressing RESET a second time will reset the ratemeter ALARM and/or ALERT condition.

Main Board Controls

Note:

To access the internal circuit boards, unlatch the latches at each end of the Model 78. 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) sets the maximum HV limit with the front-panel HV control adjusted to the maximum clockwise position. It is adjustable from 1250 to 2400 Vdc.

VOLUME (R002): a multi-turn potentiometer (approximately 20 revolutions) varies the audible click-per-event and alarm audio. Adjust the control to the maximum clockwise position for maximum volume. If the VOLUME control is adjusted to the maximum counterclockwise position the clicks-per-event or the audible alarm(s) will not be audible when active.

Cal/Switch Board Controls

Note:

In order to access the following controls, open the latches at both ends of the instrument and remove the electronics.

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

Note:

When making adjustments to the HV potentiometer, make note of the following precautions: Use a Ludlum Model 500 Pulser or high-impedance voltmeter with a high-voltage probe to measure the high voltage at the detector connector. If a Ludlum Model 500 Pulser is not available, ensure that the impedance of voltmeter used is 1000 megohms or greater.

HV1 and HV2: multi-turn potentiometers (approximately 20 revolutions) that independently vary the detector voltages from 200 to 2400 volts. The maximum high-voltage output is adjusted by the HV LIMIT potentiometer located on the internal main board.

OVL (Detector Overload): a multi-turn potentiometer (approximately 20 revolutions) that adjusts the detector current level, which 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. The Cal/Switch board also 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 of the setup parameters are stored in the non-volatile EEPROM, which will retain data even after the Model 78 batteries are removed. Changing parameters and information on switchboard controls, other than those detailed above, are covered in Section 8 of this manual.

Section

5

Safety Considerations

Environmental Conditions for Normal Use

Indoor or outdoor use

No maximum altitude

Temperature range of -20 to 50 °C (-4 to 122 °F); may be certified for operation from -40 to 65 °C (-40 to 150 °F)

Maximum relative humidity of less than 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.)

Environmental Rating: IP52

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.

Caution!

Verify instrument voltage rating before connecting to a power converter. If the wrong power converter is used, the instrument and/or power converter could be damaged.

The Model 78 Digital Analog Stretch Scope 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 any internal components.

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 front panel. See Section 9, "Recycling," for further information.

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

Cleaning and Maintenance Precautions

The Model 78 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 or performing maintenance on the instrument:

1. Turn the instrument OFF and remove the batteries.

2. Allow the instrument to sit for one minute before cleaning the exterior or accessing any internal components for maintenance.

Section 6 Maintenance

Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and the calibration. The Model 78 instrument may be externally cleaned 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 OFF and remove the batteries.

2. Allow the instrument to sit for one minute before performing any external cleaning or accessing internal components for maintenance.

Recalibration

Recalibration should be accomplished after any maintenance or adjustment of any kind has been performed on the instrument. Battery replacements are not considered to be maintenance and do not normally require the instrument to be recalibrated.

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 manufacturers' instruments as well.

See Section 8 "Instrument Setup," for further details on instrument calibration.

Batteries

The batteries should be removed and the battery contacts cleaned of any corrosion at least every three months. If the instrument has been exposed to a very dusty or corrosive atmosphere, more frequent battery servicing should be used.

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 can occur at temperatures as low as 37 °C (100 °F).

Section 7

Technical Theory of Operation

Refer to the Main Board schematic 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 is self-biased to 2 Vbe (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 (+5 volts) 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 (microprocessor) for counting.

Low Voltage Supply

Battery voltage is coupled to DC-DC converter U231. U231 and related components provide +5 V 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 ±0.1 Vdc. U121 provides the +2.5 Vdc 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 and 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 1250-2400 when the HV control on the Cal/Switch board is at maximum. The regulated HV output is controlled by the HV1 and HV2 potentiometers located on the Cal/Switch board. 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. OVL control (on Cal/Switch Board) 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. U1 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 x 8 bit EEPROM used to store the setup parameters. The information is transferred serially from the µP. The EEPROM is non-volatile, retaining memory even after power is removed.

Audio

Click-per-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 Cal/Switch Board schematic for the following:

S1 (FUNCTION)

S1 is a 16-position binary rotary switch that selects the programmable parameters for the Model 78. The switch selects the parameters using the hexadecimal numbering system via buss lines SW1-SW4.

S2-S4

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

Refer to Display Board schematic 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 5 Vdc) 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 BKLITE button instructs the μP to set the BACKLIGHT line, pin 31 on μP, to "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 +3 V to P8-3 on display board with +3 V at P8-3 (refer to display board schematic). The backlight oscillator Q011, T011, and related components start 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 LCD backlight.

Section 8

Instrument Setup

Entering or Changing Switch Board Parameters

On the switch board, select the desired parameter to enter or change by using the corresponding FUNCTION switch position. Depress the ENTER button, and a character on the LCD will start to flash. The flashing character indicates that the program is in the parameter change mode.

To change the character, press the UP button until the desired variable is reached. To shift to another character, increment the LEFT pushbutton until the desired character is reached. The LEFT pushbutton switch enables the operator to sequence through all the characters on the LCD associated with a particular parameter.

Once the desired data is entered, depress the ENTER button. The LCD characters should stop flashing, and the new parameter data should display.

To read pre-programmed setup parameters, switch the FUNCTION switch to position A and select the pre-programmed detector setup number, using the parameter change procedure above. Once the detector setup number is entered, sequence through the parameters by varying the function switch to read the variables for that specific detector number.

Note:

Once the detector setup number has been entered, the function switch can be rotated either direction to view the parameter variables.

THE FUNCTION SWITCH

FUNCTION Switch: a 16-position rotary switch labeled "0-9" and "A-F." This switch selects a parameter setup mode for the Model 78. The selector switch must be set to the "0" position for normal instrument operation.

Note:

The mR/hr – R/hr front panel toggle switch allows this instrument to have two sets of operating parameters.

FUNCTION SWITCH POSITION DESCRIPTIONS AND VARIABLES

POSITION 0: NORMAL OPERATION places the Model 78 in the normal (counting) 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 formula to the left, where:

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

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 X 10^9. The calibration constant converts counts/time base to units/time base.

POSITION 3: SERIES CONSTANT adjusts the calibration of the high-range tube; typically about 300. Adjustable from 0 to 9999.

POSITION 4: NOT USED

POSITION 5: AUDIO DIVIDE-BY selects the audible clicks-per-event division rate for the current detector setup. If the AUD ON/OFF switch is in the OFF position, no audible clicks-per-event 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 78 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 two-position F/S (Fast/Slow) toggle switch selects the maximum time constant (TC) for the variable mode. The fast position varies the TC from 4-25 seconds, and the slow position varies from 4-60 seconds.

Fixed Response - The Fast (F) response position is programmable from 2-50 seconds, and the slow response is 5 times slower than the fast TC. For MDA-type measurements, the fixed response time mode is recommended.

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. The fifth push of the left button allows the decimal point to be moved. The ratemeter alarm adjusts from 1μR to 999 R/hr.

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 labeled BKLITE. 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

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 78 (-1)	mR/hr (µSv)	R/Hr (mSv)
	Setup 01	Setup 02
Dead Time	75 µsec	40 µsec
Cal Const	645e+5	100e+4
Series Const	0	300
Rate Alarm	500 mR/hr	500 R/hr
Scaler Alarm	85000	85000
Count Time	12 sec	12 sec
Time Base	sec	sec
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 µR/hr	00.0 µR/hr
Baud Rate	9600	
LCD Time Off	5 sec	
Detector	0	

Calibration

The Model 78 calibration routine consists of entering detector parameters into memory by way of the switch board and adjusting the CAL controls (HV1, HV2, DISC and OVL) for the specific detector operating requirements.

The first subsection of calibration will give a general overview of detector setup, including the determination of various detector operating voltages (HV1 and HV2) and the adjustment of counter input sensitivity (DISC).

The following subsection deals with exposure rate calibration. The detector Calibration Constant (CC), Dead Time Correction (DTC), and Series Constant (SC) are the three primary parameters used in the exposure rate calibrations (R/hr and Sv/h). These three constants are varied to achieve linearity at the detector non-linear operating regions.

The last subsection of calibration deals with Detector Overload (OVL).

GENERAL DETECTOR SETUP INFORMATION

The operating point for the instrument and probes is established by setting the probe voltage and instrument sensitivity (HV1, HV2, and DISC).

The two energy-compensated, Geiger-Mueller detectors supplied with the Model 78 operate at: HV1 = 550 Vdc, HV2 =550 Vdc, and DISC at 50 mV.

EXPOSURE RATE CALIBRATION

To calibrate the Model 78 to exposure rate after setting the HV and DISC potentiometers, start with the following values for DT (Dead Time, Switch Position 1), CC (Calibration Constant, Switch Position 2), and SC (Series Constant Switch Position 3). Note that the SC is left at zero for the lower range tube, but is used for the high range tube's calibration.

For exposure rates:

mR/hr: DT = 75×10^{-6}, CC = 645×10^{5}, SC = 0000

R/hr: DT = 40×10^{-6}, CC = 100×10^{4}, SC = 300

For dose-equivalent rates (Sv/h Firmware 27201n07):

μSv/h: DT = 75×10^{-6}, CC = 645×10^{4}, SC=0000

mSv/h: DT = 40×10^{-6}, CC = 100×10^{3}, SC=300

For exposure rate calibrations, use a calibrated ^{137}Cs source, and set the Model 78 to mR/hr. Place the detector at the following points:

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

DETECTOR OVERLOAD (OVL) CALIBRATION

Note:

The detector operating voltage (HV) must be determined and adjusted before the OVL adjustment is performed. If the HV is varied or another detector is substituted, OVL 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 enunciator on the LCD by way of the microprocessor.

For GM detectors the OVL 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 OVL control to the maximum counterclockwise position.

Place the detector in an increasing radiation field in which the readout no longer increases, or at the maximum calibrated radiation field.

Adjust the OVL control until the OVERLOAD alarm just appears.

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, which 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

Model 78 Digital Analog Stretch Scope

Main Circuit Board, Drawing 272 x 591

Reference	Description	Part Number
UNIT	Completely Assembled Model 78 Digital Analog Stretch Scope	48-2832
BOARD	Completely Assembled Main Circuit Board	5272-585
CAPACITORS		
C1	0.1µF, 50V	04-5663
C3	0.1µF, 50V	04-5663
C001-C002	47pF, 100V	04-5660
C011	0.001µF, 100V	04-5659
C012	0.1uF, 50V	04-5663
C021	100pF, 3KV	04-5532
C031	0.0047µF, 3KV	04-5547
C032	100pF, 3KV	04-5532
C033	0.0047µF, 3KV	04-5547
C041-C043	0.0047µF, 3KV	04-5547
C101	47µF, 10V	04-5666
C121	47µF, 10V	04-5666
C122-C123	27pF, 100V	04-5658
C131	0.0047µF, 3KV	04-5547
C132-C133	0.1µF, 50V	04-5663
C134	0.01µF, 50V	04-5664
C135	47µF, 10V	04-5666
C136	0.01µF, 50V	04-5664
C137	47µF, 10V	04-5666
C138	100pF, 100V	04-5661
C139	0.001µF, 100V	04-5659
C141	0.0047F, 3KV	04-5547
C241	1µF, 35V	04-5656
C242	68µF, 10V	04-5654

	Reference	Description	Part Number
	C243	0.1µF, 50V	04-5663
	C251	68µF, 10V	04-5654
TRANSISTORS	Q101	2N7002L	05-5840
	Q141	MMBT3904LT1	05-5841
	Q211	2N7002L	05-5840
	Q212	MMBT4403LT1	05-5842
	Q241	MJD210 RL	05-5843
INTEGRATED CIRCUITS	U1	MAX810LEUR	06-6424
	U001	CD74HC4538M	06-6297
	U011	TLC372ID	06-6290
	U021	CA3096M; 16=GND	06-6288
	U111	N87C51FC	06-6303
	U121	LM285MX-2.5	06-6291
	U122	X24C02S8T5	06-6299
	U131	LM358D	06-6312
	U231	LT1073CS8-5	05-5852
	*	SOCKET-44P	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	MMBD914LT1	07-6353
	CR242	CXSH-4 EB33	07-6358
POTENTIOMETERS / TRIMMERS	R002	10K; 3269X1-103	09-6921
	R027	1M; 3269X1-105; HV LIMIT	09-6906
RESISTORS	R001	100K, 1/4W, 1%	12-7834
	R011-R012	10K, 1/4 W, 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, 1/4W, 5%	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	41M, 1/4W, 5%	10-7028
	R032	1M, 1/4W, 5%	10-7028

	Reference	Description	Part Number
	R033-R034	1G, FHV-1, 2%	12-7686
	R111-R113	22.1K, 1/4W, 1%	12-7843
	R121	100 Ohm, 1/4W, 1%	12-7840
	R122	6.81K, 1/4W, 1%	12-7857
	R131	1M, 1/4W, 1%	12-7844
	R132	511K, 1/8W, 1%	12-7896
	R133	750K, 1/4W, 1%	12-7882
	R134	1M, 1/4W, 1%	12-7844
	R135	82.5K, 1/8W, 1%	12-7849
	R136	10K, 1/4W, 1%	12-7839
	R141	22.1K, 1/4W, 1%	12-7843
	R211	2.21K, 1/4W, 1%	12-7835
	R231	100Ohm, 1/4W, 1%	12-7840
	R241	2.21K, 1/4W, 1%	12-7835
	R242	200Ohm, 1/8W, 1%	12-7846
CRYSTALS	Y221	6.144 MHZ, 2=GND, 3=GND	01-5262
INDUCTOR	L231	100µH, CTX100-2	21-9740
TRANSFORMERS	T101	4275-083, AUDIO	4275-083
	T141	L8050	40-0902
MISCELLANEOUS	P1	1-640456-2, MTA100×12	13-8061
	P2	1-640456-3, MTA100×13	13-8100
	P3	640456-6, MTA100×6	13-8095
	P4	640456-2, MTA100×2	13-8073
	P5	1-640456-2, MTA100×12	13-8061
	*	CLVRLF	18-8771
Cal/Switch Board, Drawing 272 × 352	BOARD	Completely Assembled Cal/Switch Board	5272-352
CAPACITORS	C1-C7	0.1µF, 100V	04-5521
	C8	0.47µF, 100V	04-5565
TRANSISTORS	Q1	2N7000	05-5820
DIODES	CR1	LM385Z-2.5	05-5791
INTEGRATED CIRCUITS	U1	OPA2337	06-6590

	Reference	Description	Part Number
POTENTIOMETERS	R3	1M, 64W105, HV1 SET	09-6814
	R4	1M, 64W105, OVERLOAD	09-6814
	R8	100K, 64W104, DISC	09-6813
	R13	5K, 64W502, METER	09-6929
	R17	1M, 64W105, HV2 SET	09-6814
RESISTORS	R1-R2	1M, 1/3W, 1%	12-7751
	R5	10K, 1/2W, 1%	12-7750
	R6-R7	10K, 1/4W, 5%	10-7016
	R9	1K, 1/3W, 1%	12-7750
	R10	4.7K, 1/4W, 5%	10-7014
	R11	1M, 1/4W, 5%	10-7028
	R12	100K, 1/4W, 5%	10-7023
	R14	1.5K, 1/4W, 5%	10-7065
	R15	1K, 1/4W, 5%	10-7009
	R16	1M, 1/4W, 5%	10-7028
SWITCHES	SW1	3CTH9 PB, UP	08-6716
	SW2	3CTH9 PB, LEFT	08-6716
	SW3	3CTH9 PB, ENTER	08-6716
	SW4	350134GSK, FUNCTION	08-6721
CONNECTORS	P6	640456-5 MTA100x5	13-8057
	P7	640456-3 MTA100x3	13-8081
	P9	1-640456-0 MTA100x10	13-8066
	P10	640456-6 MTA100x6	13-8095
	P11	640456-2 MTA100x2	13-8073
	P13	640456-2 MTA100x2	13-8073
Display Board, Drawing 408 × 259	BOARD	Completely Assembled Display Board	5408-259
CAPACITORS	C1	27PF, 100V	04-5658
INTEGRATED CIRCUITS	U1	AY0438-I/L	06-6358
	U2	AY0438-I/L	06-6358
RESISTORS	R001-R004	10.0K, 1%, 125mW	12-7839

	Reference	Description	Part Number
	R5	392 OHM, 1/8W, 1%,	12-7054
MISCELLANEOUS	J1	CONN-640456-8, MTA100	13-8039
	DS111	EL-BACKLIGHT-LCD-8246	07-6527
	DSP1	MAIN DISPLAY; LCD-8246-365-4E1-A/W-REV1	07-6383

Wiring Diagram, Drawing 272 × 596

SWITCHES	SW1	7205SYZQE TOGGLE	08-6750
	SW2-SW4	7101-SYZ-QE TOGGLE	08-6511
	SW5	7301-SYZ_QE TOGGLE	08-6852
CONNECTORS	J1	CONN-1-640442-2, MTA100×2	13-8407
	J2	CONN-1-640442-3, MTA100×3	13-8138
	J3	CONN-640442-6, MTA100×6	13-8171
	J4	CONN-640442-2, MTA100×2	13-8178
	J5	CONN-1-640442-2, MTA100×2	13-8407
	J6	CONN-1-640442-5, MTA100×5	13-8140
	J7	CONN-640442-3, MTA100×3	13-8512
	J8	CONN-640442-8, MTA100×8	13-8184
	J9	CONN-1-640442-0 MTA100×10	13-8136
	J10	CONN-640442-7 MTA100	13-8171
	J11	CONN-640442-2 MTA 100	13-8178
	J12	JACK-TINI #42A	21-9333
	J13	CONN-640440-2 MTA 100×2	13-8202
RESISTORS	R1	10M, 1/4W, 5%	10-7031
	R2	3.3M, 1/4W, 5%	10-7044
	R3	10M, 1/4W, 5%	10-7031
AUDIO	DS1	UNIMORPH	21-9251
BATTERY	B1-B2	"D" Duracell Battery	21-9313
MISCELLANEOUS	*	CONNECTOR CAP	7272-358
	M1	METER 0-1 Ma	15-8066
	*	DETECTOR ASSY	4272-284

Reference	Description	Part Number
*	BODY DETECTOR	2272-287
W2	RG 174/U #8612	21-9463
BOARD	ASSEMBLY TUBE	5272-584
V1	GM TUBE-71210	01-5295
V2	GM TUBE-71616	01-5298
*	SHLD-THOMPSON TUBE	01-5055
W1	COIL CORD 8348	8272-309
*	LABEL-AVERY S1014	03-5352
*	6 FT SHOULDER STRAP	22-9649

Section

11

Drawings

Main Circuit Board, Drawings 272 x 591 (3 sheets)

Main Circuit Board Component Layout, Drawing 272 x 590A

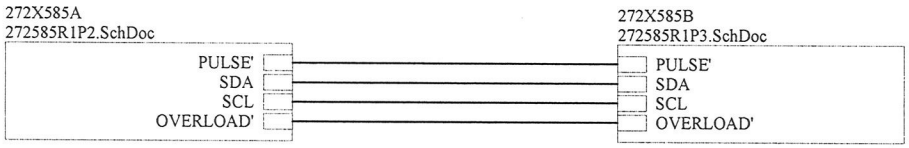
Cal/Switch Board, Drawing 272 × 352

Cal/Switch Board Component Layout, Drawing 272 × 353

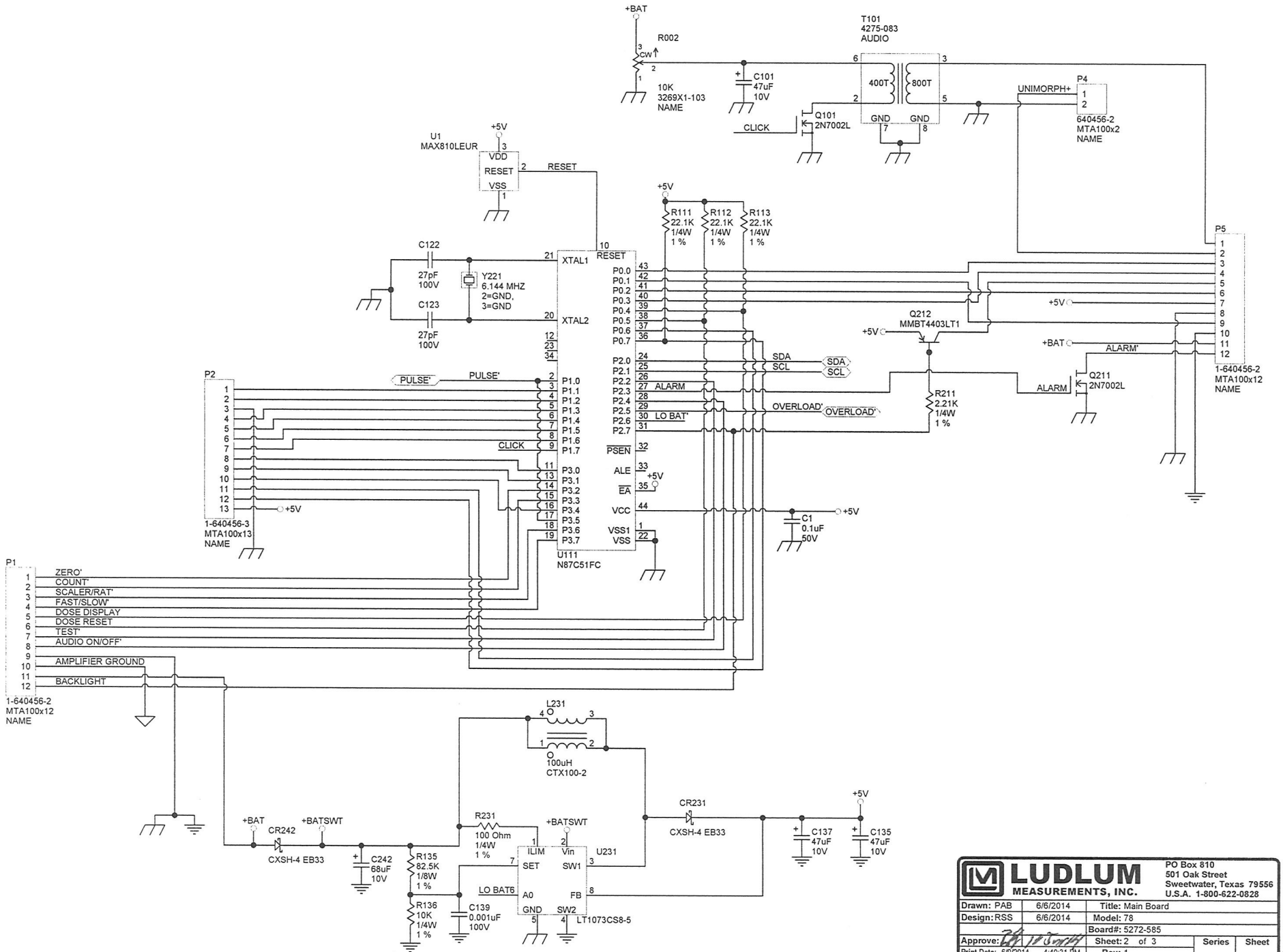
Display Board, Drawing 408 × 259

Display Board Component Layout, Drawings 408 × 260 (2 sheets)

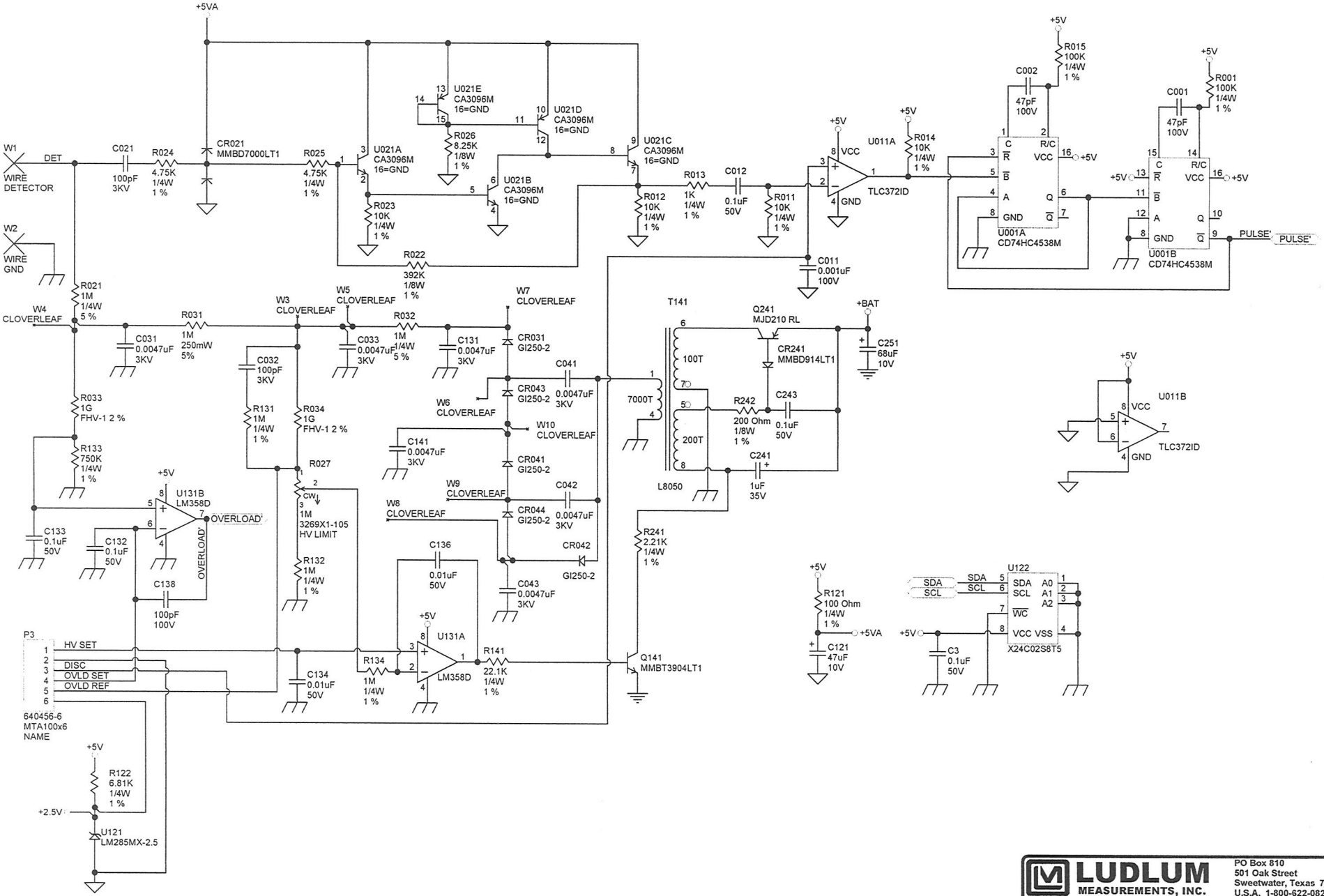
Wiring Diagram, Drawing 272 × 596



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: PAB	6/6/2014	Title: Main Board	
Design: RSS	6/6/2014	Model: 78	
		Board#: 5272-585	
Approve:		Sheet: 1 of 3	Series: 272 / Sheet: 591
Print Date: 6/9/2014 4:40:31 PM		Rev: 1	
272585R1P1.SchDoc			

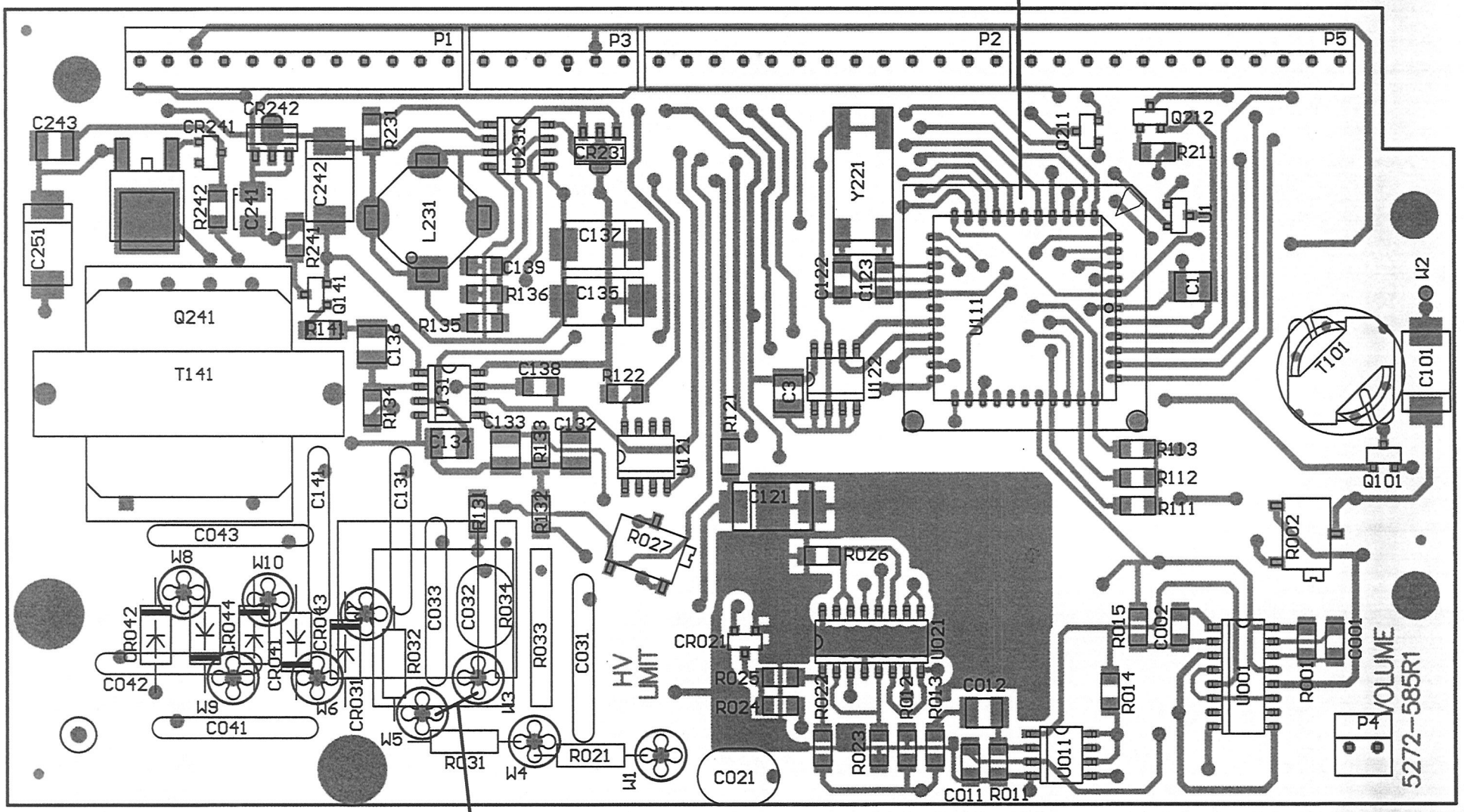


LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: PAB	6/6/2014	Title: Main Board	
Design: RSS	6/6/2014	Model: 78	
		Board#: 5272-585	
Approve:		Sheet: 2 of 3	Series 272 / Sheet 591
Print Date: 6/9/2014 4:40:31 PM		Rev: 1	
W:\Projects\LM\M 78\5272-585\Rev1\272585R1P2.SchDoc			



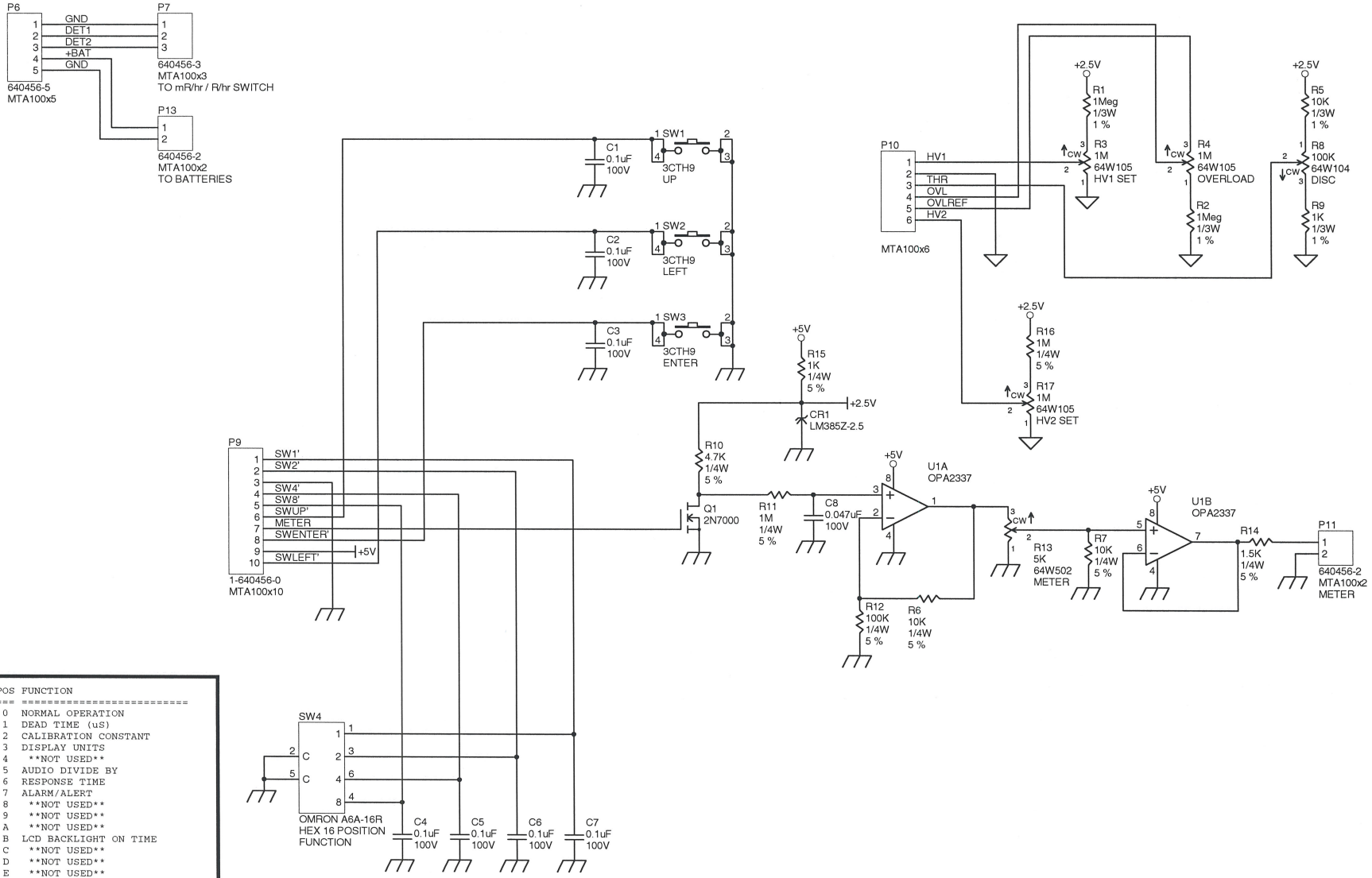
LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: PAB	6/6/2014	Title: Main Board	
Design: RSS	6/6/2014	Model: 78	
		Board#: 5272-585	
Approve:		Sheet: 3 of 3	Series 272 / Sheet 591
Print Date: 6/9/2014 4:40:31 PM		Rev: 1	
W:\Projects\LM\M 78\5272-585\Rev1\272585R1P3.SchDoc			

SEND 06-6893 W/ Job for Tech's to Program
06-6613 Socket



BUSS WIRE

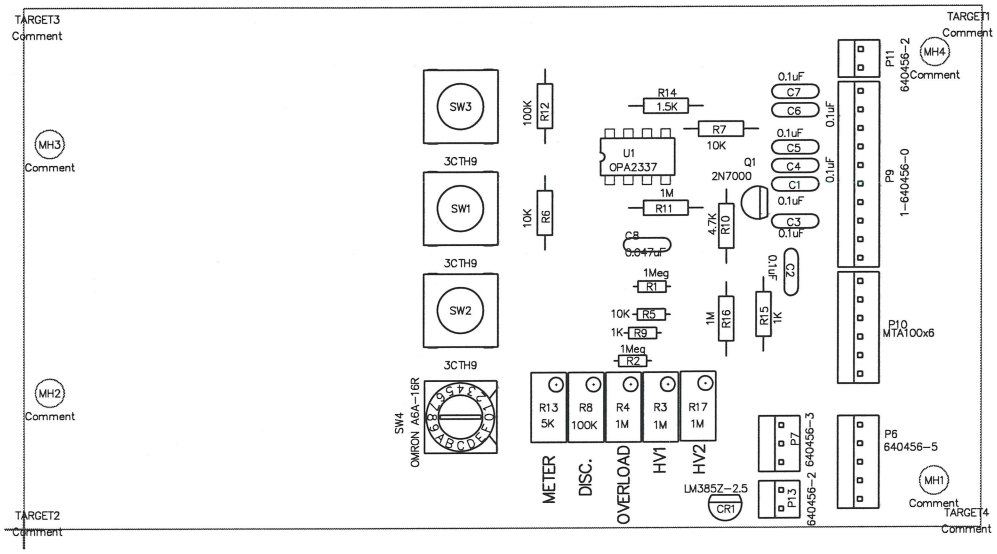
LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828	
Title: Main Board			
Drawn: PAB	6/6/2014	**Model:** 78	
Design: RSS	6/6/2014	**Board#:** 5272-585	
Approve: KRS	13 JUN 14	**Rev:** 1	
PCBA Drawing		**SCALE:** 1.04	**Series** 272 / **Sheet** 590A
Print Date: 1/13/2015 9:45:53 AM		Top Overlay	
W:\Projects\LM\M 78\5272-585\Rev1\272585R1_Assy.PcbDoc			



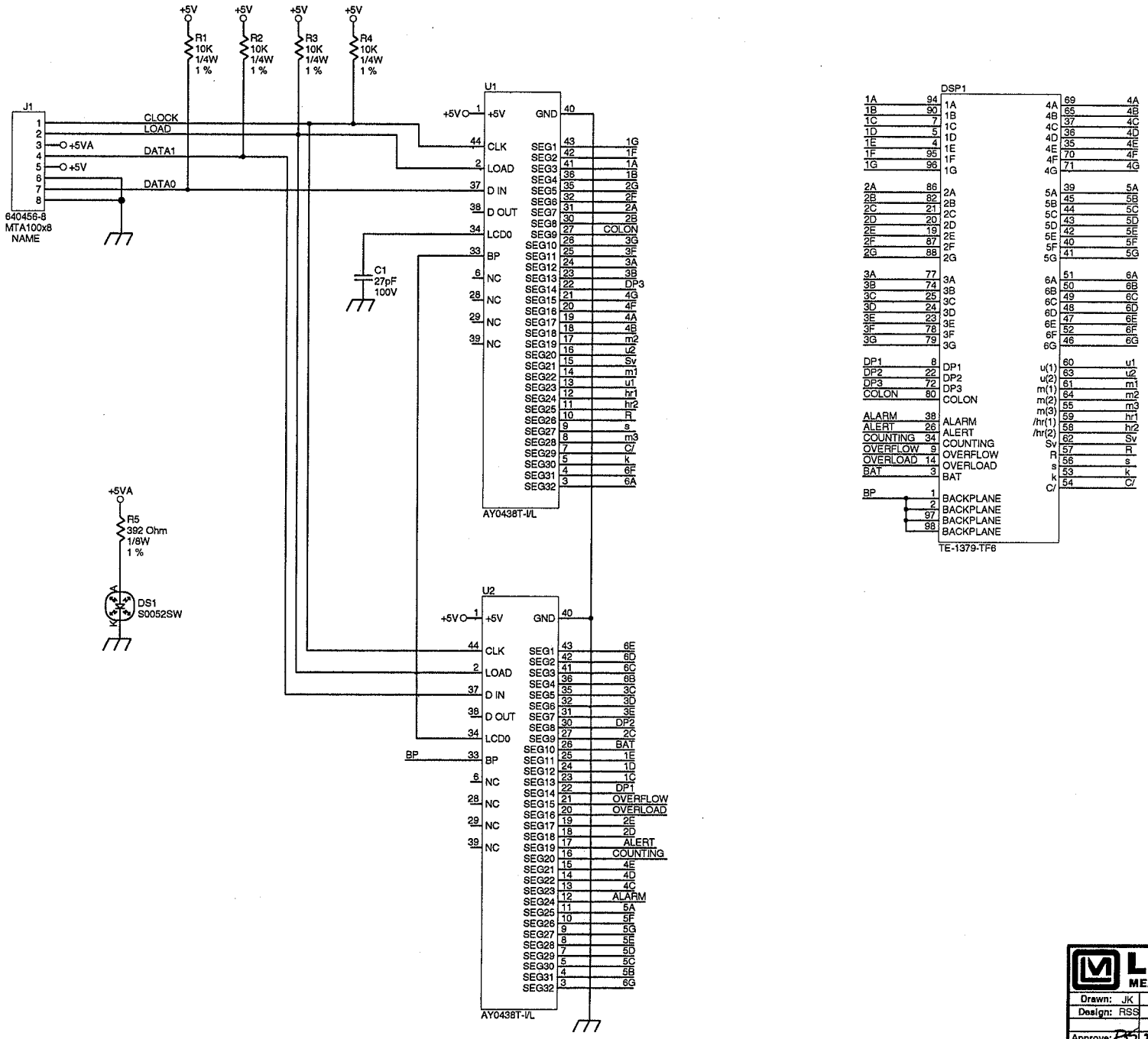
POS	FUNCTION
0	NORMAL OPERATION
1	DEAD TIME (uS)
2	CALIBRATION CONSTANT
3	DISPLAY UNITS
4	**NOT USED**
5	AUDIO DIVIDE BY
6	RESPONSE TIME
7	ALARM/ALERT
8	**NOT USED**
9	**NOT USED**
A	**NOT USED**
B	LCD BACKLIGHT ON TIME
C	**NOT USED**
D	**NOT USED**
E	**NOT USED**
F	**NOT USED**

LUDLUM MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828

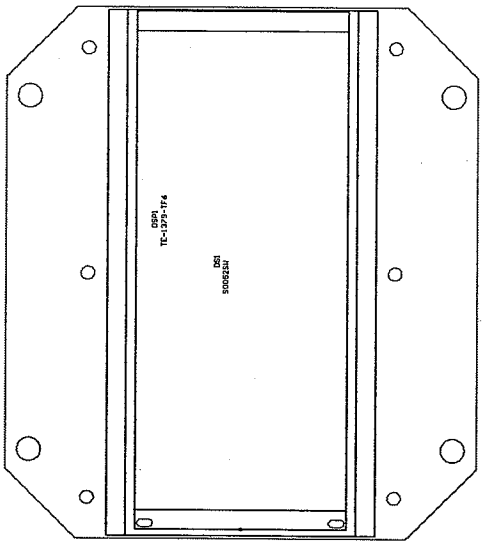
Drawn: KKH	30-JUL-02	Title: CAL/SWITCH BOARD	
Design: RSS	30-JUL0-1	Model: 78	
		Board#: 5272-352	
Approve: BS 3/Mar/04		Sheet: 1 of 1	Series 272 / Sheet 352
08:31:12	3-Mar-2004	Rev: 1.0	
272X352			



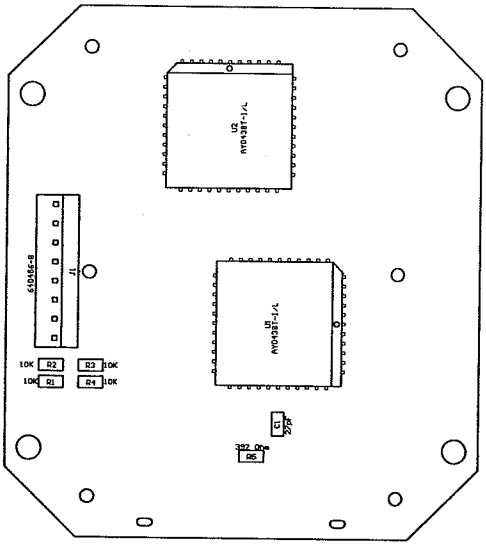
Drawn: KKH	11-DEC-02	Title: CAL/SWITCH BOARD	
Design: RSS	08-FEB-01		
Check:		Model: 78	
Approve: RSS	26 Jun 03	Board#: 5272-352	
Layer: Top Overlay Mech.1 Mech.2 Mech.3 Mech.4		Rev: 1.0	Series 272 / Sheet 353
	MID: 14:51:16 24-Jun-2003	SCALE: 0.96	



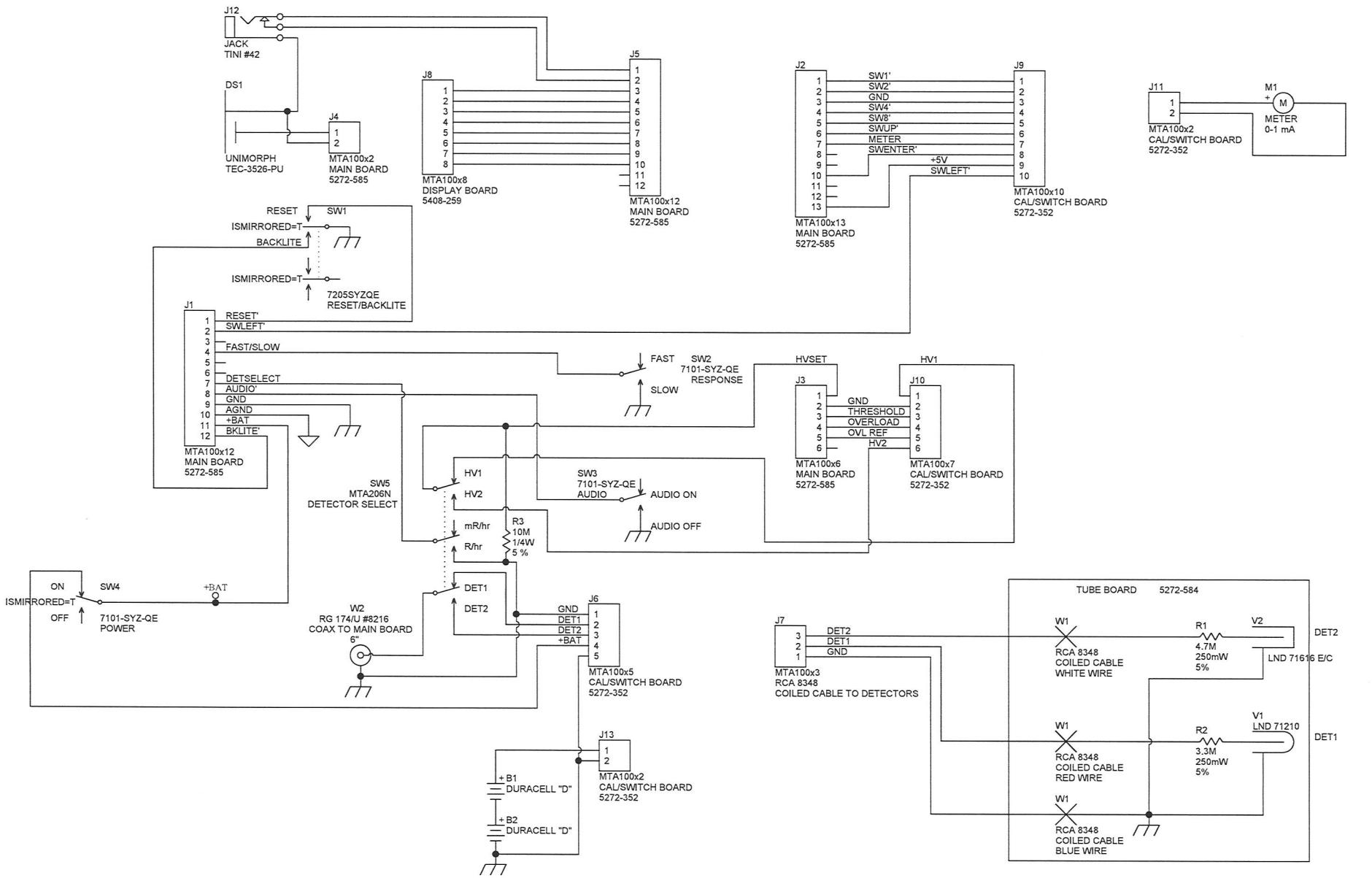
LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: JK	03-JAN-07	Title: LED BACKLITE DISPLAY BOARD	
Design: RSS	03-JAN-07	Model: M2241	
		Board#: 5408-259	
Approve: RSS 24 May 07		Sheet: 1 of 1	Series 408 / Sheet 259
13:12:20	24-May-2007	Rev: 2.0	
408259R2P1.SCH			



Drawn: JK	23–FEB–07	Title: LED BACKLITE DISPLAY BOARD			
Design: RSS	23–FEB–07				
		Model: M2241			
Approve: RK	24 May 07	Board#: 5408–259			
Layer:		Rev: 2.0	Series	Sheet	
MID:		SCALE: 1.00	408	260	
13:15:16	24–May–2007				
408259R2X1.PCB					



Drawn: JK	23–FEB–07	Title: LED BACKLITE DISPLAY BOARD			
Design: RSS	23–FEB–07				
		Model: M2241			
Approve: RSS		Board#: 5408–259			
Layer:		Rev: 2.0	Series	Sheet	
	MID:		408	260	
	13:15:16 24–May–2007	SCALE: 1.00			
408259R2X1.PCB					



LUDLUM MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828

Drawn: PAB	6/9/2014	Title: Project Title
Design: RSS	6/9/2014	Model: 78 & 78-1 (2014)
		Board#: 5272-587
Approve:		Sheet: 1 of 1
Print Date: 8/25/2015 2:04:30 PM		Rev: 1

W:\Projects\LM\M 78\272-587\Rev1\272587R1.SchDoc

Series	Sheet
272	596