LUDLUM MODEL 2221
PORTABLE SCALER RATEMETER

Revised January 2025

Serial Number 343649 and Succeeding Serial Numbers

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LUDLUM MEASUREMENTS, INC
501 OAK STREET, P.O. BOX 810
SWEETWATER, TEXAS 79556
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ATTN: REPAIR DEPARTMENT
501 OAK STREET
SWEETWATER, TX 79556

800-622-0828 325-235-5494
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REV #	ALTERATIONS	DATE	BY
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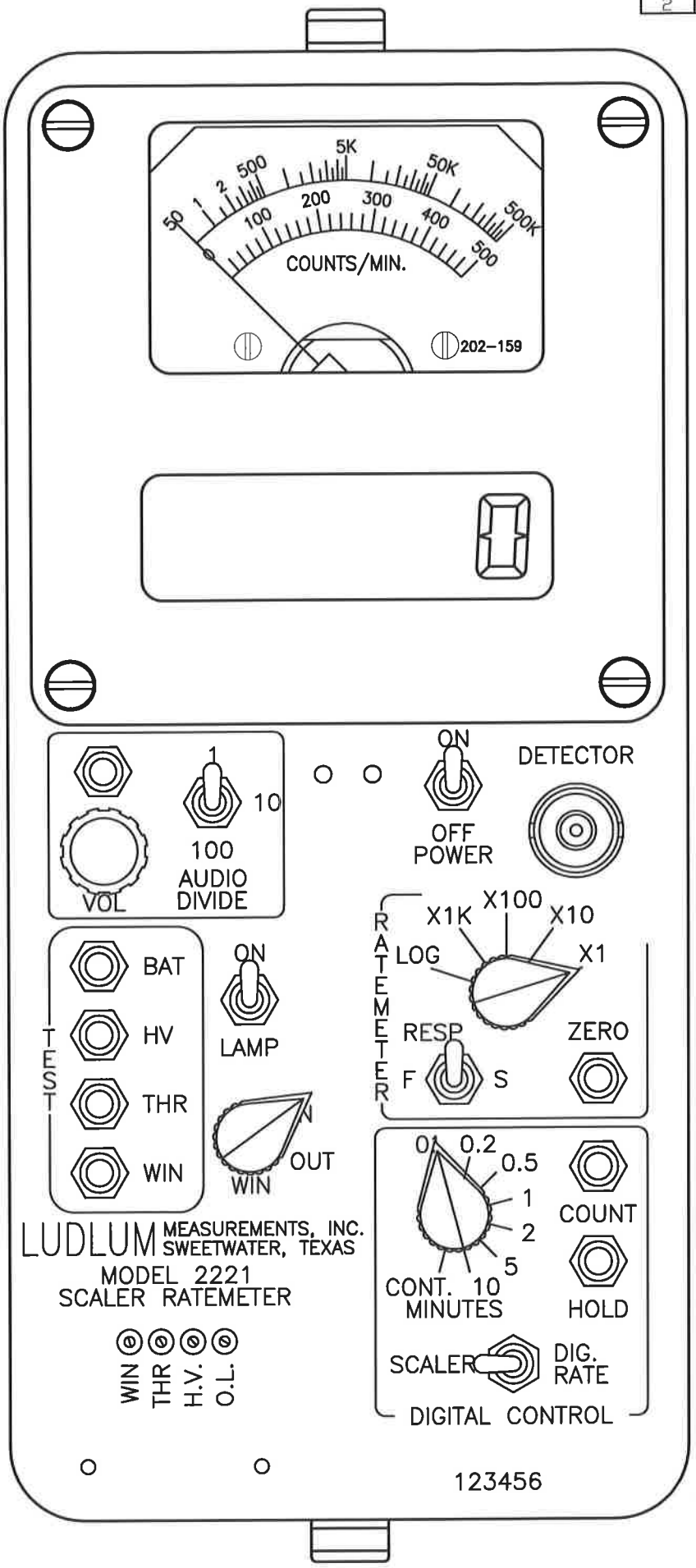

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TITLE: MODEL 2221 PORTABLE SCALER

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

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Model 2221 Portable Scaler Ratemeter
January 2025

1. GENERAL

The Ludlum Model 2221 Portable Scaler Ratemeter is a self-contained counting instrument designed for operation with scintillation, proportional, or GM detectors. Power is derived from four "D" cell batteries.

The unit is complete with a voltage-sensitive preamplifier, linear amplifier, electronic timer, detector high-voltage power supply, and detector overload detection circuitry.

A single channel analyzer is also featured in this unit for use in gamma spectrum analysis. The analyzer may be switched on or off, allowing gross or window counting.

The unit has a combination four-decade linear and log ratemeter and a six-digit LCD readout for the scaler and digital ratemeter. Potentiometers are supplied for threshold, window, and high-voltage controls.

2. SPECIFICATIONS

- **HIGH VOLTAGE**: 400-2400 volts with digital readout
- **CALIBRATION STABILITY**: less than 3% variance to battery endpoint
- **SENSITIVITY**: voltage sensitive and adjustable from 1.5 mV to 100 mV; typically factory calibrated to 10 mV = 100 on the THR display
- **INPUT IMPEDANCE**: 22k ohm
- **READOUT**: six-digit liquid crystal display, 1.3 cm (0.5 in.) characters with backlight selection
- **METER**: 6.4 cm (2.5 in.) scale, 1 mA, pivot and jewel suspension
- **SCALES/RANGE**: four-decade log ratemeter ranging from 50 to 500 kcpm; four-decade linear ratemeter, 0-500 cpm meter dial with range multipliers of X1K, X100, X10, X1 producing an overall range of 0-500 kcpm
- **OPERATING TEMPERATURE**: -20 to 50 °C (-4 to -122 °F)
- **LINEARITY**: ±10% of the true value for the analog and digital ratemeter; ±2% of the true value for the digital Scaler, HV, THR, and WIN digital voltmeter readings; ±4% of the true value for the BAT voltmeter reading
- **RESPONSE**: two positions. Fast response = 4 ±1 second. Slow response = 22 ± 2 second. All response times are measured from 10-90% of final reading.
- **CALIBRATION CONTROLS**: recessed screwdriver adjustments with calibration cover
- **AUDIO**: built-in unimorph speaker with click-per-event and switch selectable divide-by 1, 10, and 100
- **CONNECTOR**: Series "C"
- **BATTERY LIFE**: approximately 250 hours; 4 "D" cell batteries
- **SIZE**: 22.9 x 10.9 x 25.4 cm (9 x 4.3 x 10 in.) (H x W x L), including handle
- **WEIGHT**: 2.5 kg (5.5 lb), including batteries
- **FINISH**: polyurethane enamel with silk-screened nomenclature

3. DESCRIPTION OF CONTROLS AND FUNCTIONS

- **POWER**: two-position ON-OFF switch

- **DETECTOR**: Series "C" connector for detector

  Input Impedance: 22kΩ

  Ballast Resistor: 1M

  RATEMETER:

- **F-S RESP Switch**: two-position switch for selecting ratemeter response. F position 4 ±1 second; S position 22 ±2 seconds.

- **ZERO**: when pressed, resets the ratemeter

- **RANGE SELECTOR**: Five-position switch labeled LOG, X1K, X100, X10, X1 used to select the analog ratemeter range. The LOG position selects the upper meter scale to provide a four decade logarithmic reading from 50-500k CPM. The X1, X10, X100, and X1K range multipliers used with the lower 0-500 CPM meter scale, providing an overall measuring range from 0-500k CPM. Multiply the meter reading by the respective range position.

  DIGITAL CONTROL:

- **COUNT Pushbutton**: When pressed, resets and starts the counter. While the counter is counting, two sets of colons are displayed.

- **HOLD Pushbutton**: When pressed, stops the counter and leaves the count in the display.

- **SCALER/DIG RATE Toggle Switch**: Two-position toggle switch for selecting scaler or digital ratemeter

  SCALER Position: The display shows the counter contents.

  DIG. RATE Position: The display shows the ratemeter count rate.

  Note: The scaler and digital ratemeter are active even when not selected. This allows the user to start a timed count, switch to the digital ratemeter, and then switch back to scaler without having to restart the counter.

  MINUTES Selector Switch: Eight-position switch used for selecting the count times for the scaler:

POSITION	COUNT TIME IN MINUTES
0.1	0.1
0.2	0.2
0.5	0.5
1	1
2	2
5	5
10	10
CONT	

COUNTER COUNTS UNTIL HOLD IS PRESSED

CALIBRATION CONTROLS:

- **WIN**: 20-turn potentiometer used to adjust window width when the window toggle switch, WIN, is in the "IN" position

- **THR**: 20-turn potentiometer used to adjust the threshold

- **HV**: 20-turn potentiometer used to adjust detector voltage

- **O.L.**: 20-turn potentiometer used to adjust detector overload current

TEST:

- **BAT Pushbutton Switch**: When pressed, displays the battery voltage in the digital display.

- **HV Pushbutton Switch**: When pressed, displays the detector high voltage in the digital display.

- **THR Pushbutton Switch**: When pressed, displays the threshold setting in the digital display.

- **WIN Pushbutton Switch**: When pressed, displays the window setting in the digital display.

- **LAMP Toggle Switch**: Two-position switch to turn on the display lights.

- **WIN Toggle Switch**: Two-position switch for switching the window IN or OUT.

  IN position: The SCA (Single Channel Analyzer) is set up as a window counter. Detector pulses to be counted must be above the threshold but below the window.

  OUT position: The SCA is set up as a gross counter. All detector pulses above the threshold are counted.

AUDIO:

- **VOL Control**: One-turn potentiometer used to adjust the volume of the speaker or headset.

- **AUDIO DIVIDE**:

  1 Position: provides 1 click per event
  10 Position: provides 1 click per 10 events
  100 Position: provides 1 click per 100 events

- **1/8 inch HEAD PHONE JACK**: used for headset. When headset is plugged in, the unimorph speaker on the can is disabled.

- **LIQUID CRYSTAL DISPLAY**: 16.5 cm (6.5 in.) high digits, displaying counter contents or digital count rate

STATUS INDICATORS:

Counter Overflow: When in SCALER mode, the left digit alternates between the correct digit and an "H."

Detector Overload: The display flashes all dashes. ("------").

Battery: When the battery voltage is 4.4 volts or less, all decimal points are turned on. This indicates that the batteries should be changed immediately.

Scaler Counting: The two colons are turned on when MINUTES selector switch is in CONT position.

4. OPERATING PROCEDURES

4.1 Initial Preparation

1. Unscrew battery door latch.

2. Install 4 "D" size batteries in the battery holder. The correct position of the batteries is indicated on the bottom of the battery door.

3. Switch the POWER ON/OFF switch to the ON position. A random number will first be observed in the display, then 8.8:8.8:8.8. The third displayed number will be the program version. (At the time of this printing, program version is #261010.)

4. Press COUNT pushbutton. The display should zero. Two sets of colons should appear on the display.

5. Press HOLD pushbutton. The colons should disappear.

6. Switch LAMP toggle switch to the ON position. LCD display backlighting and two lamps at the bottom of the analog meter should be illuminated.

NOTE: If the Lamp switch is left in the ON position for extended periods of time, battery life will decrease rapidly.

7. Check TEST pushbutton functions for proper operation.

4.2 Operating Point

Instrument and detector operating point is established by setting the probe voltage (HV) and instrument sensitivity (THR). For a given detector system, efficiency, background and noise are fixed by the physical makeup of the detector and rarely vary from unit to unit. However, the selection of the operating point makes a marked difference in the apparent contribution of these three sources of count.

In the singular case of the GM detector, a minimum operating voltage is required to establish the GM operating region. (At lower voltages, the detector operates as a very insensitive proportional counter.) This detector is not capable of energy discrimination (pulse-height discrimination). The threshold (THR) is typically adjusted to 550, with a THR reading of 100 = 10 mV input pulse for GM detectors.

For gain sensitive detectors (proportional or scintillation), the most straightforward method of selecting the operating point is to develop a graph, relating count rate to system gain. This relationship is commonly referred to as a plateau or instrument plateau curve. System gain may be changed by adjusting detector high voltage or THR control. The threshold is typically adjusted for 100 = 10 mV for scintillation detectors and 50 (5mV equivalent) on the THR readout for proportional detectors.

4.3 Limitation of Controls

HV Control provides a linear adjustment of the detector voltage supply. The range is approximately 400 to 2400 volts. Changing the detector voltage will cause the detector gain to change. It should be remembered that a linear change in voltage will cause an exponential change in detector gain. THR Control sets the basic pulse discrimination point of the scaler.

WIN Control is calibrated with the THR control so that the reading of the WIN control is equivalent to the reading of the THR control.

As an example, 100 on the THR is equal to 100 on the WIN.

5. DETERMINING INSTRUMENT PLATEAU AND SELECTING OPERATING POINT

1. Set WIN ON/OFF to OFF.
2. Set MINUTES switch to 0.1 minutes.
3. Set THR control at 100.
4. With detector shielded from source, turn up high-voltage control and take a plot of HV versus background count rate until the detector maximum voltage rating is reached. (Maximum voltage on most scintillation detectors is 1500-1600 Vdc; maximum voltage on proportional detectors is reached at the continuous discharge point. Return HV control to minimum.
5. Expose the detector to a source and again make a plot of voltage versus count.
6. Plot both sets of data and select the operating point to correspond with maximum source count and minimum background count. Avoid areas of very fast count rate changes with small changes in detector voltage. The optimum operating point for low-background detectors is just above the inflection point (or break-over point or knee) of the plateau curve. If background count is irrelevant, shift operating point to the plateau center for greater stability.

6. WINDOW OPERATION AND ENERGY CALIBRATION PROCEDURES

The following procedure calibrates threshold directly in keV:

1. Place RATEMETER multiplier switch to LOG position.
2. Unscrew and remove CAL cover.
3. Press HV pushbutton. The HV should read out on the display directly in volts. While depressing the HV pushbutton, turn HV potentiometer maximum counterclockwise. The HV should be less than 50 volts.
4. Depress the THR pushbutton. Turn the THR potentiometer clockwise until 652 displays.
5. With WIN IN/OUT switch IN, depress the WIN pushbutton. Turn the WIN potentiometer until 20 appears on the display.
6. Switch WIN IN/OUT to OUT.
7. Connect the probe and expose to a ^{137}Cs source (a source of approximately 10μCi placed 3-4 inches away is recommended).
8. Increase HV. (If HV potentiometer is at minimum, it will take approximately three turns before any change is indicated.) While increasing the HV, observe the log scale of the ratemeter. Increase HV until ratemeter indication occurs.
9. Switch WIN IN/OUT switch to IN.
10. Turn the HV control until maximum reading occurs on the log scale. Increase HV until reading starts to drop off, then decrease the HV for maximum reading.
11. Turn RATEMETER selector switch to the X1K position.

12. Press ZERO pushbutton and release. If meter does not read, switch to a lower range until a reading occurs.

13. Carefully adjust HV potentiometer until maximum reading is achieved on the range scale. The instrument is now peaked for ^{137}Cs on both the LOG and Linear scales.

    NOTE: When the THR control is adjusted, the effective window width remains constant. As an example, if the THR is set at 612, and the WIN at 100, a 662 keV peak 612 + (100 divided by 2) will be centered in the window. Then the threshold point is equivalent to 612 keV with a 100 keV window and calibrated for 100 keV per turn. If the threshold is reduced to 250, the threshold is equivalent to 250 keV, but the window (100) is still equal to 100 keV. Proportionally, this represents a broader window.

7. OVERLOAD DETECTION CALIBRATION

1. Detector count saturation is detected in this instrument and is indicated by the LCD display by flashing all dashes and the analog ratemeter deflecting full scale. The count saturation or "overload" point is calibrated by the O.L. front-panel control.

2. Adjust the O.L. control to fully clockwise position.

3. Connect detector and set HV for correct detector operating voltage.

4. Expose detector to radiation field and while observing ratemeter, increase field intensity until a decrease in count rate is noticed. For alpha scintillators, the detector photomultiplier tube (PMT) should be exposed to a small light leak through the probe face to establish the detector saturation point.

5. With the detector in the count saturation field, adjust the O.L. control counterclockwise until the overload alarm point is reached (flashing dashes in LCD display).

6. Position detector in a lower field intensity just below the saturation point and confirm overload is defeated.

   Example: Ludlum Model 44-9 GM pancake detector saturates at approximately 500 mR/hr (5 mSv/h).

7. Full-scale instrument analog meter reading = 200 mR/hr (2 mSv/h). Set the Model 2221 to overload at 500 mR/hr (5 mSv/h) field, then position detector in a 300 mR/hr (3 mSv/h) field and confirm that overload alarm is defeated. The O.L. control will have to be "fine adjusted" to perform the above procedure.

8. CALIBRATION

Refer to schematic and component layout for the following calibration:

8.1 Ratemeter Calibration

1. Set THR control to 100 and Window IN/OUT switch to the OUT position.

2. Connect Ludlum Model 500 Pulser or equivalent and adjust count rate for 40,000 CPM.

3. Switch Ratemeter Multiplier switch to the X100 position and the Response switch to "F."

4. Adjust pulse amplitude above threshold until a steady count rate is observed on ratemeter.

5. Adjust R4 Meter Cal (labeled MCAL) on Processor board, for 40,000 CPM on meter.

6. Switch SCALER/DIG RATE switch to the SCALER position.

7. Confirm counter time operation by taking 0.1 minute count. Colons should be observed during count cycle.

8.2 TEST Pushbutton/Display Calibration

1. Adjust THR control to fully clockwise position.

2. Connect positive voltmeter lead to pin 7 of U220 (TLC27M7IP) on the amplifier/power supply board. Connect negative lead to ground near U3.

3. Press the THR test pushbutton and adjust R208 Volt Cal (labeled "V"), so that the front-panel display reading corresponds to the voltmeter reading at pin 7 of U3.

8.3 High Voltage Calibration

1. Connect HV meter (1000 Megohm input impedance or greater) to the junction of R110 (4.7 Meg) and R140 (1 Meg) on the amplifier/power supply board.

2. While pressing the HV Test pushbutton, adjust the HV front-panel control until the display reads 1500.

3. Adjust R272 HV Cal on amplifier/power supply board for 1500 ±5 volts on external HV meter.

4. Confirm HV will adjust from 400 to 2400-2500 volts. Ensure HV displayed reading tracks within 2% of HV output.

8.4 Threshold/Gain Calibration

1. Set pulser pulse amplitude to 10 mV.

2. With THR set at 100, fine adjust R257 gain control (on Power Supply board) until ratemeter reads 30,000 CPM with 40,000 CPM from pulser.

3. Adjust THR control for readings of 200, 300, 400, and 500 to ensure the pulser input is 20, 30, 40, and 50 mV respectively. Use the 3/4 CPM input setting to discriminate turn on points as in procedure above.

4. Adjust THR control back to 100.

5. Switch Window IN/OUT switch to the IN position. Adjust WIN control for 100, 200, 300, 400, and 500 to confirm

20, 30, 40, and 50 mV window cut-off points.

6. Set WIN back to 100 and OUT position.

7. Check the rest of the front-panel functions for proper operation.

9. OVERHAUL PROCEDURE

The checkout below can be performed with boards in instrument. An extender board (LMI part # 5261-098) is available if better access to board components is necessary:

9.1 Amplifier/Power Supply Board

1. Connect low-voltage power supply, capable of supplying 4.0-5.0 Vdc to the Model 2221 and plug in amplifier/power supply board (component side to back of instrument).

2. Adjust the WIN, THR, and O.L. front-panel controls to maximum clockwise position. Turn HV control to maximum counterclockwise position. Switch the lamp switch to the OFF position. Window IN/ OUT switch to the OUT position.

3. Adjust input voltage for approximately +4 Vdc and turn instrument to the ON position. Battery current should be approximately 30 mA or less.

4. Confirm pin 8 of U187 (CA3290A) is equal to or greater than +6.4 Vdc.

5. Increase supply voltage to approximately +5 Vdc and pin 8 of U187 should increase to +9 ±1 Vdc.

6. Check for +5 ±0.15 Vdc at pin 8 of any of the TLC27M7IP circuits (such as U220 or U153).

7. Check for -6.5 ± 0.5 Vdc at pin 4 of any of the same TLC27M7IP circuits.

8. Connect subminax wire from detector input to amplifier/power supply board.

9. Connect HV meter to detector input and adjust front-panel HV control to fully clockwise position.

10. Adjust the HV front panel control to the fully clockwise position. Then adjust R272 HV CAL for approximately 2400-2450 Vdc. Decrease front-panel HV control to the fully counterclockwise position and confirm that HV output is 50 volts or less. Then set HV for approximately 1000 Vdc.

11. Connect voltmeter to pin 1 of U220 (TLC27M7IP).

12. With HV output set at approximately 1000 volts, adjust R268 Current Cal (labeled "O") for approximately 0.1 Vdc at pin 1 of U220.

13. Connect Overrange Simulator (needs to have a 1000 meg resistor) to detector input and confirm pin 1 of U220 increases to approximately 0.15 ±0.01 Vdc.

14. Connect voltmeter to pin 1 of U191 (LM358) and with the over-range simulator connected, adjust O.L. control on the front panel counterclockwise until the voltmeter reads approximately +0.5 Vdc. Disconnect simulator and confirm pin 1 of U2 goes above +3 volts.

15. Turn O.L. control to its maximum clockwise position.

16. Connect positive voltmeter lead to pin 7 of U220 (TLC27M7IP) and connect negative lead to ground close to U3.

17. Press the WIN test pushbutton and confirm pin 7 of U220 is approximately 2.7 to 3.8 volts.

18. Press THR test and confirm pin 7 is 1.23 ±0.02 Vdc.

19. Press BAT test pushbutton and confirm pin 7 is approximately 0.5 with supply voltage at +5 Vdc.

20. With the HV still set at 1000 Vdc, pin 7 of U3 should be approximately 1 ±0.1 Vdc while pressing the HV test pushbutton.

21. Connect oscilloscope to pin 3 of U5 (LM331) and adjust R171 Volt Cal (labeled "V") for approximately 2 kHz (0.5 millisecond period) with the HV pushbutton pressed.

22. Connect voltmeter to pin 7 of U3, and while pressing the THR test pushbutton, adjust THR control for approximately +0.1 Vdc.

23. Switch the Window IN/OUT switch to the IN position. While pressing the WIN test pushbutton, adjust the WIN control for approximately +0.1 Vdc at pin 7 of U3 also. Then switch the Window to the OUT position.

24. Connect oscilloscope to pin 2 of U8 (CA3096).

25. Connect pulser and set pulse amplitude for approximately 10 millivolts. Set CPM to 40,000.

26. Adjust R174 Gain (labeled "G") to maximum clockwise position and confirm positive pulses at pin 2 of U8 are approximately 1 ±0.1 volt in amplitude.

27. Connect oscilloscope to pin 10 of U105 (CD4098).

28. Adjust R174 Gain until pulses just start to appear at pin 10 of U105. Then adjust pulser amplitude until pulses are clearly visible.

29. Adjust R173 T Pulse (labeled "T") for a 2.5 microsecond positive pulse width at pin 10 of U105.

30. Connect oscilloscope to pin 7 of U105 and adjust R172 Width (labeled "W") for a 3 microsecond negative pulse width.

31. Switch the Window IN/OUT switch to the IN position and verify that the pulses are present at pin 7 of U105 from 10 to 20 mV input pulse amplitude and off approximately above 20 mV.

32. Switch Window IN/OUT switch to the OUT position and verify the pulses appear above the window limit as in the above step.

33. Battery current should be less than 30 mA with +5 Vdc supply input.

9.2 Processor Board Checkout

1. The procedure below is to be used without the Amplifier/Power Supply board. If the Amplifier/Power Supply board is used, delete the steps containing the signal generator use. Use the pulser for the standard count rate inputs. Window, Threshold, HV, and Bat Test will display the control setting.

2. Plug in amplifier/power supply simulator board and connect signal generator to jumper wires (black= probe ground).

3. Plug in processor board with component side toward back of instrument. Connect display ribbon cable.

4. Set signal generator to square wave function.

5. Range = 10k and all other switches to the OUT position.

6. Adjust the Frequency Symmetry, Amplitude and D.C. Offset controls to achieve a 5 volt negative pulse with a pulse width of approximately 50 microseconds and a period of approximately 1.2 milliseconds.

7. With supply voltage set at +5 ±0.15 Vdc, turn instrument ON and observe display = 8.8:8.8:8.8 for approximately 2 seconds, then 261010 indicating the program number.

8. Connect frequency counter to pin 18 of U22 (80C51FA) and confirm crystal frequency is 6 MHz ±0.1% (6006-5994 kHz).

9. Switch the Scaler/Dig. Rate Switch to the Dig. Rate position.

10. Counts should start accumulating every 2 seconds until approximately 50,000 CPM is observed. (The symmetry control can be fine adjusted until 50,000 CPM is achieved.) At this displayed count rate, the low BAT Test indication should be observed, indicated by 5 decimal points across the bottom of the display.

11. Press BAT Test and display should be 4.1 ±0.2.

12. Press HV and WINDOW = 410 ±20. Threshold pushbutton has no effect without amplifier/power supply plugged in.

13. Switch ratemeter response time to F.

14. Switch Ratemeter multiplier to X100.

15. Adjust R40 Meter Cal (labeled MCAL) until ratemeter matches displayed accumulated count (approximately 50,000 CPM).

16. Change the multiplier range on the signal generator to correspond to each decade on the rate multiplier to confirm range switch operation.

17. Connect voltmeter to recorder output and confirm R41 RCDR CAL (labeled RCAL) will adjust from 0 to approximately 3.7 Vdc, with full-scale CPM on display and ratemeter. Then set for 1 Vdc to equal full-scale meter deflection.

18. Connect oscilloscope to pin 9 of U10 (ICM7556) and decade sweep generator down to the 1k range.

19. Switch the Audio Divide switch between the 1, 10, and 100 positions to confirm audio frequency divides or multiplies by 10 between each position.

20. Connect headset or turn on unimorph and confirm volume control operation.

21. With full-scale meter deflection (500), check F/S response time (90% full scale) for 4.5 ±0.5 seconds and 22 ±2 seconds respectively.

22. Check Count, Hold, and Zero pushbutton functions.

23. Switch Scaler/Dig. Rate switch to the Scaler position and check the 0.1, 0.2, and 2 minute time multipliers for correct time operation.

24. With +5 volts supply input, battery current should be less than approximately 15 mA, with full-scale meter deflection.

9.3 Functional/Chassis Checkout

1. This procedure requires a checked-out amplifier/power supply board and processor board.

2. Connect one lead of an ohmmeter to chassis ground.

3. Connect other lead of ohmmeter to the processor board cinch connector pins below to check count time switch operation. Boards are not plugged in yet.
    a. 1= open
    b. 0= shorted

COUNT TIME POSITION	PROCESSOR BOARD CINCH CONNECTOR PIN 8	30	31
0.1	0	0	0
0.2	0	0	1
0.5	1	0	0
1	1	0	1
2	0	1	0
5	0	1	1
10	1	1	0
CONT	1	1	1

4. Connect external power supply and set input voltage for approximately +5 Vdc.

5. Turn Lamp switch to the OFF position, THR, and O.L. controls to maximum clockwise position, and HV to maximum counterclockwise position.

6. Plug in processor and amplifier/power supply boards and related cable connections.

7. Turn instrument ON. Current draw should be less than 45 mA.

8. Confirm display reads 8.8:8.8:8.8 for approximately 2 seconds, then 261010 indicating the program version.

9. Connect positive voltmeter lead to pin 7 of U3 (TLC27M7IP) on the amplifier/power supply board. Connect negative lead to ground near U3.

10. With the THR control full clockwise, press the THR test pushbutton and adjust R171 Volt Cal (labeled "V"), so that the front-panel display reading corresponds to the voltmeter reading at pin 7 of U3.

11. Connect HV meter (2500 Megohm input impedance or greater) to the junction of R32 (4.7 Meg) and R33 (1 Meg) on power supply board.

12. While pressing the HV Test pushbutton, adjust HV control until the display reads 1500. R176 Current Cal may have to be adjusted counterclockwise to defeat the Overrange function.

13. Adjust R175 HV Cal on amplifier/power supply board for 1500 ±5 on external HV meter.

14. Confirm HV will adjust from 400 to 2400 volts. Ensure HV displayed reading tracks within 2% of HV output.

15. Adjust HV for approximately 1000 volts.

16. Adjust R176 Current Cal (labeled "0") for approximately 0.1 volt at pin 1 of U3 (TLC27M7IP) on amplifier/power supply board.

17. Connect over-range simulator (1000 megohm) to the detector input.

18. Adjust the O.L. control counterclockwise until hyphens start flashing across the display every other count interval. Disconnect over-range simulator and confirm overrange

function is defeated. Then adjust to fully clockwise position.

19. Set THR control to 100 and Window IN/OUT switch to the OUT position.

20. Connect pulser and adjust count rate for 40,000 CPM.

21. Switch ratemeter multiplier switch to the X100 position and the response switch to "F."

22. Adjust pulse amplitude above threshold until a steady count rate is observed on ratemeter.

23. Adjust R40 Meter Cal (labeled MCAL) on processor board, for 400 CPM on meter.

24. Adjust pulser for 10,000 CPM and check meter for ±10% linearity of reading. Adjust pulser and rate multiplier switch to confirm linear readings on all ranges.

25. Switch SCALER/DIG. RATE switch to the SCALER position.

26. Confirm count time switch operation by taking a 0.1 minute and 0.5 minute count. Colons should be observed during count cycle.

27. Check HOLD and ZERO pushbutton functions.

28. Switch SCALER/DIG. RATE switch to the DIG. RATE position and confirm update count display operation approximately every two seconds.

29. Connect unimorph and headset to the audio outputs and confirm audio divide and volume control functions.

    NOTE: Unimorph should shut off when headset is connected.

30. With the THR control adjusted for 100, adjust R174 Gain (labeled G) for 1.5 millivolt input sensitivity. Ensure instrument functions at low input sensitivity without noise.

31. Instrument may have to be placed in can to permit noise-free operation.

32. Set pulser pulse amplitude to 10 mV.

33. With THR still set at 100, fine adjust R174 gain control until ratemeter reads 30,000 CPM with 40,000 CPM from pulser.

34. Adjust THR control for readings of 200, 300, 400, and 500 to ensure the pulser input is 20, 30, 40, and 50 mV respectively. Use the 3/4 CPM input setting to discriminate turn-on points as in procedure above.

35. Adjust THR control back to 100.

36. Switch Window IN/OUT switch to the IN position. Adjust WIN control for 100, 200, 300, 400, and 500 to confirm 20, 30, 40, and 50 mV window cut-off points.

37. Set WIN back to 100 and OUT position for instrument shipment.

38. Input a full-scale ratemeter count rate (500 CPM) and connect voltmeter to the recorder output. Adjust R41 (labeled RCAL) on processor board for 1 volt.

39. Check F/S ratemeter response time for 4.5 ±0.5 and 22 ±2 seconds at 90% of full scale.

40. Decrease input supply voltage until periods are observed at bottom of display. Press BAT Test pushbutton and confirm low BAT Test is 4.4 ±0.1 Vdc. Adjust supply voltage back to 5 volts

and confirm BAT test and actual supply input is 5 ±0.05 Vdc.

41. Switch SCALER/DIG. RATE switch to the SCALER position, Count Time multiplier to CONT., then press count pushbutton and start with low enough count rate to observe each digital number count sequence from least significant digit to most significant digit (MSD). Decade pulser count rate to speed up digit segment display check.

42. Increase count rate enough to overflow counter. An "H" should be observed in the MSD flashing every count interval.

43. Turn Lamp switch to the ON position and confirm two lamps in the display and two lamps below the meter are illuminated.

44. Current draw with lamps on should be 210 ±20 mA.

45. Turn lamp OFF, and current should be approximately 40 ±5 mA.

10. PARTS LIST

Ref. No.	Description	Part No.
Model 2221 Portable Scaler Ratemeter		
UNIT	Completely Assembled Model 2221 Portable Scaler Ratemeter	48-2065
Amplifier/Power Supply Board, Drawing 261 X 216		
BOARD	Assembled Board	5261-216
CAPACITORS		
C111	0.1µF, 100V, X7R	04-5521
C116	0.0056µF, 3kV, C	04-5522
C118	0.1µF, 100V, X7R	04-5521
C122	0.0015µF, 3kV, NPO	04-5518
C124	0.0015µF, 3kV, NPO	04-5518
C127-C128	0.0015µF, 3kV, NPO	04-5518
C136-C137	0.1µF, 100V, X7R	04-5521
C142	100pF, 3kV, C	04-5532
C143	100pF, 100V, COG	04-5527
C154	0.1µF, 100V, X7R	04-5521
C155	100µF, 10V, DT	04-5576
C156	0.1µF, 100V, X7R	04-5521
C159	47pf, 100V, C	04-5533
C161	47pf, 100V, C	04-5533
C162	4.7µF, 10V, DT	04-5578
C169	100pF, 100V, COG	04-5527
C172	100µF, 10V, DT	04-5576
C179	0.0022µF, 100V, P	04-5580
C180	1µF, 35V, DT	04-5575
C188	0.01µF, 100V, X7$	04-5523
C190	0.1µF, 100V, X7R	04-5521
C199	0.1µF, 100V, X7R	04-5521
C200	1µF, 35V, DT	04-5575
C205	0.1µF, 100V, X7R	04-5521
C212	100pF, 3kV, C	04-5532
C221	4.7µF, 10V, DT	04-5578
C222	100µF, 10V, DT	04-5576
C224	0.1µF, 100V, X7R	04-5521
C232-C233	0.0056µF, 3kV, C	04-5522
C239	10pF, 100V, C	04-5573
C240	0.001µF, 100V, X7R	04-5519
C241	2.2µF, 25V, DT	04-5559
C245	10µF, 20V, DT	04-5592
C250	4.7µF, 10V, DT	04-5578

Ref. No.	Description	Part No.
TRANSISTORS		
Q130	2N3904G	05-5755
Q173	MPS-W51AG	05-5765
Q175	MPS-W01	05-5578
INTEGRATED CIRCUITS		
U1-U2	CMXT3904TRLF	05-5888
U3	CMXT3906TRLF	05-5890
U4-U6	CMXT3904TRLF	05-5888
U146	CMXT3906TRLF	05-5890
U153	TLC27M7IPE4	06-6248
U171	CD4098BE	06-6066
U187	TLC372IP	06-6265
U191	LM358NG	06-6024
U203	LM331N/NOPB	06-6156
U211	CMXT3906TRLF	05-5890
U220	TLC27M7IPE4	06-6248
U230	LM2578	06-6223
U235	TLC27M7IPE4	06-6248
U248	CD4052BE	06-6141
U256	CMXT3904TRLF	05-5888
DIODES		
CR121	GI250-2	07-6266
CR123	GI250-2	07-6266
CR125	GI250-2	07-6266
CR126	GI250-2	07-6266
CR133	IN4148	07-6272
CR141	GI250-2	07-6266
CR174	IN4148	07-6272
CR176	1N4148	07-6272
CR182	1N4148	07-6272
CR183	1N4148	07-6272
CR192	1N4148	07-6272
CR213	1N5819	07-6306
CR228	1N5819	07-6306
CR236	1N4148	07-6272
CR243	1N5819	07-6306
CR244	1N5252	07-6265
CR246	IN4148	07-6272
RESISTORS		
R110	4.7M	10-7030
R112	1k	12-7750
R113	10k	12-7748
R114	220 OHM	12-7753
R115	200k	12-7752
R117	4.7k	12-7755
R119	100k	12-7747

Ref. No.	Description	Part No.
R120	220 OHM	12-7753
R131	470k	12-7757
R132	10k	12-7748
R134	100k	12-7747
R135	1k	12-7750
R139	1G	12-7686
R140	1M	10-7028
R144	100k	12-7747
R145	10k	12-7748
R147	1M	12-7751
R148	470k	12-7757
R149	1M	12-7609
R150-R152	10k	12-7748
R157	470k	12-7757
R160	10k	12-7748
R163	10k	12-7748
R166-R168	10k	12-7748
R177	200k	12-7752
R178	47OHM	12-7756
R181	100k	12-7747
R184-R185	10k	12-7748
R186	22K	12-7754
R189	10k	12-7748
R193	40.2k	12-7761
R194	4.42k	12-7760
R195	4.7k	12-7755
R197	178k	12-7769
R198	1M	12-7609
R201	100k	12-7747
R202	10k	12-7748
R204	17.8k	12-7759
R206	10k	12-7748
R207	100 OHM	12-7746
R208	1M	12-7609
R210	4.7k	12-7755
R215	1M	10-7028
R216	22k	12-7554
R217	10k	12-7748
R218	1M	12-7609
R219	100k	12-7747
R223	1.5k	10-7065
R225	10M	10-7102
R226	1G	12-7686
R227	0.1 OHM	12-7647
R229	10k	12-7748
R231	100k	12-7747
R237-R238	1M	12-7609
R247	220 OHM	12-7753
R249	200k	12-7752
R251	10k	12-7748
R252	100k	12-7747
R253	10k	12-7748
R255	1k	12-7750
R257	10k	09-6822
R258	100k	09-6823
R259	10k	09-6822
R260	100k	09-6823
R268	1M	09-6828
R272	1M	09-6778

TRANSFORMERS

T129	HVPS	4275-037
T242	2221 LVPS	4275-094

MISCELLANEOUS

W1-W8	CLOVERLEAF RECEPTACLES	
	011-6809-00	18-8771
3 EA.	SPACERS	18-8933
*	AMPLIFIER SHIELD	7261-100

Processor Board, Drawing 261 X 91

BOARD	Assembled Board	5261-136

CAPACITORS

C1	10µF, 25V	04-5655
C2-C3	18pF, 100V	04-5960
C4	100µF, 10V	04-5820
C5	22µF, 20V	04-5672
C6	100µF, 10V	04-5820
C7	47pF, 100V	04-5660
C8	.047µF, 200V	04-5869
C9	0.001µF, 100V	04-5659
C10	4.7µF, 35V	04-5653
C11-C12	10µF, 25V	04-5655
C13	4.7µF, 35V	04-5653
C14-C15	68µF, 10V	04-5654

TRANSISTOR

Q1	MMBT3904	05-5841

INTEGRATED CIRCUITS

U1	CD4056BME	06-6906
U2	CD4054BM	06-6905
U3	IC-AT89C51RC2-SLSUM	06-6893
U4	CD4056BME	06-6906
U5	SN74HC08DR	06-6313
U6	CD4056BME	06-6906
U7	CD74HC573M96	06-6298
U8-U9	CD4056BME	06-6906
U10	LM358DG	06-6312
U11	RDD106 DIVIDER	06-6060
U12	CD4056BME	06-6906
U13	ICM7556ISD	06-6904
U14	TCM810	06-6424
U15	CD74HC238M	06-6346
U16	MAX220ESE	06-6329

DIODE

D1	MMBD914	07-6353

Ref. No.	Description	Part No.
RESISTORS		
R1	1M, RCDRCAL	09-6828
R2	221k, 250mW	12-7845
R3	5.62k, 250mW	12-7871
R4	1M, METER CAL	09-6828
R5	2.21k, 250mW	12-7835
R6	3.32k, 250mW	12-7870
R7	137k, 250mW	12-7061
R8	221k, 250mW	12-7845
R9	475k, 250mW	12-7859
R12	22.1k, 250mW	12-7843
R13	1k, 250mW	12-7832
RESISTOR NETWORKS		
R10-R11	22k, SMT R	12-7917
TRANSFORMER		
T1	300-9 X25	4275-074
CRYSTAL		
Y1	6.000 MHZ	01-5985
CONNECTOR		
P3	RIBBON-1-5102159-0	13-7834
Calibration Board, Drawing 261 X 59		
BOARD	Assembled Board	5261-075
VOLTAGE REFERENCES		
U1	LM385Z-1.2	05-5808
U2	LM385Z-1.2	05-5808
U3	LM385Z-1.2	05-5808
RESISTORS		
R4	22k	12-7754
R10	22k	12-7754
R11	100k TRIMMER	09-6813
R12	100k TRIMMER	09-6813
R13	100k TRIMMER	09-6813
R14	100k TRIMMER	09-6813

Ref. No.	Description	Part No.
CONNECTOR		
P6/1-7	640457-7 MTA100	13-8183

Ref. No.	Description	Part No.
LCD Display Board, Drawing 261 X 58		
BOARD	Assembled Board	5261-074
INTEGRATED CIRCUIT		
U7	3918	07-6252
RESISTORS		
R4	22 OHM	10-7072
R14	22 OHM	10-7072
CONNECTORS		
P4	7-146256-5 HEADER	13-8186
P5	640456-2 MTA100	13-8073
MISCELLANEOUS		
DS10-DS13	BULB-#6833	22-9613
Backplane Board, Drawing 261 X 60		
BOARD	Assembled Backplane Board	5261-076
DIODE		
CR6	1N5819	07-6306
CONNECTORS		
J1-J2	EZA22DRSN	13-8181
P7	640456-7 MTA100	13-8115
P8	1-640456-4 MTA100	13-8141
P9	640456-5 MTA100	13-8057
P10	640456-2 MTA100	13-8073
P11	1-640456-4 MTA100	13-8141
Chassis Wiring Diagram, Drawing 261 X 61		
AUDIO		
DS1	UNIMORPH 60690	21-9251
CONNECTORS		
J1	CONN-640456-2 MTA100	13-8073
J2	UG706/U SERIES C	4478-011

Ref. No.	Description	Part No.
J5	PHONE JACK TINI #42A	21-9333
J6-J7	(ON CAL HARNESS)	8261-088
J8	(ON MAIN HARNESS)	8261-087
J9	(ON BATTERY HARNESS)	8261-089
J10	NOT USED	
J11	(ON MAIN HARNESS)	8261-087

Ref. No.	Description	Part No.
SWITCHES		
S1-S7	30-1-PB GRAYHILL	08-6517
S8-S12	7101-SYZ-QE TOGGLE	08-6511
SW1	513381	08-6656
SW2	513381	08-6656
SW3	MTA-206PA	08-6657
BATTERY		
B1-B4	1.5 VOLT "D" DURACELL	21-9313
RESISTORS		
R1	10k NON-LOCKING	09-6753
MISCELLANEOUS		
M1	Model 2221 METER ASSY.	4261-091

RS-232 Port Kit (optional) 4261-148

RS-232 Board, Drawing 261 X 179

BOARD	Assembled RS-232 Board	5261-179
CAPACITORS		
C1	4.7µF, 20V, SMT	04-5653
C2	10µF, 20V, SMT	04-5655
C3	4.7µF, 20V, SMT	04-5653
C4	10µF, 20V, SMT	04-5655
C5-C6	68µF, 10V, SMT	04-5654
INTEGRATED CIRCUITS		
U001	IC-MAX220CSE, SMT	06-6329

11. RS-232 Port Addition (LMI Part No. 4261-148)

The Model 2221 RS-232 port addition allows the Model 2221 data to be read as output to a computer or serial printer, by dumping either the ratemeter or scaler reading as desired. The desired reading is selected with a toggle switch located in the digital control section of the front panel, labeled with two positions: SCALER and DIG. RATE. The port addition kit (LMI Part No. 4261-148) includes the internal board and a cable that will connect directly to a 9-pin PC port.

The scaler reading dumps when the scaler has completed a count. The ratemeter is dumped every two seconds in one of three formats, depending on the firmware installed. The three available formats are 1 count per 2 seconds, 2 counts per 60 seconds (cpm), or 3 counts per second (cps). Data output is always in a six-digit format with a letter prefix, corresponding to the following:

Ratemeter: "R"

Scaler: According to the table below

Letter Prefix	Time of Count (min)	Time of Count (sec)
	Format 1 or 2	**Format 3 (cps version)**
A	0.1	1
B	0.2	2
C	0.5	5
D	1.0	10
E	2.0	30
F	5.0	60
G	10.0	120

A carriage return and then a line-feed character follows the sixth digit.

The communication protocol is 9600 baud, no parity, 1 stop bit, and 8 data bits. The RS-232 port is for output only with no handshaking available.

The Model 2221 will dump the data, no matter what, even if the attached computer or printer is not read. The cable provided is a coaxial cable, providing TXD and GND to a 9-pin D connector, ready to plug into a standard PC serial port.

Windows Hyper Terminal may be used to display and/or log the readings.

The Model 2221 processor board utilizes an EPROM with one of the following firmware numbers, depending on the desired rate:

Rate Dump as counts per 2 seconds – #261-06-N03.

Rate Dump as counts per 60 seconds – #261-07-N02.

Rate Dump as counts per second with meterface 202-930 – #261-02-N02.

261-06-N03 RS-232 output rate dump as counts per 2 seconds.

261-07-N02 RS-232 output rate dump as counts per 60 seconds.

261-02-N02 RS-232 output rate dump as counts per second (cps) with special meterface 202-930 (0-10 kcps).

261-02-N04 NEW RS-232 output every second, 0-10 kcps meterface 202-930, 1,2,5,10,30,60,120 sec scaler.

261-02-N07 NEW RS-232 output every second, original meterface, cpm RS-232 output.

12. DRAWINGS AND DIAGRAMS

Amplifier/Power Supply Board Schematic, Drawing 261 x 216
Amplifier/Power Supply Board Component Layout, Drawing 261 x 219 (2 sheets)

Processor Board Schematic, Drawing 261 x 91
Processor Board Component Layout, Drawing 261 x 103 (2 sheets)

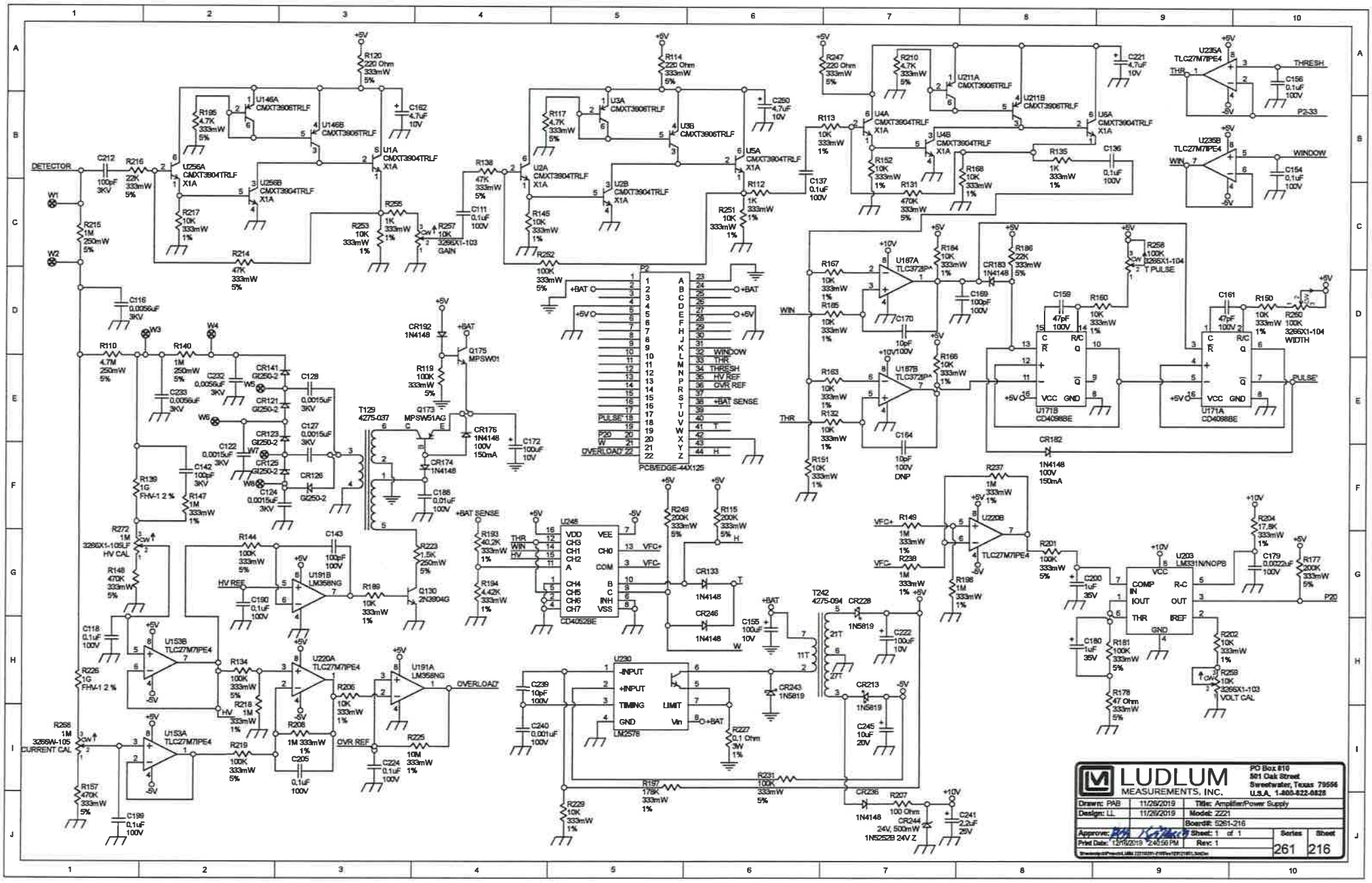
Calibration Board Schematic, Drawing 261 x 59
Calibration Board Component Layout, Drawing 261 x 59A

LCD Display Board Schematic, Drawing 261 x 58
LCD Display Board Component Layout, Drawing 261 x 209 (2 sheets)

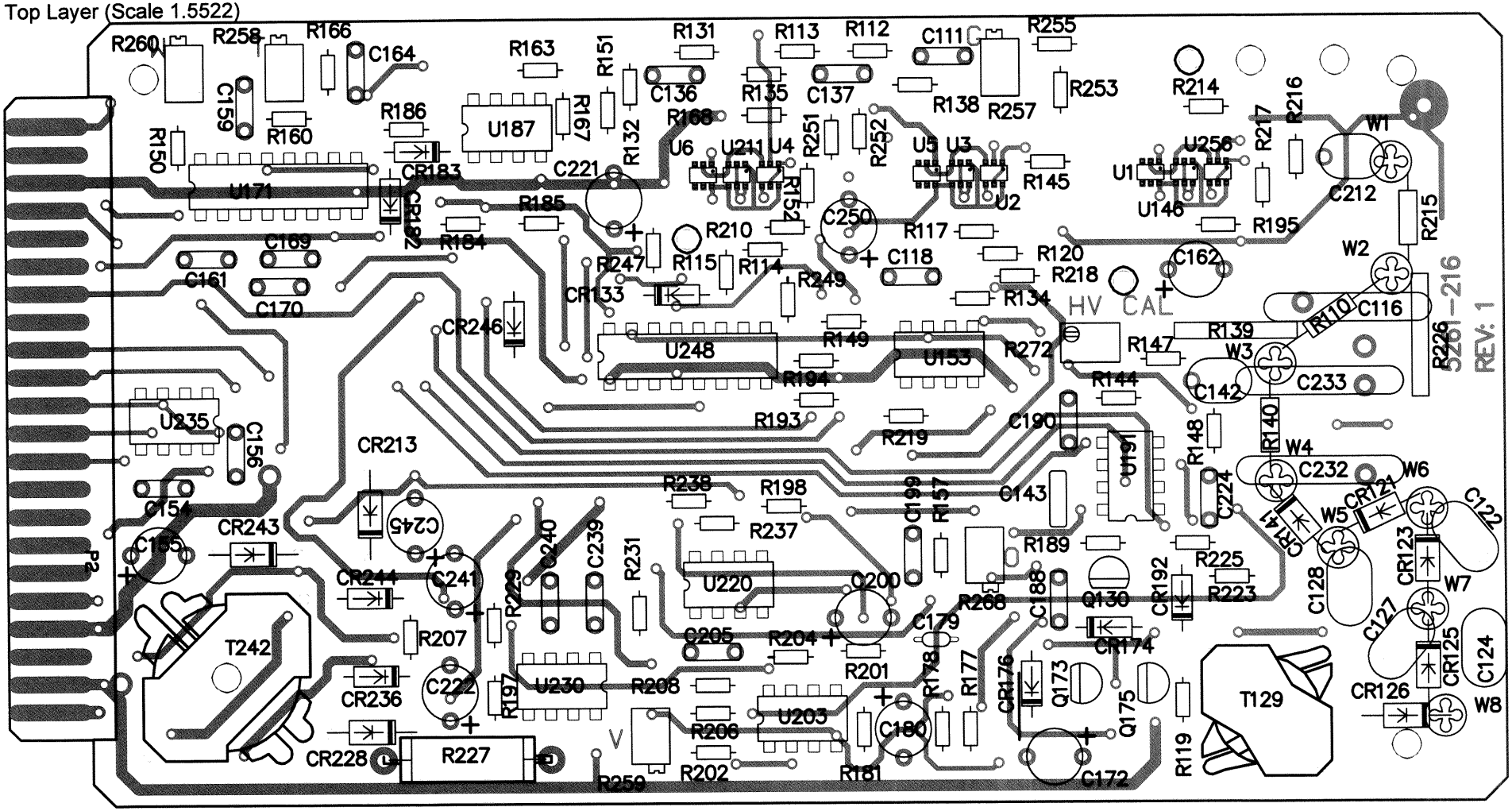
Backplane Board Schematic, Drawing 261 x 60
Backplane Board Component Layout, Drawing 261 X 76A

RS-232 Board Schematic, Drawing 261 x 179
RS-232 Board Component Layout, Drawing 261 x 180

Wiring Diagram, Drawing 261 x 61

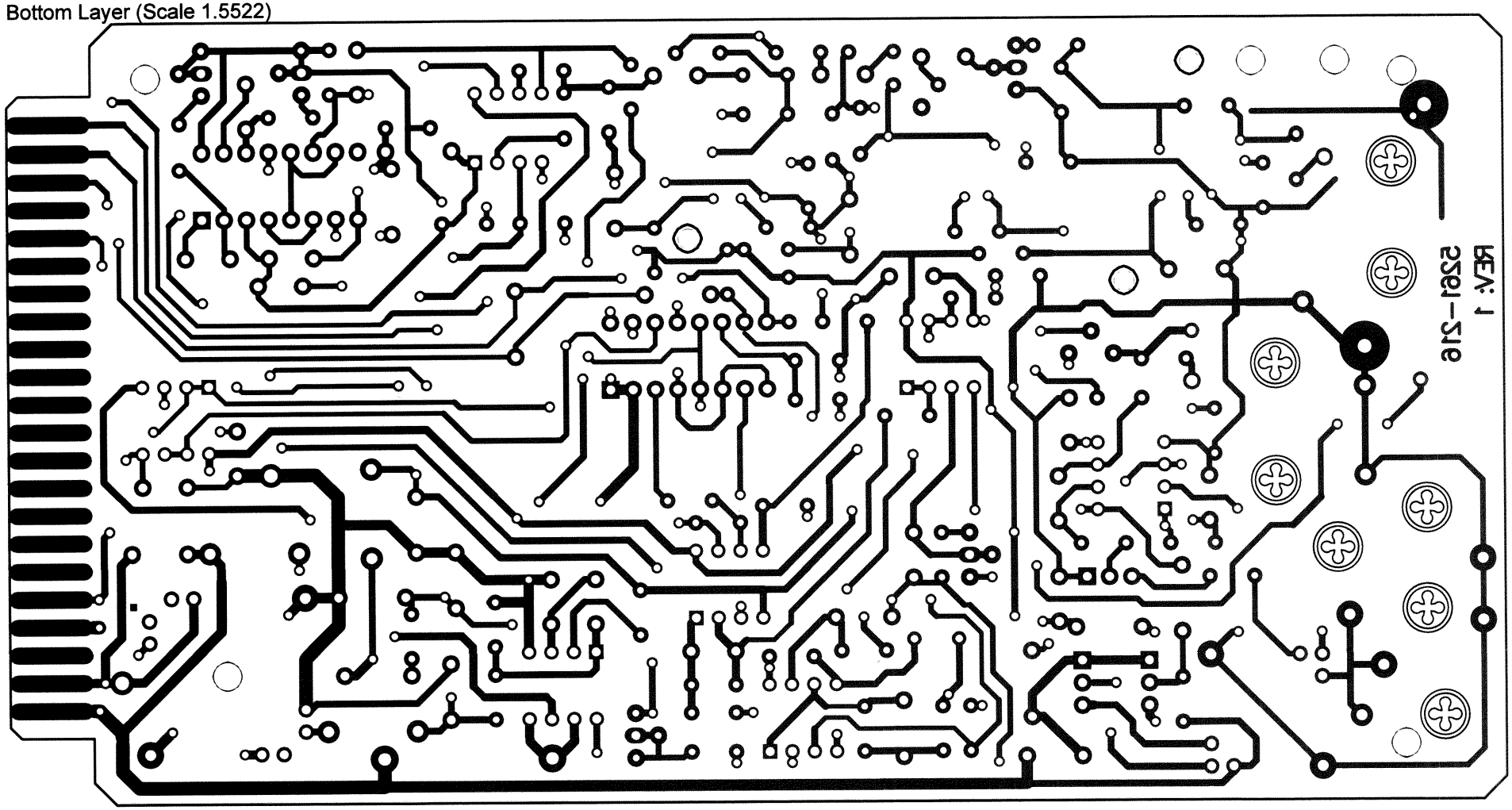

DETECTOR
W1
W2
R215 1M 250mW 5%
C212 100pF 3KV
R216 22K 333mW 5%
R214 47K 333mW 5%
U256A CMXT3904TRLF X1A
U256B CMXT3904TRLF X1A
U1A CMXT3904TRLF X1A
U1B CMXT3906TRLF
U146A CMXT3906TRLF
U146B CMXT3906TRLF
R195 4.7K 333mW 5%
R217 10K 333mW 1%
R253 10K 333mW 1%
R255 1K 333mW 1%
R257 10K 3266X-103 GAIN
C111 0.1uF 100V
C162 4.7uF 10V
R138 47K 333mW 5%
R145 10K 333mW 1%
R252 100K 333mW 5%
U2A CMXT3904TRLF X1A
U2B CMXT3904TRLF X1A
U3A CMXT3906TRLF
U3B CMXT3906TRLF
U5A CMXT3904TRLF X1A
R114 220 Ohm 333mW 5%
R117 4.7K 333mW 5%
R112 1K 333mW 1%
R251 10K 333mW 1%
C137 0.1uF 100V
C250 4.7uF 10V
R247 220 Ohm 333mW 5%
R210 4.7K 333mW 5%
U211A CMXT3906TRLF
U211B CMXT3906TRLF
U6A CMXT3904TRLF X1A
U4A CMXT3904TRLF X1A
U4B CMXT3904TRLF X1A
R113 10K 333mW 1%
R152 10K 333mW 1%
R131 470K 333mW 5%
R168 10K 333mW 1%
R135 1K 333mW 1%
C136 0.1uF 100V
C221 4.7uF 10V
U235A TLC27M7IPE4
U235B TLC27M7IPE4
THRESH
WINDOW
C156 0.1uF 100V
C154 0.1uF 100V
P2-33
C116 0.0056uF 3KV
W3
W4
R110 4.7M 250mW 5%
R140 1M 250mW 5%
C232 0.0056uF 3KV
C233 0.0056uF 3KV
CR141 GI250-2
CR121 GI250-2
CR123 GI250-2
CR125 GI250-2
CR126 GI250-2
W5
W6
W7
W8
C128 0.0015uF 3KV
C127 0.0015uF 3KV
C122 0.0015uF 3KV
C124 0.0015uF 3KV
C142 100pF 3KV
R139 1G FHV-1 2 %
R147 1M 333mW 1%
T129 4275-037
CR174 1N4148
C188 0.01uF 100V
CR192 1N4148
Q175 MPSW01
R119 100K 333mW 5%
Q173 MPSW51AG
CR175 1N4148 100V 150mA
C172 100uF 10V
+BAT
+BAT SENSE
P2
PCBEDGE-44X125
WINDOW
THR
THRESH
HV REF
OVR REF
PULSE'
P20
OVERLOAD'
R272 1M 3266X1-105LF HV CAL
R148 470K 333mW 5%
R144 100K 333mW 5%
C143 100pF 100V
C190 0.1uF 100V
U191B LM358NG
R189 10K 333mW 1%
Q130 2N3904G
R223 1.5K 250mW 5%
R193 60.2K 333mW 1%
R194 4.42K 333mW 1%
U245 CD4052BE
R249 200K 333mW 5%
R115 200K 333mW 5%
VFC+
VFC-
CR133 1N4148
CR246 1N4148
C155 100uF 10V
T242 4275-094
CR228 1N5819
C222 100uF 10V
CR213 1N5819
C245 10uF 20V
R237 1M 333mW 1%
R149 1M 333mW 1%
R238 1M 333mW 1%
R198 1M 333mW 1%
U220B TLC27M7IPE4
R201 100K 333mW 5%
C200 1uF 35V
U203 LM331N/NOPB
R204 17.8K 333mW 1%
C179 0.0022uF 100V
R177 200K 333mW 5%
C180 1uF 35V
R181 100K 333mW 5%
R178 47 Ohm 333mW 5%
R202 10K 333mW 1%
R259 10K 3266X1-103 VOLT CAL
C118 0.1uF 100V
U153B TLC27M7IPE4
R226 1G FHV-1 2 %
R134 100K 333mW 5%
R218 1M 333mW 1%
U220A TLC27M7IPE4
R206 10K 333mW 1%
R208 1M 333mW 1%
C205 0.1uF 100V
U191A LM358NG
R225 10M 333mW 1%
C224 0.1uF 100V
OVERLOAD'
OVR REF
R256 1M 3266W-105 CURRENT CAL
U153A TLC27M7IPE4
R219 100K 333mW 5%
R157 470K 333mW 5%
C199 0.1uF 100V
C239 10pF 100V
C240 0.001uF 100V
U230 LM2576
-INPUT
+INPUT
TIMING
GND
LIMIT
Vin
R227 0.1 Ohm 3W 1%
C243 1N5819
R197 178K 333mW 1%
R231 100K 333mW 5%
R229 10K 333mW 1%
CR236 1N4148
R207 100 Ohm 24V, 500mW 1N5252B 24V Z
CR244
C241 2.2uF 25V
U187A TLC372IP
U187B TLC372IP
U171B CD4098BE
U171A CD4098BE
R167 10K 333mW 1%
R185 10K 333mW 1%
R163 10K 333mW 1%
R132 10K 333mW 1%
R151 10K 333mW 1%
R164 10K 333mW 1%
R166 10K 333mW 1%
R169 10K 333mW 1%
C169 100pF 100V
C170 10pF 100V
C164 10pF 100V DNP
CR183 1N4148
R186 22K 333mW 5%
R258 100K 3266X1-104 PULSE
C159 47pF 100V
R160 10K 333mW 1%
C161 47pF 100V
R150 10K 333mW 1%
R250 100K 3266X1-104 WIDTH
CR182 1N4148 100V 150mA
LUDLUM MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828
Drawn: PAB 11/26/2019
Design: LL 11/26/2019
Title: Amplifier/Power Supply
Model: 2221
Board#: 5261-216
Approve:
Sheet: 1 of 1
Rev: 1
Print Date: 12/16/2019 2:40:56 PM
Series 261
Sheet 216

Top Layer (Scale 1.5522)

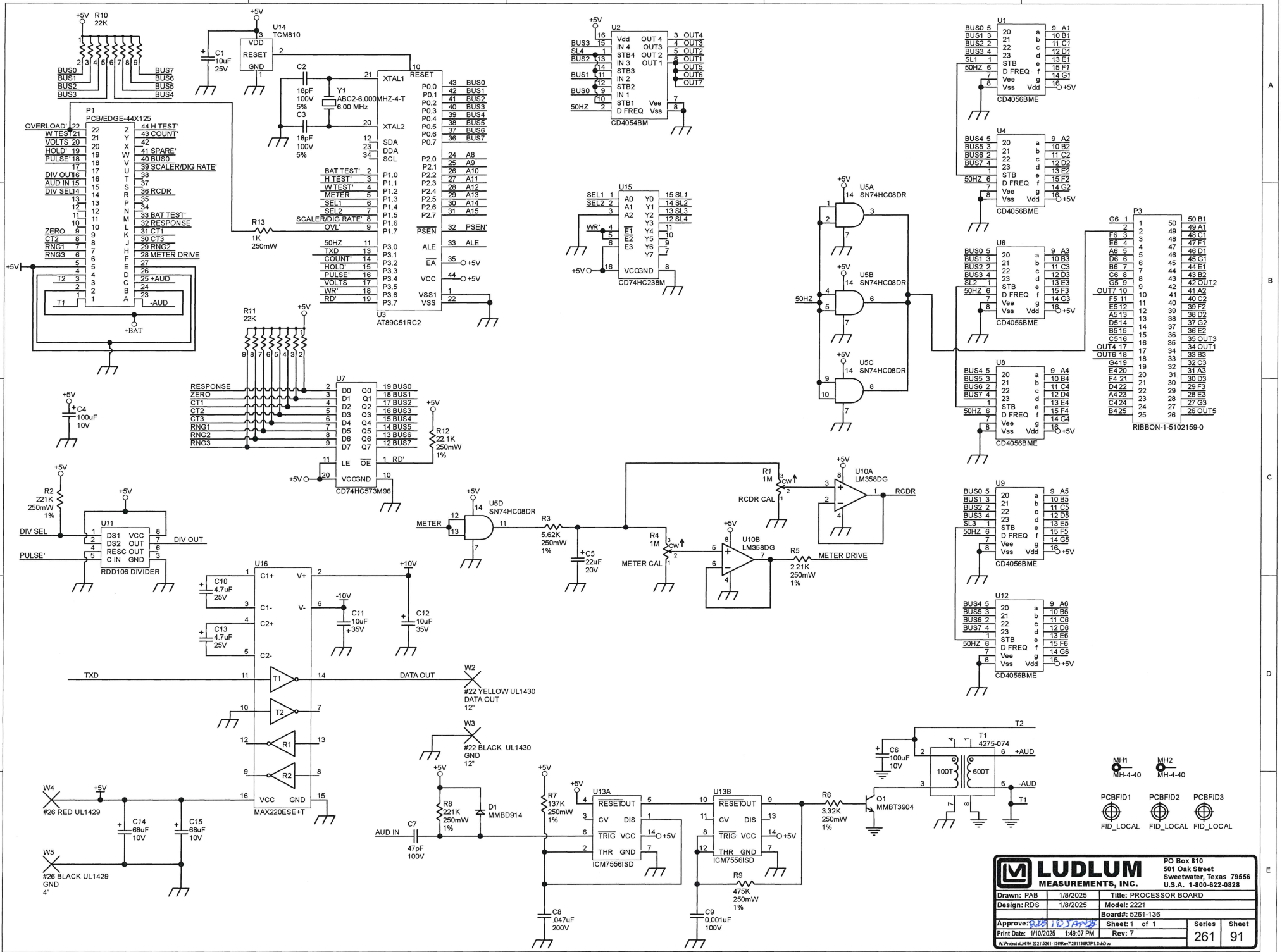


LUDLUM MEASUREMENTS			
Part: 5261-216	**Model:** 2221		
Desc: Amplifier/Power Supply		**Rev:**	1
	SHEET: 1 of 4	**SERIES**	**SHEET**
DWN: PAB	**DATE:** 2/26/2021	261	219
APR: RDS	**DATE:** 28 JUL 21		

Bottom Layer (Scale 1.5522)



LUDLUM MEASUREMENTS			
Part: 5261-216	Model: 2221		
Desc: Amplifier/Power Supply		Rev:	1
	SHEET: 2 of 4	SERIES	SHEET
DWN: PAB	DATE: 2/26/2021	261	219
APR: RJS	DATE: 28 JUL 21		



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: PAB	1/8/2025	Title: PROCESSOR BOARD	
Design: RDS	1/8/2025	Model: 2221	
		Board#: 5261-136	
Approve: RDS 10 Jan 25		Sheet: 1 of 1	Series 261 / Sheet 91
Print Date: 1/10/2025 1:49:07 PM		Rev: 7	
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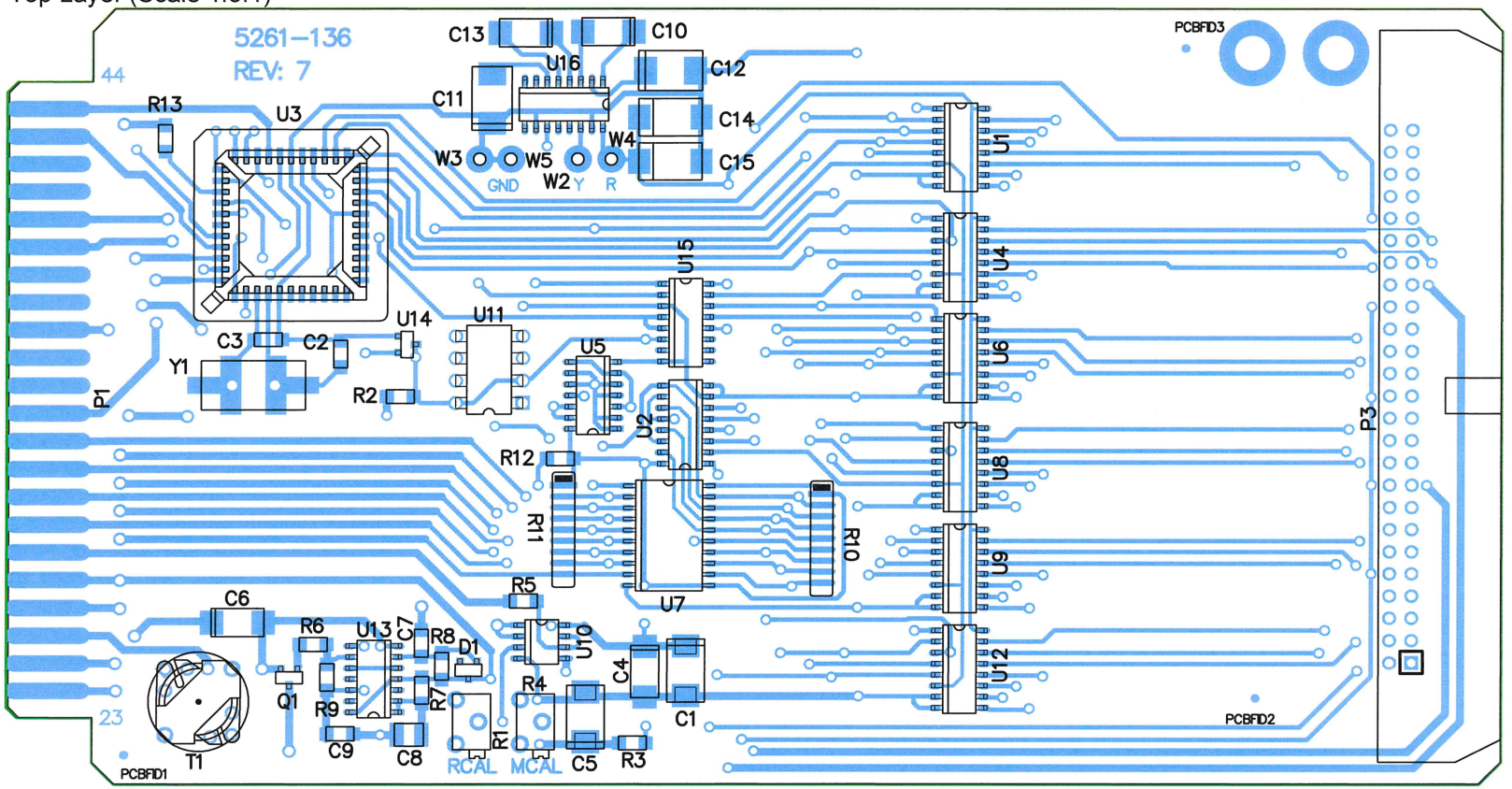
Top Layer (Scale 1.3:1)



LUDLUM MEASUREMENTS				
Part: 5261-136	**Model:** 2221			
Desc: PROCESSOR BOARD				
Design: RDS	**Date:** 1/8/2025		**Rev:**	7
Drawn: PAB	**Date:** 1/8/2025	**SHEET**	**SERIES**	**SHEET**
Apr: RDS	**Date:** 10Jan25	1 of 3	261	103
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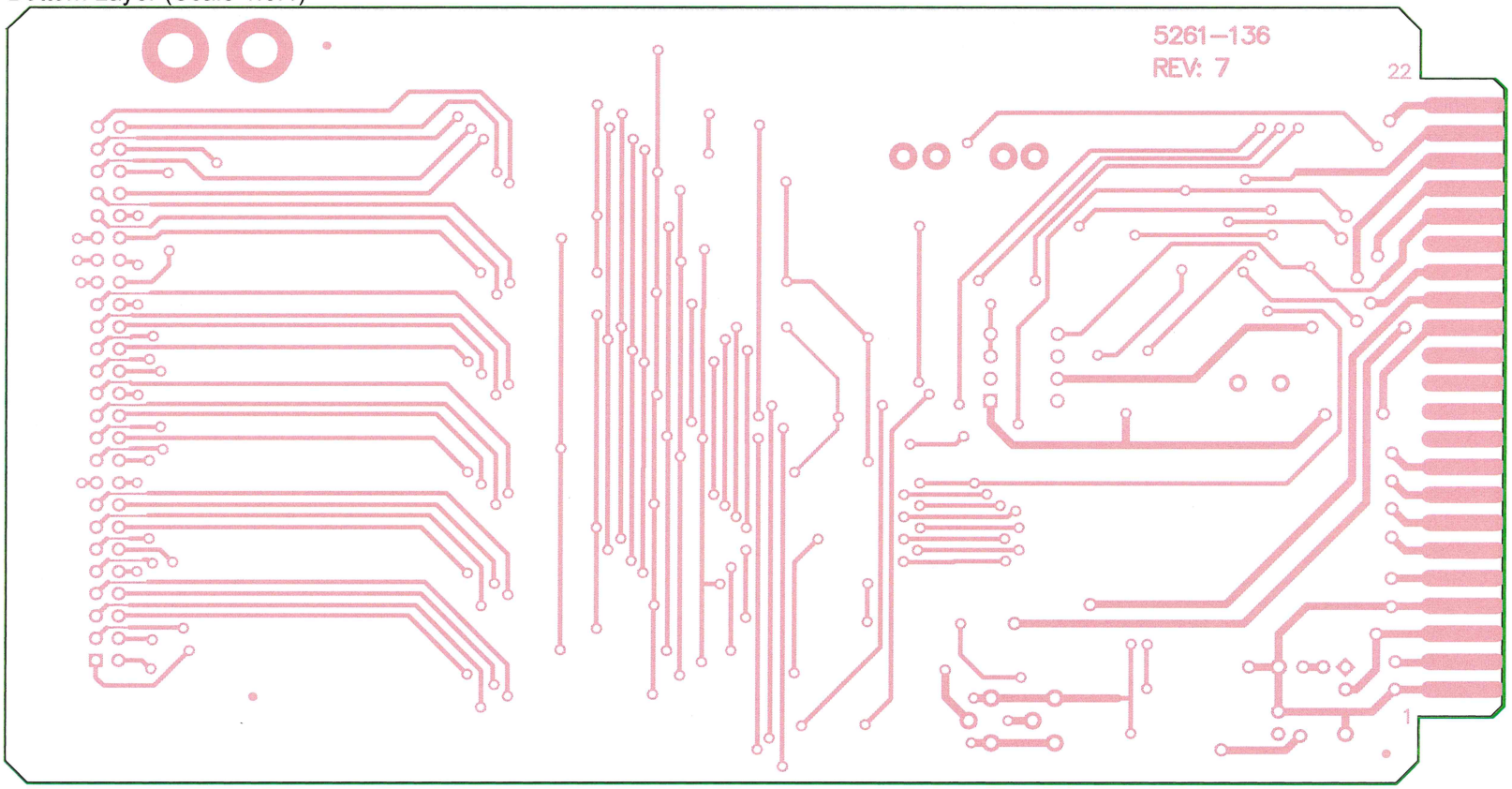
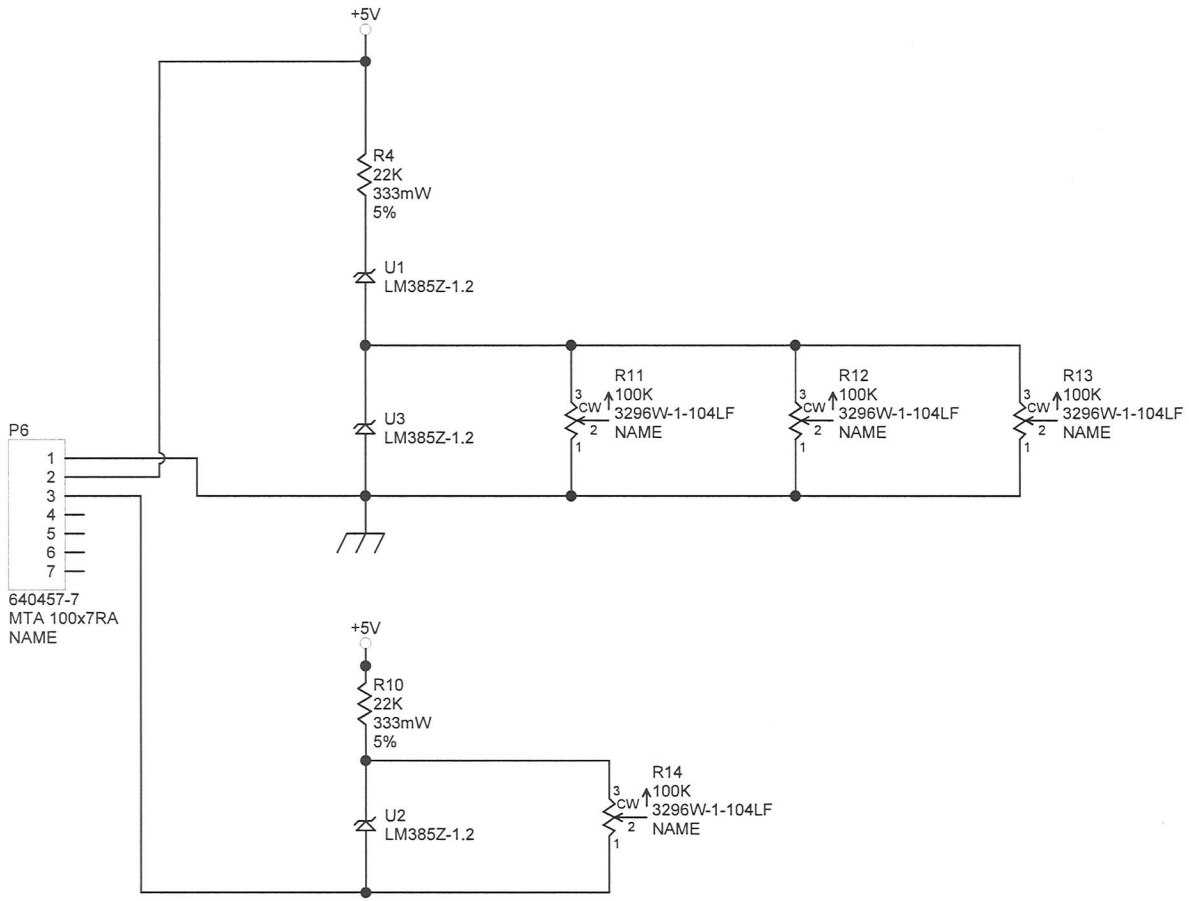
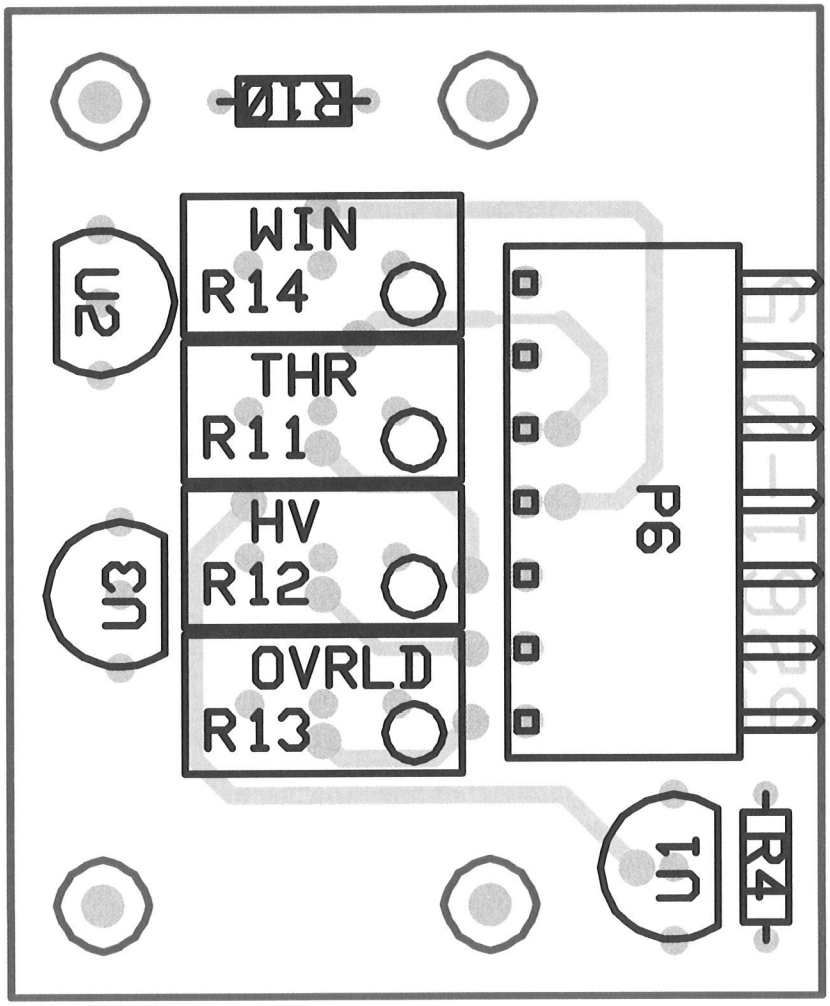
Bottom Layer (Scale 1.3:1)



LUDLUM MEASUREMENTS				
Part: 5261-136	**Model:** 2221			
Desc: PROCESSOR BOARD				
Design: RDS	**Date:** 1/8/2025		**Rev:**	7
Drawn: PAB	**Date:** 1/8/2025	**SHEET**	**SERIES**	**SHEET**
		2 of 3	261	103
W:\Projects\LMI\M 2221\5261-136\Rev7				

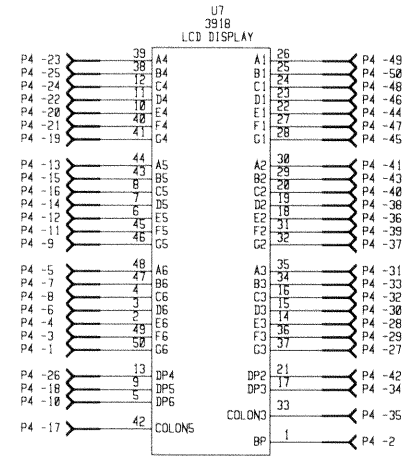


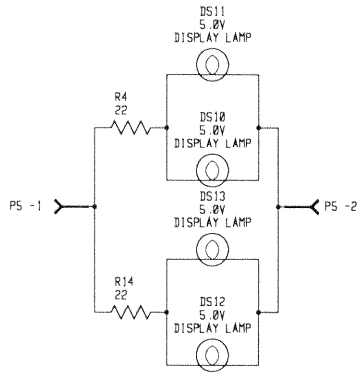
LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: LL	3/16/89	**Title:** Calibration Board	
Design: LL	3/16/89	**Model:** 2221	
		Board#: 5261-075	
Approve: DHS	28 JAN 15	**Sheet:** 1 of 1	**Series** 261 / **Sheet** 59
Print Date: 1/27/2015 5:06:45 PM		**Rev:** 1	
W:\Projects\LM\M 2221\5261-075\Rev1\261075R1.SchDoc			



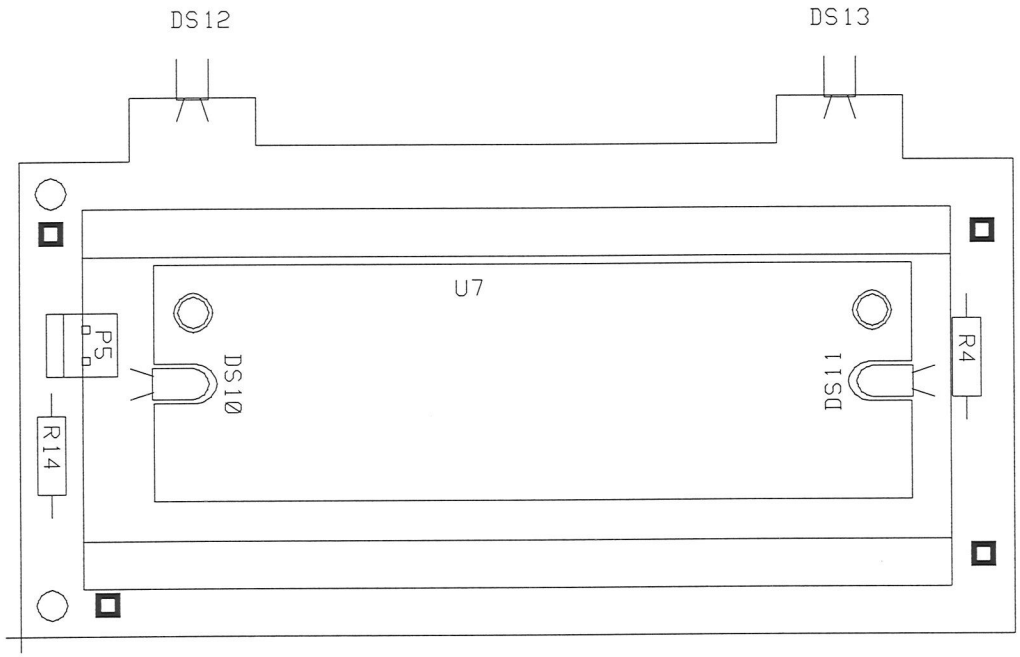
LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828		
Title: Calibration Board				
Drawn: LL	3/16/89	**Model:** 2221		
Design: LL	3/16/89	**Board#:** 5261-075		
Approve: RDS	8 Jul 14	**Rev:** 1		
PCBA Drawing		**SCALE: 1.00**	**Series** 261	**Sheet** 59A
Print Date: 7/8/2014 11:17:46 AM		Top Overlay		
W:\Projects\LM\M 2221\5261-075\Rev1\261075R1_Assy.PcbDoc				

REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED

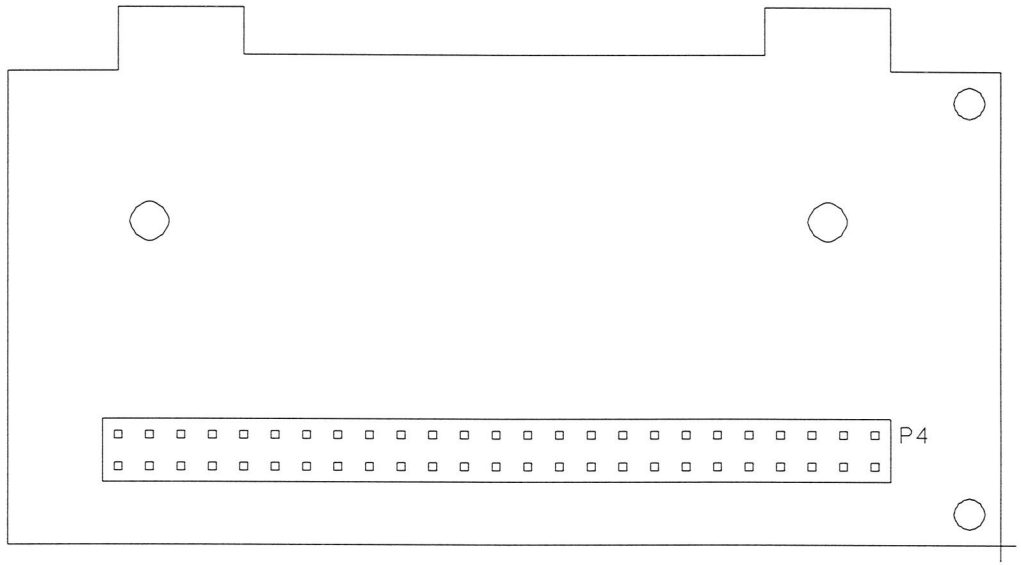




UPDATED	-	LUDLUM MEASUREMENTS INC.	
DR LL	3/16/89	TITLE: LCD DISPLAY	
CHK			
DSGN LL	3/16/89	BOARD# 5261-074	
APPD		SIZE C / MODEL 2221 / SERIES 261 / SHEET 58	
NEXT HIGHER ASSY.			
14:47:32	20-Apr-00	S8261074	SHEET 1 OF 1

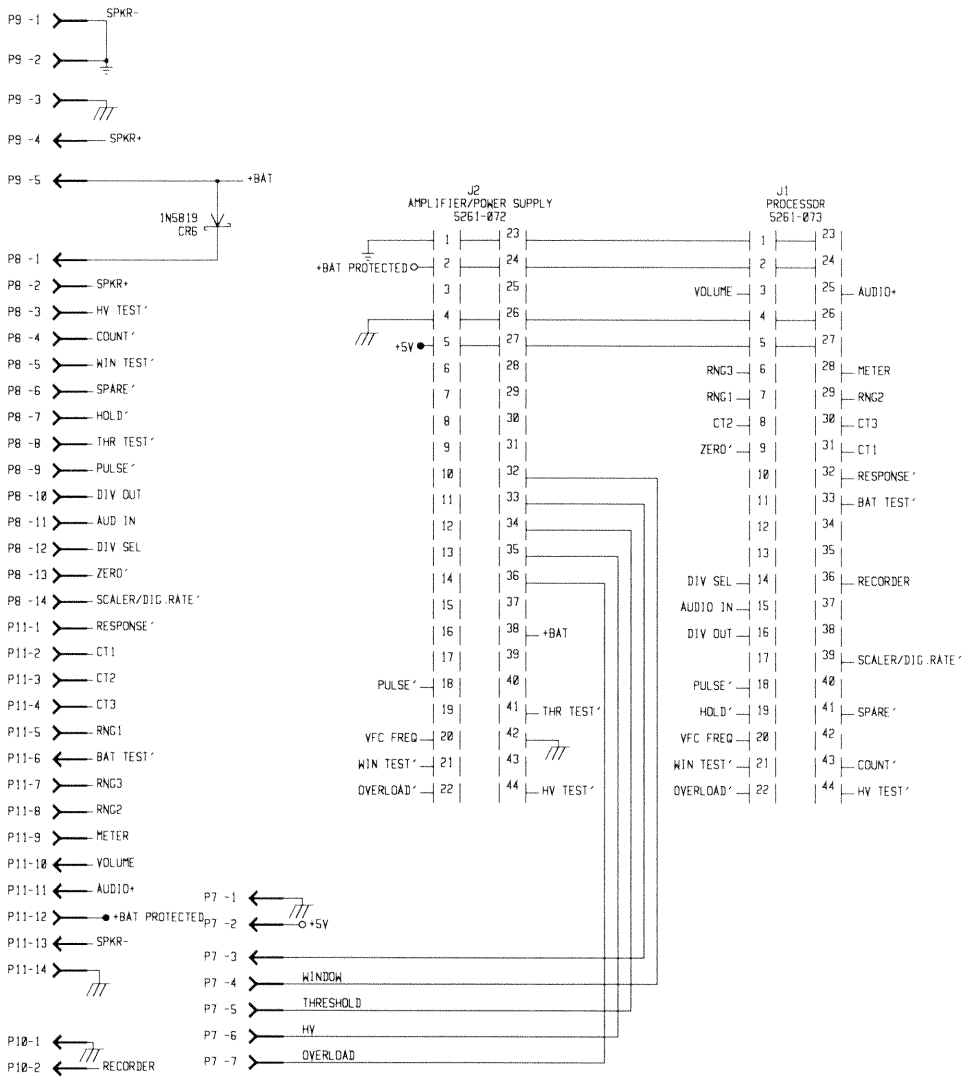


LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR LL	03/27/89	TITLE: DISPLAY BOARD	
		BOARD: 5261-074	
DSGN LL	03/16/89	MODEL: 2221	
APP RJS	7Nov13	FILENAME: BS261074	
		09:51:12	7-Nov-13
COMPONENT	SOLDER	REVISION	SERIES / SHEET
OUTLINE	OUTLINE	1.0	261 / 209

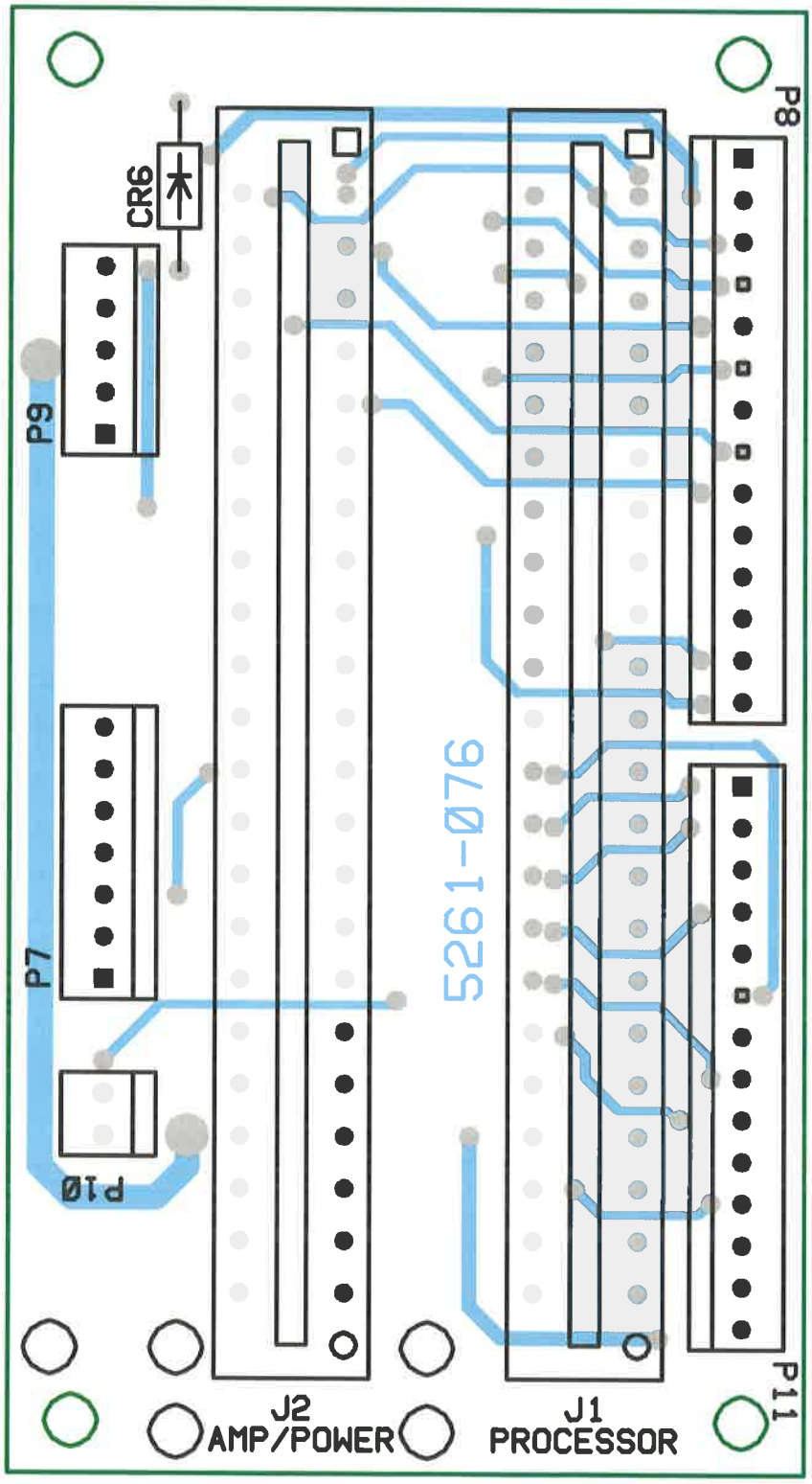


LUDLUM MEASUREMENTS INC. SWEETWATER, TX.				
DR LL	03/27/89	TITLE: DISPLAY BOARD REV 1		
		BOARD# 5261-074 FILE		
DSGN LL	03/16/89	MODEL 2221	SERIES 261	SHEET 209
APP RGS	7Nov13	COMP ARTWORK ☐	SLDR ARTWORK ☐	
00:00:00	00/00/00	COMP OUTLINE ☐	SLDR OUTLINE ☒	
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR MASK ☐	

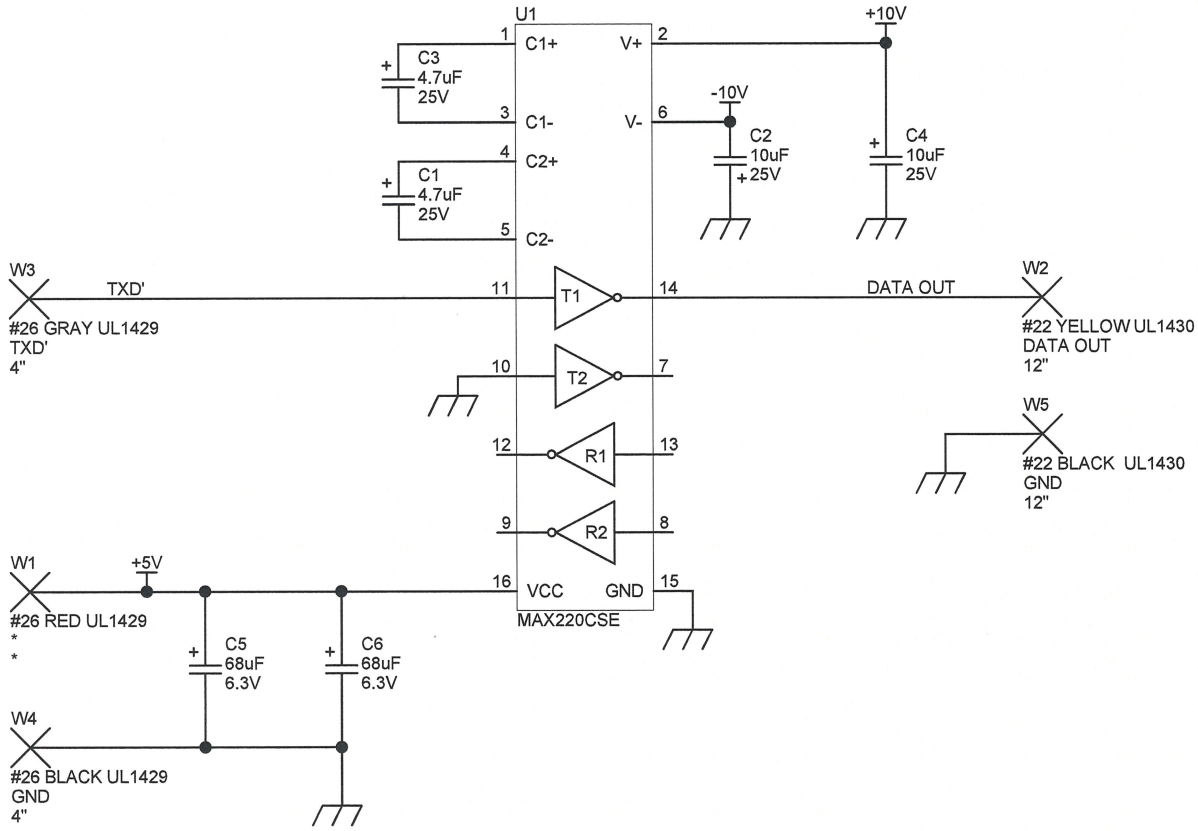
REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



UPDATED -		LUDLUM MEASUREMENTS INC.	
DR LL	3/16/89	TITLE: BACKPLANE	
DSGN LL	3/16/89	BOARD# 5261-076	
APPD RJ	3/16/89	SIZE C / MODEL 2221	SERIES 261 / SHEET 60
NEXT HIGHER ASSY. -			
14:57:34	22-May-08	S8261076	SHEET 1 OF 1



LUDLUM MEASUREMENTS, INC.	PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828			
Title: Backplane				
Drawn: LL	3/16/89	**Model:** 2221		
Design: LL	3/16/89	**Board#:** 5261-076		
Approve: LL	22 Nov 18	**Rev:** 1		
PCBA Drawing		**SCALE: 1.08**	**Series** 261	**Sheet** 76
Print Date: 11/21/2018 9:12:03 AM		Top Overlay		
\\freedom\pcb\Projects\LMI\M 2221\5261-076\Rev1\261076R1_Assy.PcbDoc				



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: CKB	03/21/2001	**Title:** RS-232 BOARD	
Design: RDS	11/11/1999	**Model:** 2221	
		Board#: 5261-179	
Approve: RDS	11 Feb 13	**Sheet:** 1 of 1	**Series** 261 / **Sheet** 179
Print Date: 2/8/2013	1:57:38 PM	**Rev:** 1	
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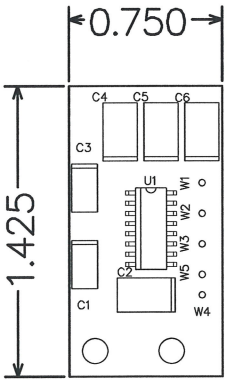
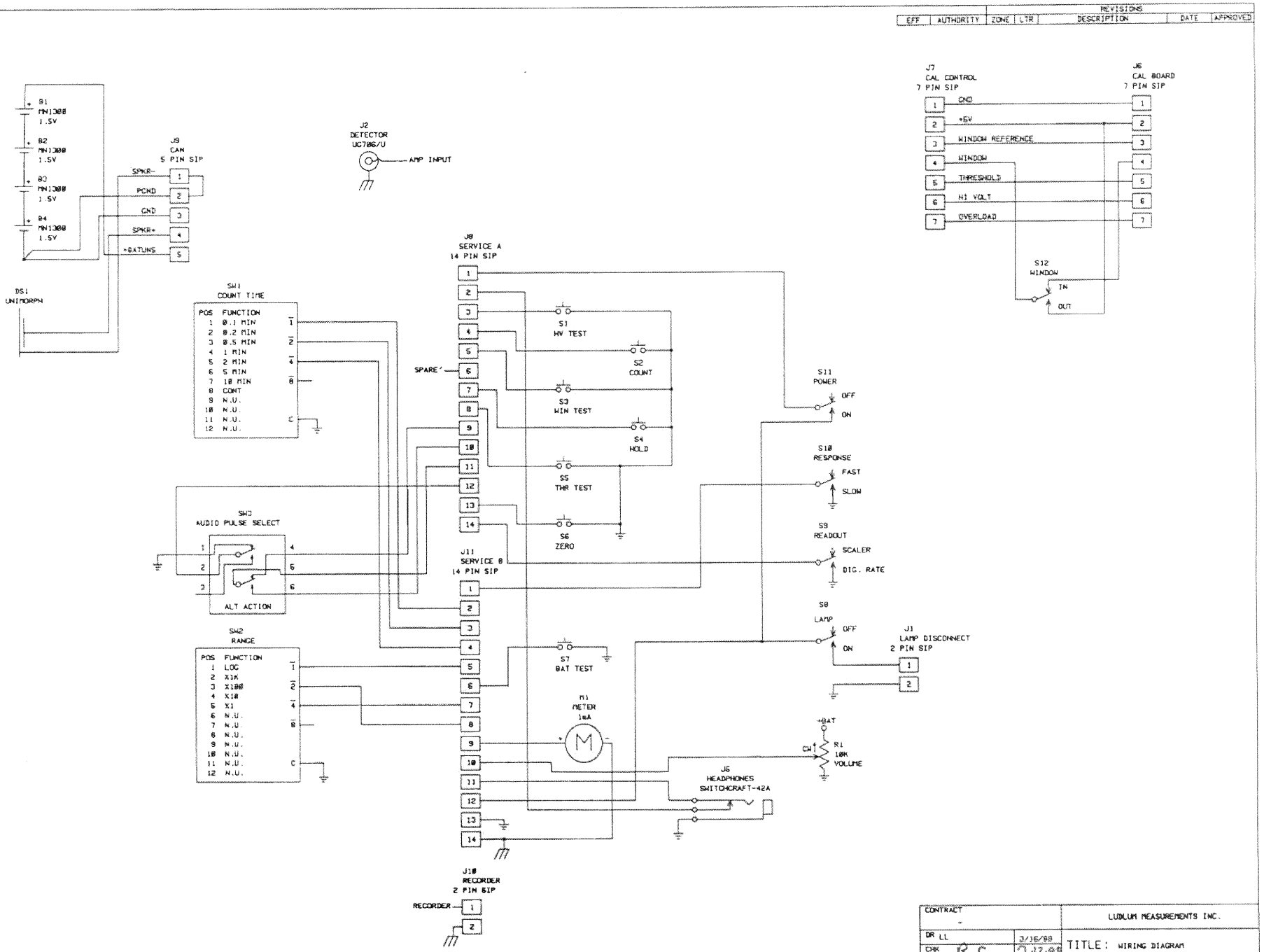


LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828	
Title: RS-232 BOARD			
Drawn: CKB	03/21/2001	**Model:** 2221	
Design: RDS	11/11/1999	**Board#:** 5261-179	
Approve: RDS	11Feb13	**Rev:** 1	
Print Date: 2/8/2013 1:57:39 PM		**SCALE: 1.00** Top Overlay	**Series** 261 / **Sheet** 180
W:\Projects\LMI\M 2221\5261-179\rev1.0\261179R1_Manual.PcbDoc			


REVISIONS
EFF | AUTHORITY | ZONE | LTR | DESCRIPTION | DATE | APPROVED
B1 MN1300 1.5V
B2 MN1300 1.5V
B3 MN1300 1.5V
B4 MN1300 1.5V
J9 CAN 5 PIN SIP
SPKR-
PGND
GND
SPKR+
+8ATUNS
J2 DETECTOR UG70S/U
AMP INPUT
J7 CAL CONTROL 7 PIN SIP
J6 CAL BOARD 7 PIN SIP
GND
+5V
WINDOW REFERENCE
WINDOW
THRESHOLD
HI VOLT
OVERLOAD
S12 WINDOW
IN
OUT
DS1 UNIMORPH
SW1 COUNT TIME
POS FUNCTION
1 0.1 MIN
2 0.2 MIN
3 0.5 MIN
4 1 MIN
5 2 MIN
6 5 MIN
7 10 MIN
8 CONT
9 N.U.
10 N.U.
11 N.U.
12 N.U.
J8 SERVICE A 14 PIN SIP
SPARE
S1 HV TEST
S2 COUNT
S3 WIN TEST
S4 HOLD
S5 THR TEST
S6 ZERO
S7 BAT TEST
S11 POWER
OFF
ON
S10 RESPONSE
FAST
SLOW
S9 READOUT
SCALER
DIG. RATE
S8 LAMP
OFF
ON
J1 LAMP DISCONNECT 2 PIN SIP
SW3 AUDIO PULSE SELECT
ALT ACTION
J11 SERVICE B 14 PIN SIP
SW2 RANGE
POS FUNCTION
1 LOG
2 X1K
3 X100
4 X10
5 X1
6 N.U.
7 N.U.
8 N.U.
9 N.U.
10 N.U.
11 N.U.
12 N.U.
M1 METER 1mA
+BAT
CW
R1 10K VOLUME
J5 HEADPHONES SWITCHCRAFT-42A
J10 RECORDER 2 PIN SIP
RECORDER
CONTRACT
-
LUDLUM MEASUREMENTS INC.
DR LL 3/16/98
CHK R.C. 7/13/98
DSGN LL 3/16/98
APP'D BS 7/13/98
NEXT HIGHER ASST.
-
TITLE: WIRING DIAGRAM
BOARD 261-877
SIZE D
MODEL 2221
SERIES 200
SHEET 61
10:41:05 05-28-98
S8261877.DRW
SHEET 1 OF 1

261 x 61