LUDLUM MODEL 2221
PORTABLE SCALER RATEMETER

Revised March 2016

Serial Number 161568 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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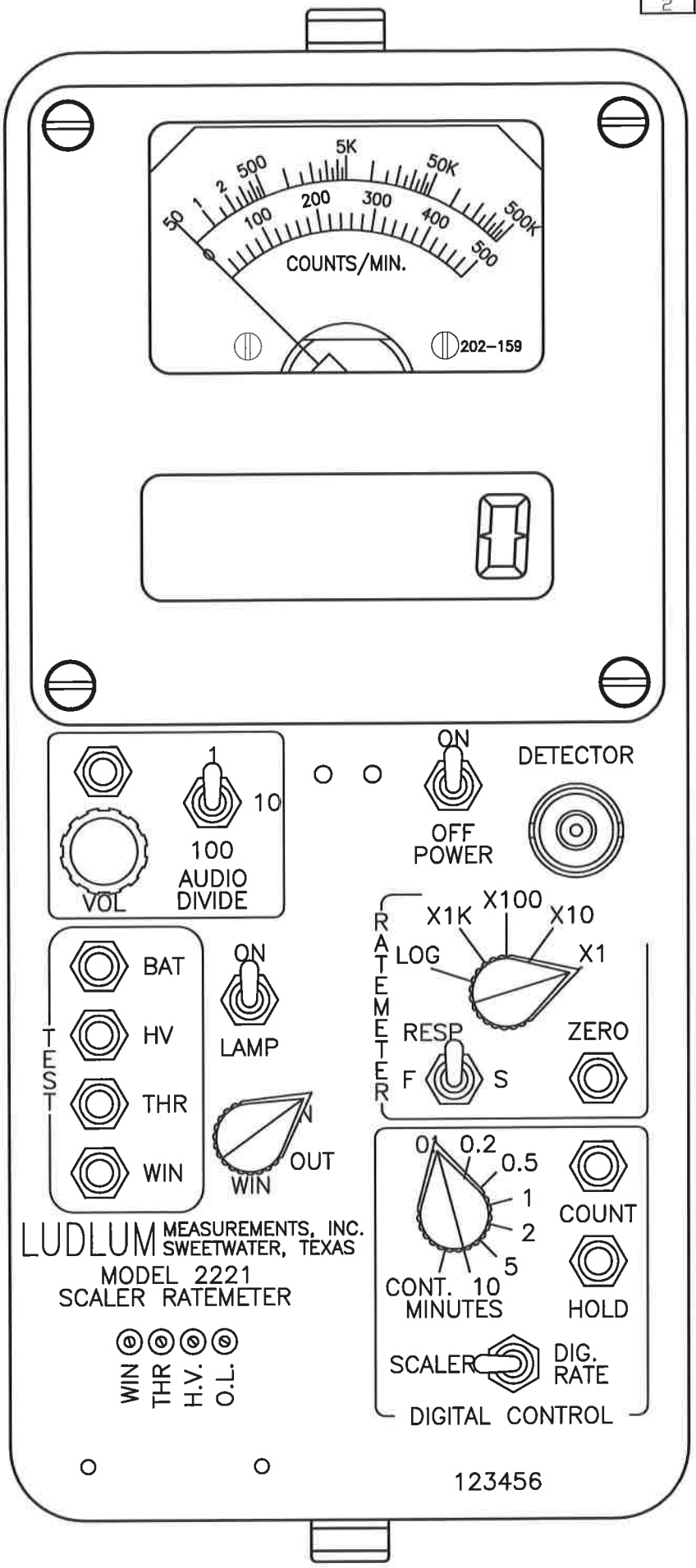

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TITLE: MODEL 2221 PORTABLE SCALER

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

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Model 2221 Portable Scaler Ratemeter
March 2016

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 to 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 COMPLEMENT**: four each "D" cell batteries
- **BATTERY LIFE**: approximately 250 hours

- **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

- Unscrew battery door latch.
- Install 4 "D" size batteries in the battery holder. The correct position of the batteries is indicated on the bottom of the battery door.
- 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.)
- Press COUNT pushbutton. The display should zero. Two sets of colons should appear on the display.
- Press HOLD pushbutton. The colons should disappear.
- 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.

- 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

- Set WIN ON/OFF to OFF.
- Set MINUTES switch to 0.1 minutes.
- Set THR control at 100.
- 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.
- Expose the detector to a source and again make a plot of voltage versus count.
- 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:

- Place RATEMETER multiplier switch to LOG position.
- Unscrew and remove CAL cover.
- 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.
- Depress the THR pushbutton. Turn the THR potentiometer clockwise until 652 displays.
- With WIN IN/OUT switch IN, depress the WIN pushbutton. Turn the WIN potentiometer until 20 appears on the display.
- Switch WIN IN/OUT to OUT.
- Connect the probe and expose to a ^{137}Cs source (a source of approximately 10μCi placed 3-4 inches away is recommended).
- 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.
- Switch WIN IN/OUT switch to IN.
- 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.
- Turn RATEMETER selector switch to the X1K position.
- Press ZERO pushbutton and release. If meter does not read, switch to a lower range until a reading occurs.

- 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

- 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.

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

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

- 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.

- 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).

- 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).

- 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

- Connect frequency counter to pin 18 of U22 (80C51FA) on processor board, #5261-073. Confirm crystal frequency is 6 MHz ±0.1% (6006-5994 kHz).

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

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

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

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

- Adjust R40 Meter Cal (labeled MCAL) on Processor board, for 40,000 CPM on meter.

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

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

8.2 TEST Pushbutton/Display Calibration

- Adjust THR control to fully clockwise position.

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

- 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.

8.3 High Voltage Calibration

- Connect HV meter (1000 Megohm input impedance or greater) to the junction of R32 (4.7 Meg) and R33 (1 Meg) on the amplifier/power supply board.

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

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

- 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

- Set pulser pulse amplitude to 10 mV.

- With THR set at 100, fine adjust R174 gain control (on Power Supply board) until ratemeter reads 30,000 CPM with 40,000 CPM from pulser.

- 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.

- Adjust THR control back to 100.

- 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.

- Set WIN back to 100 and OUT position.

- 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

- 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).
- 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.
- Adjust input voltage for approximately +4 Vdc and turn instrument to the ON position. Battery current should be approximately 30 mA or less.
- Confirm pin 8 of U7 (CA3290A) is equal to or greater than +6.4 Vdc.
- Increase supply voltage to approximately +5 Vdc and pin 8 of U7 should increase to +9 ±1 Vdc.
- Check for +5 ±0.15 Vdc at pin 8 of any of the TLC27M7IP circuits (such as U3 or U4).
- Check for -6.5 ± 0.5 Vdc at pin 4 of any of the same TLC27M7IP circuits.
- Connect subminax wire from detector input to amplifier/power supply board.
- Connect HV meter to detector input and adjust front-panel HV control to fully clockwise position.
- Adjust the HV front panel control to the fully clockwise position. Then adjust R175 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.
- Connect voltmeter to pin 1 of U3 (TLC27M7IP).
- With HV output set at approximately 1000 volts, adjust R176 Current Cal (labeled "O") for approximately 0.1 Vdc at pin 1 of U3.
- Connect Overrange Simulator (needs to have a 1000 meg resistor) to detector input and confirm pin 1 of U3 increases to approximately 0.15 ±0.01 Vdc.
- Connect voltmeter to pin 1 of U2 (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.
- Turn O.L. control to its maximum clockwise position.
- Connect positive voltmeter lead to pin 7 of U3 (TLC27M7IP) and connect negative lead to ground close to U3.
- Press the WIN test pushbutton and confirm pin 7 of U3 is approximately 2.7 to 3.8 volts.
- Press THR test and confirm pin 7 is 1.23 ±0.02 Vdc.
- Press BAT test pushbutton and confirm pin 7 is approximately 0.5 with supply voltage at +5 Vdc.

- 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.

- 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.

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

- 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.

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

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

- 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.

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

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

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

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

- 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.

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

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

9.2 Processor Board Checkout

- 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.

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

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

- Set signal generator to square wave function.

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

- 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.

- 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.

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

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

- 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.

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

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

- Switch ratemeter response time to F.

- Switch Ratemeter multiplier to X100.

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

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

- 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.

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

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

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

- 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.

- Check Count, Hold, and Zero pushbutton functions.

- 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.

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

9.3 Functional/Chassis Checkout

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

- Connect one lead of an ohmmeter to chassis ground.

- 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.
  1= open
  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

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

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

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

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

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

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

- 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.

- 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.

- 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.

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

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

- Adjust HV for approximately 1000 volts.

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

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

- 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.

- Set THR control to 100 and Window IN/OUT switch to the OUT position.
- Connect pulser and adjust count rate for 40,000 CPM.
- Switch ratemeter multiplier switch to the X100 position and the response switch to "F."
- Adjust pulse amplitude above threshold until a steady count rate is observed on ratemeter.
- Adjust R40 Meter Cal (labeled MCAL) on processor board, for 400 CPM on meter.
- 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.
- Switch SCALER/DIG. RATE switch to the SCALER position.
- Confirm count time switch operation by taking a 0.1 minute and 0.5 minute count. Colons should be observed during count cycle.
- Check HOLD and ZERO pushbutton functions.
- Switch SCALER/DIG. RATE switch to the DIG. RATE position and confirm update count display operation approximately every two seconds.
- 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.
- 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.
- Instrument may have to be placed in can to permit noise-free operation.
- Set pulser pulse amplitude to 10 mV.
- With THR still set at 100, fine adjust R174 gain control until ratemeter reads 30,000 CPM with 40,000 CPM from pulser.
- 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.
- Adjust THR control back to 100.
- 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.
- Set WIN back to 100 and OUT position for instrument shipment.
- 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.
- Check F/S ratemeter response time for 4.5 ±0.5 and 22 ±2 seconds at 90% of full scale.
- 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.
- 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.

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

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

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

- 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 56		
BOARD	Assembled Board	5261-072
CAPACITORS		
C107	1µF, 35V, DT	04-5575
C108	2.2µF, 25V, DT	04-5559
C109	4.7µF, 10V, DT	04-5578
C110	4.7µF, 10V, DT	04-5578
C111	100µF, 10V, DT	04-5576
C112	4.7µF, 10V, DT	04-5578
C114	10pF, 100V, C	04-5573
C115	0.1µF, 100V, C	04-5521
C116	0.1µF, 100V, C	04-5521
C117	0.1µF, 100V, C	04-5521
C118	0.1µF, 100V, C	04-5521
C120	0.0022µF, 100V, P	04-5580
C121	0.001µF, 100V, C	04-5519
C122	0.1µF, 100V, C	04-5521
C123	100pF, 100V, C	04-5527
C124	0.1µF, 100V, C	04-5521
C125	0.01µF, 100V, C	04-5523
C126	47pF, 100V, C	04-5533
C127	0.1µF, 100V, C	04-5521
C128	47pF, 100V, C	04-5533
C129	100pF, 100V, C	04-5527
C130	10pF, 100V, C	04-5573
C131	0.1µF, 100V, C	04-5521
C132	10pF, 100V, C	04-5573
C133	0.0015µF, 3kV, C	04-5518
C135	0.0015µF, 3kV, C	04-5518
C136	0.0015µF, 3kV, C	04-5518
C137	100pF, 3kV, C	04-5532
C138	100pF, 3kV, C	04-5532
C139	0.0056µF, 3kV, C	04-5522
C140	0.0056µF, 3kV, C	04-5522
C141	0.0056µF, 3kV, C	04-5522
C145	1µF, 35V, DT	04-5575
C146	100µF, 10V, DT	04-5576
C147	100µF, 10V, DT	04-5576
C148	10µF, 20V, DT	04-5592
C154	0.0015µF, 3kV, C	04-5518
C164	0.1µF, 100V, C	04-5521
C165	0.1µF, 100V, C	04-5521
TRANSISTORS		
Q142	2N3904	05-5755
Q143	MPSU51	05-5765
INTEGRATED CIRCUITS		
U1	TLC27M7	06-6248
U2	LM358	06-6024
U3	TLC27M7	06-6248
U4	TLC27M7	06-6248
U5	LM331	06-6156
U6	LM2578	06-6223
U7	CA3290AE	06-6140
U8	CA3096	06-6023
U9	CA3096	06-6023
U105	CD4098	06-6066
U106	CA3096	06-6023
U144	CD4052	06-6141
DIODES		
CR10	IN5819	07-6306
CR12	MR-250-2	07-6266
CR13	MR-250-2	07-6266
CR14	MR-250-2	07-6266
CR15	MR-250-2	07-6266
CR16	1N4148	07-6272
CR17	1N4148	07-6272
CR18	1N4148	07-6272
CR19	1N4148	07-6272
CR20	1N4148	07-6272
CR21	1N4148	07-6272
CR22	1N4148	07-6272
CR24	1N5819	07-6306
CR25	1N5819	07-6306
CR151	MR-250-2	07-6266
CR177	1N5252	07-6265
RESISTORS		
R32	4.7M	10-7030
R33	1M	10-7028
R34	1M	10-7028
R35	1G	12-7686
R36	1G	12-7686
R37	0.1 OHM, 1%	12-7647

Ref. No. Description Part No.

Ref. No. Description Part No.

R38	10k	12-7748
R39	1M, 1%	12-7609
R40	10k	12-7748
R41	10k	12-7748
R42	10k	12-7748
R43	10k	12-7748
R44	47k	12-7758
R45	4.7k	12-7755
R46	10k	12-7748
R47	10k	12-7748
R48	10k	12-7748
R49	1k	12-7750
R50	220 OHM	12-7753
R51	220 OHM	12-7753
R52	470k	12-7757
R53	47k	12-7758
R54	1k	12-7750
R55	10k	12-7748
R56	4.7k	12-7755
R57	10k	12-7748
R58	10k	12-7748
R59	10k	12-7748
R60	1k	12-7750
R61	178k, 1%	12-7769
R62	4.7k	12-7755
R63	100k	12-7747
R64	10k	12-7748
R65	10k, 1%	12-7764
R66	220 OHM	12-7753
R68	10k	12-7748
R69	1.5k	12-7773
R70	100k, 1%	12-7747
R71	200k	12-7752
R72	200k	12-7752
R73	100k	12-7747
R74	100k	12-7747
R78	22k	12-7754
R79	10k	12-7748
R80	10k	12-7748
R81	100k	12-7557
R82	200k	12-7752
R83	22k	12-7754
R84	10k	12-7748
R85	1M	12-7609
R86	4.42k	12-7760
R87	47 OHM	12-7756
R88	100k, 1%	12-7747
R89	17.8k	12-7759
R90	10k,1%	12-7764
R91	1M, 1%	12-7609
R92	1M, 1%	12-7609
R93	40.2k, 1%	12-7761
R94	100 OHM	12-7746
R95	10k	12-7748
R96	1M, 1%	12-7609
R97	10M	12-7749
R98	1M	12-7751
R99	470k	12-7757
R100	470k	12-7757
R101	100k	12-7747
R102	1M, 1%	12-7609
R171	10k TRIMMER	09-6822
R172	100k TRIMMER	09-6823
R173	100k TRIMMER	09-6823
R174	10k TRIMMER	09-6822
R175	1M TRIMMER	09-6828
R176	1M TRIMMER	09-6828

TRANSFORMERS

T103	M2300 HVPS	4275-037
T104	M2221 LVPS	4275-094

MISCELLANEOUS

9 EA.	CLOVERLEAF RECEPTACLES	
	011-6809-00	18-8771
3 EA.	SPACERS	18-8933
*	TRANSISTOR SPACER	18-8992
*	AMPLIFIER SHIELD	7261-100

Processor Board, Drawing 261 X 91

BOARD	Assembled Board	5261-136

CAPACITORS

C1	47pF, 100V, C	04-5533
C2	0.047µF, 100V, C	04-5565
C3	0.001µF, 100V, C	04-5519
C4	27pF, 100V, C	04-5614
C5	27pF, 100V, C	04-5614
C6	22µF, 15V, DT	04-5579
C7	10µF, 20V, DT	04-5592
C8	100µF, 10V, DT	04-5576
C9	100µF, 10V, DT	04-5576

TRANSISTOR

Q36	2N3904	05-5755

INTEGRATED CIRCUITS

U10	ICM7556	06-6244
U11	CD74HCO8	06-6222
U13	CD4054	06-6245
U14	CD4056	06-6095
U15	CD4056	06-6095
U16	CD4056	06-6095
U17	CD4056	06-6095

U18	CD4056	06-6095
U19	CD4056	06-6095
U20	CD74HC573	06-6093
U21	87C257	06-6278
U22	80C51FA	06-6236
U25	RDD104	06-6060
U26	LM358	06-6024
U43	CD74HC238	06-6246

DIODE

CR45	1N4148	07-6272

RESISTORS

R27	3.3k	10-7013
R28	220k	10-7066
R29	130k	10-7067
R30	470k	10-7026
R31	220k	10-7066
R32	1.2k	10-7058
R33	5.6k	10-7042
R40	1M TRIMMER	09-6828
R41	1M TRIMMER	09-6828

RESISTOR NETWORKS

R34-R35	NETWORK-22k SIP 10 PIN	12-7566

TRANSFORMER

T37	Model 300-9	4275-074

CRYSTAL

Y39	6.000 MHZ	01-5209

CONNECTOR

P3/1-50	RIBBON-1-102159-0	13-7834

MISCELLANEOUS

*	28P SOCKET	06-6096
7 EA.	SPACER-816-045 16P	18-8990
*	SPACER-470-015	18-8991
2 EA.	RIBBON-102312-2 LATCH	13-7805

Ref. No. Description Part No.

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

CONNECTOR

P6/1-7	640457-7 MTA100	13-8183

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	RIBBON-RD67 50BRN EDGE 50P	13-7816
P5	640456-2 MTA100	13-8073

MISCELLANEOUS

DS10-DS13	BULB-#6833	22-9613

Ref. No. Description Part No.

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	13-7751
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

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

Ref. No.	**Description**	**Part No.**
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 56
Amplifier/Power Supply Board Component Layout, Drawing 261 x 205

Processor Board Schematic, Drawing 261 x 91
Processor Board Component Layout, Drawing 261 x 103

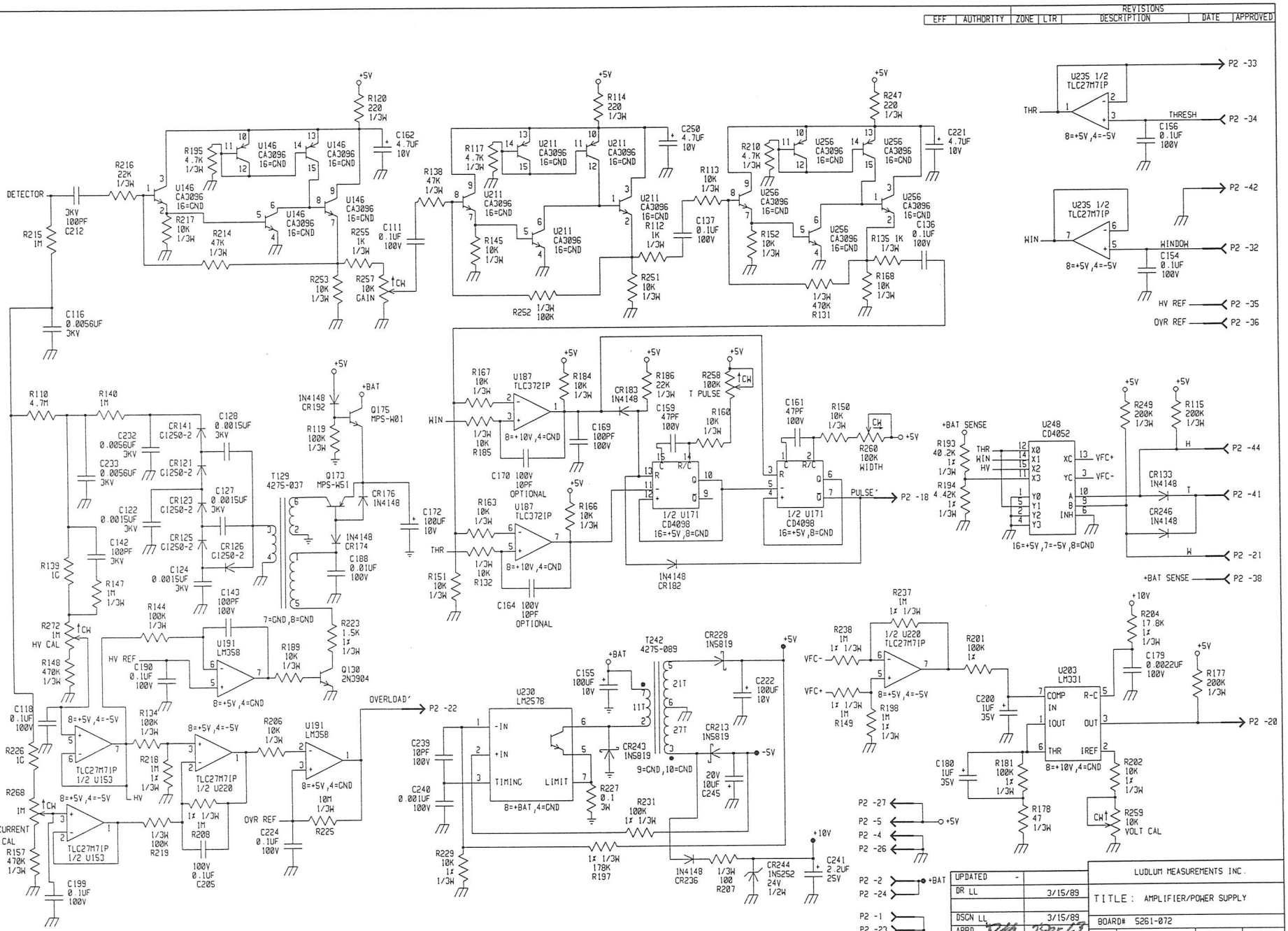
Calibration Board Schematic, Drawing 261 x 59
Calibration Board Component Layout, Drawing 261 x 59A

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

Backplane Board Schematic, Drawing 261 x 60
Backplane Board Component Layout, Drawing BS261076

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

Wiring Diagram, Drawing 261 x 61


REVISIONS
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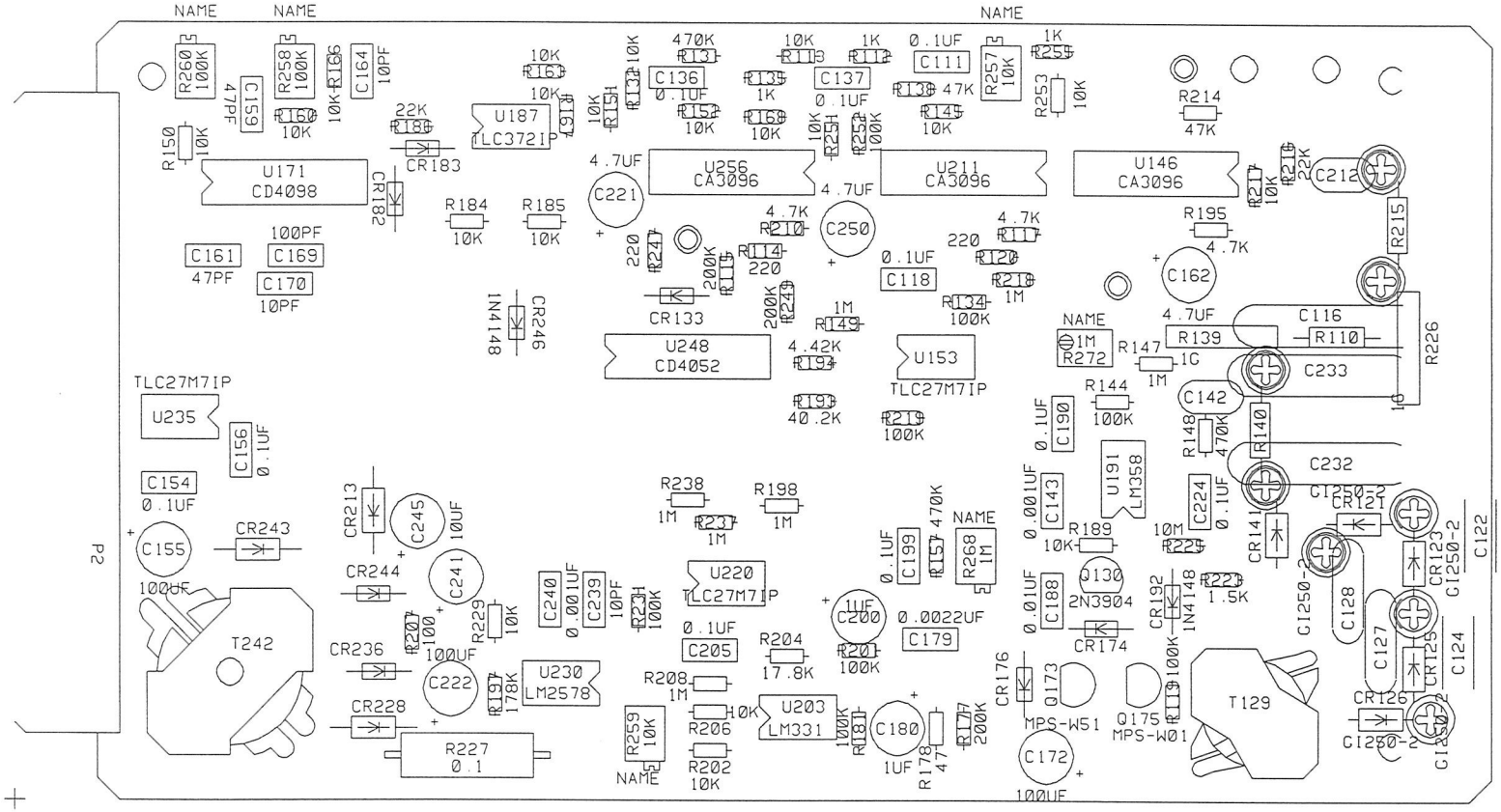
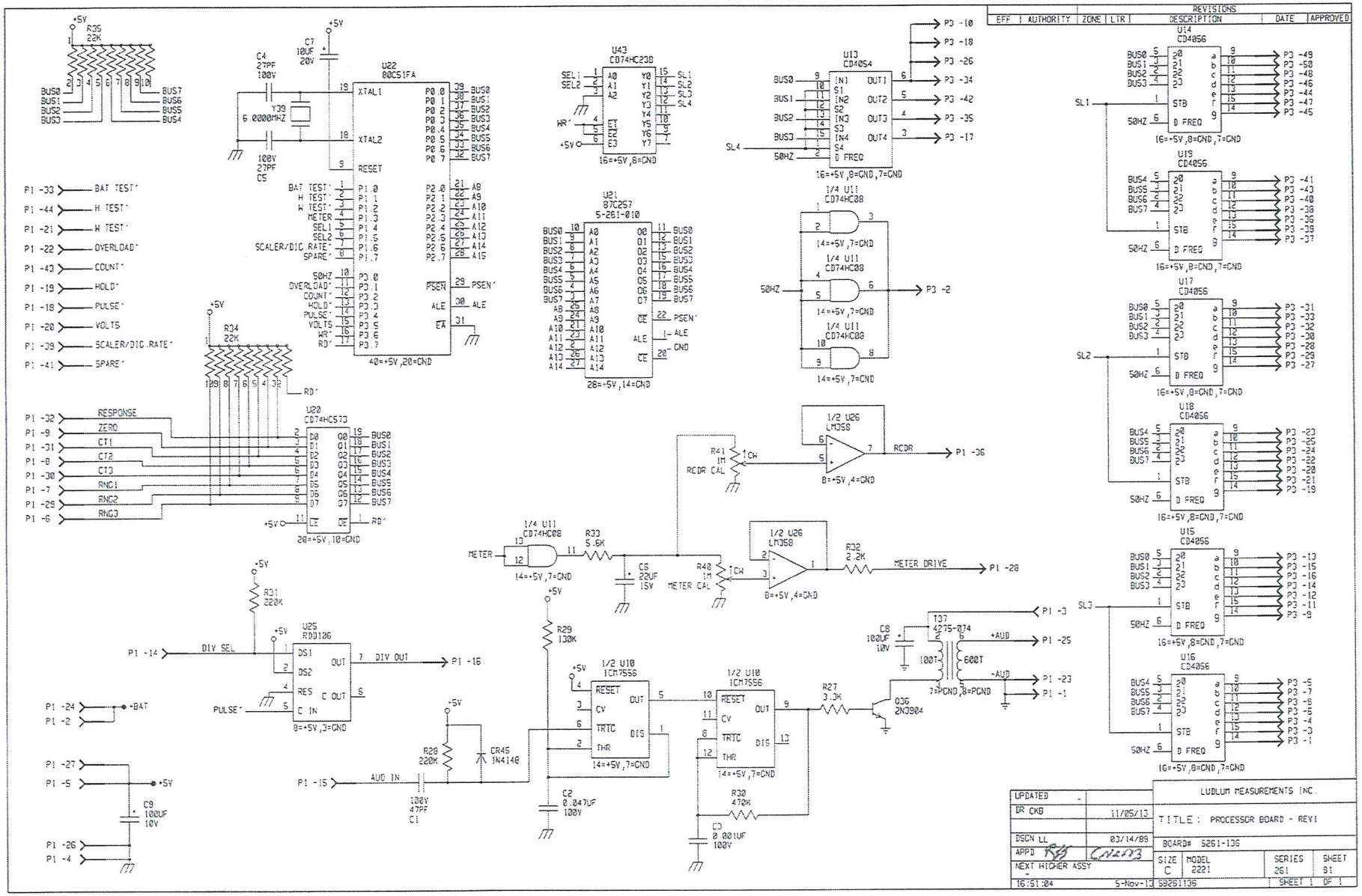
DETECTOR
3KV 100PF C212
R215 1M
C116 0.0056UF 3KV
R216 22K 1/3W
R120 220 1/3W
+5V
C162 4.7UF 10V
U146 CA3096 16=GND
R195 4.7K 1/3W
R217 10K 1/3W
R214 47K 1/3W
R255 1K 1/3W
C111 0.1UF 100V
R253 10K 1/3W
R257 10K GAIN
CW
R138 47K 1/3W
R114 220 1/3W
C250 4.7UF 10V
U211 CA3096 16=GND
R117 4.7K 1/3W
R145 10K 1/3W
R112 1K 1/3W
C137 0.1UF 100V
R252 1/3W 100K
R251 10K 1/3W
R247 220 1/3W
C221 4.7UF 10V
U256 CA3096 16=GND
R210 4.7K 1/3W
R152 10K 1/3W
R113 10K 1/3W
R135 1K 1/3W
C136 0.1UF 100V
R168 10K 1/3W
1/3W 470K R131
U235 1/2 TLC27M7IP
THR
8=+5V,4=-5V
THRESH
C156 0.1UF 100V
P2 -33
P2 -34
WIN
WINDOW
C154 0.1UF 100V
P2 -42
P2 -32
HV REF
OVR REF
P2 -35
P2 -36
R110 4.7M
R140 1M
C232 0.0056UF 3KV
C233 0.0056UF 3KV
C122 0.0015UF 3KV
C142 100PF 3KV
R139 1C
R147 1M 1/3W
R272 1M HV CAL
R148 470K 1/3W
C118 0.1UF 100V
R226 1C
R268 1M CURRENT CAL
R157 470K 1/3W
C199 0.1UF 100V
CR141 C1250-2
CR121 C1250-2
CR123 C1250-2
CR125 C1250-2
CR126 C1250-2
C128 0.0015UF 3KV
C127 0.0015UF 3KV
C124 0.0015UF 3KV
C143 100PF 100V
R144 100K 1/3W
C190 0.1UF 100V
R134 100K 1/3W
R218 1M 1% 1/3W
R219 100K 1/3W
R208 1M 1% 1/3W
C205 100V 0.1UF
C224 0.1UF 100V
R225 10M 1/3W
R206 10K 1/3W
R189 10K 1/3W
R223 1.5K 1% 1/3W
Q130 2N3904
T129 4275-037
7=GND,8=GND
+BAT
1N4148 CR192
R119 100K 1/3W
Q175 MPS-W01
Q173 MPS-W51
CR176 1N4148
1N4148 CR174
C188 0.01UF 100V
C172 100UF 10V
U191 LM358
HV REF
8=+5V,4=GND
8=+5V,4=-5V
TLC27M7IP 1/2 U153
TLC27M7IP 1/2 U220
HV
OVERLOAD'
P2 -22
R167 10K 1/3W
U187 TLC3721P
R184 10K 1/3W
R185 10K 1/3W
C170 100V 10PF OPTIONAL
C169 100PF 100V
R163 10K 1/3W
R166 10K 1/3W
R132 10K 1/3W
R151 10K 1/3W
C164 100V 10PF OPTIONAL
8=+10V,4=GND
CR183 1N4148
R186 22K 1/3W
C159 47PF 100V
R160 10K 1/3W
R258 100K T PULSE
C161 47PF 100V
R150 10K 1/3W
R260 100K WIDTH
1/2 U171 CD4098 16=+5V,8=GND
PULSE'
P2 -18
1N4148 CR182
+BAT SENSE
R193 40.2K 1% 1/3W
R194 4.42K 1% 1/3W
U248 CD4052
16=+5V,7=-5V,8=CND
VFC+
VFC-
R249 200K 1/3W
R115 200K 1/3W
CR133 1N4148
CR246 1N4148
P2 -44
P2 -41
P2 -21
P2 -38
T242 4275-089
21T
11T
27T
9=CND,10=CND
C155 100UF 10V
C222 100UF 10V
CR228 1N5819
CR213 1N5819
CR243 1N5819
20V 10UF C245
-5V
U230 LM2578
-IN
+IN
TIMING
LIMIT
8=+BAT,4=GND
C239 10PF 100V
C240 0.001UF 100V
R227 0.1 3W
R231 100K 1% 1/3W
R229 10K 1% 1/3W
1% 1/3W 178K R197
1N4148 CR236
1/3W 100 R207
CR244 1N5252 24V 1/2W
C241 2.2UF 25V
+10V
R237 1M 1% 1/3W
R238 1M 1% 1/3W
1/2 U220 TLC27M7IP
R201 100K 1%
R198 1M 1% 1/3W
R149 1M 1% 1/3W
R204 17.8K 1% 1/3W
C179 0.0022UF 100V
R177 200K 1/3W
U203 LM331
COMP
IN
IOUT
THR
R-C
OUT
IREF
C200 1UF 35V
C180 1UF 35V
R181 100K 1% 1/3W
R178 47 1/3W
R202 10K 1% 1/3W
R259 10K VOLT CAL
P2 -20
P2 -27
P2 -5
P2 -4
P2 -26
P2 -2
P2 -24
P2 -1
P2 -23
UPDATED -
DR LL 3/15/89
DSCN LL 3/15/89
APPD
NEXT HIGHER ASSY. -
09:57:00 2-Dec-13
LUDLUM MEASUREMENTS INC.
TITLE: AMPLIFIER/POWER SUPPLY
BOARD# 5261-072
SIZE D | MODEL 2221 | SERIES 261 | SHEET 56
SB261072
SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR CKB	05/17/91	TITLE: AMP/POWER SUPPLY BOARD	
		BOARD: 5261-072	
DSCN RDS	04/07/91	MODEL: 2221	
APP RDS	2Dec13	FILENAME: BS261072	
COMPONENT	SOLDER	09:33:25	2-Dec-13
		REVISION	SERIES / SHEET
OUTLINE	OUTLINE	1.0	261 / 205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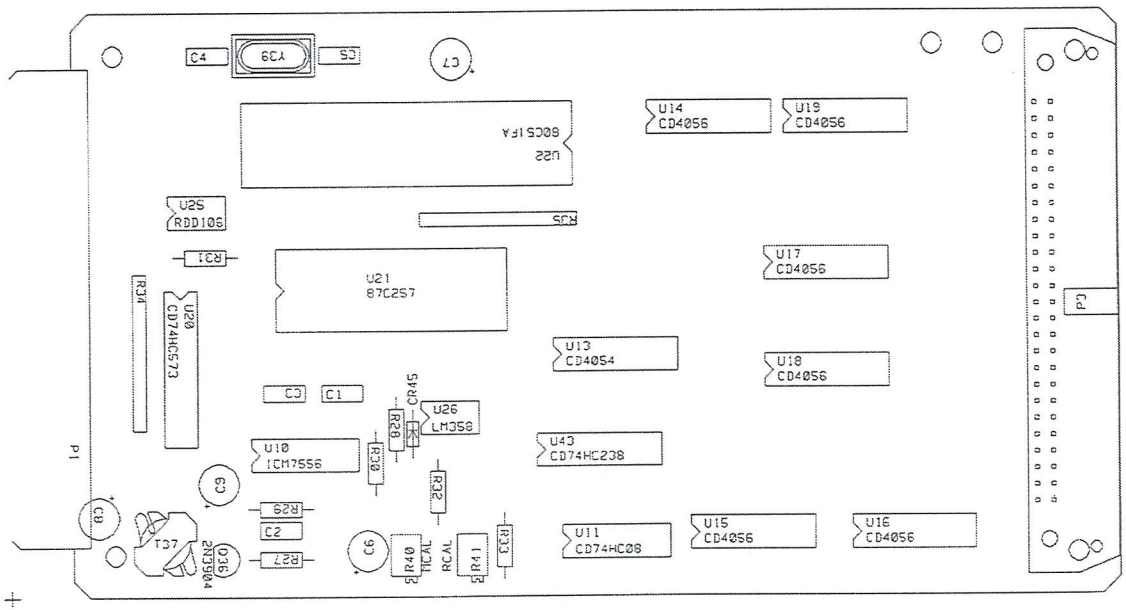
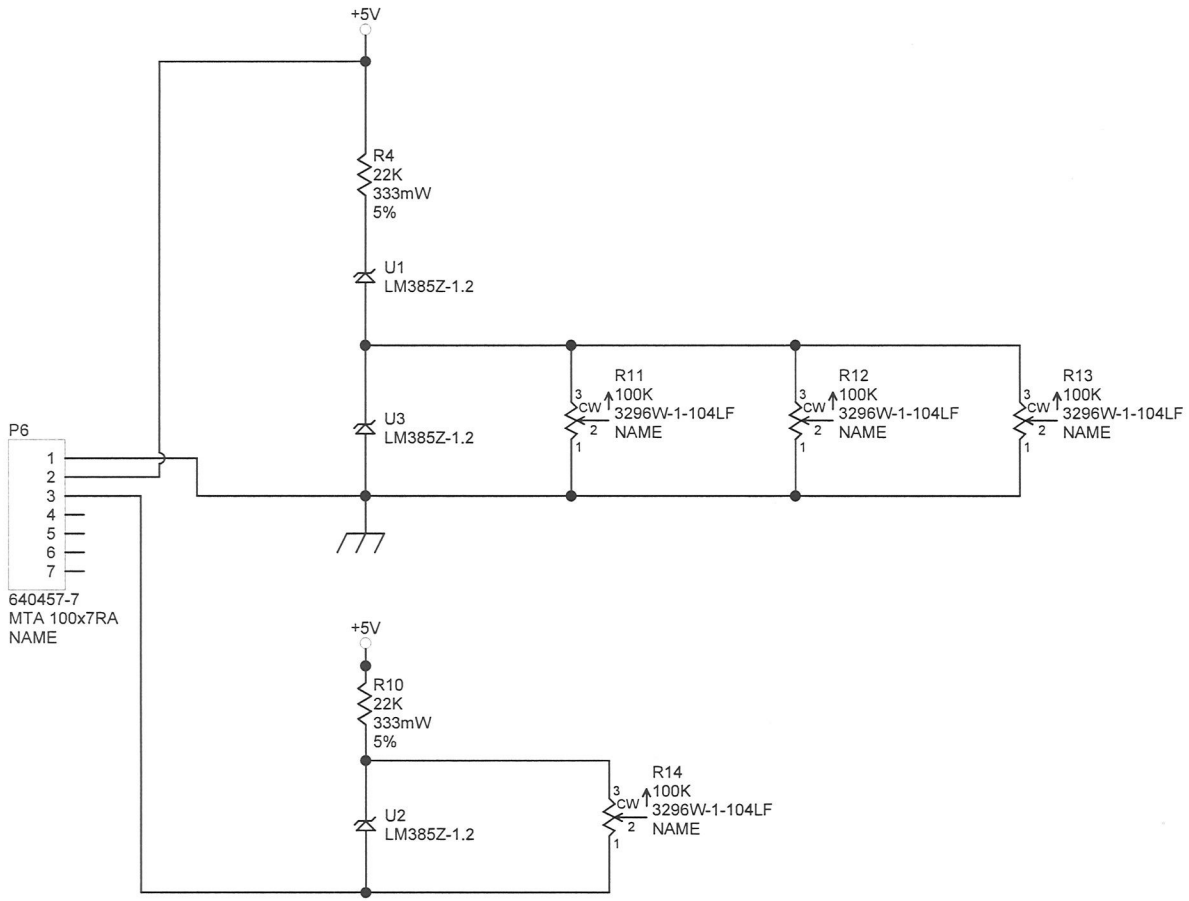
BUS0 BUS1 BUS2 BUS3 BUS4 BUS5 BUS6 BUS7
C4 27PF 100V
C5 27PF 100V
Y39 6.0000MHZ
C7 10UF 20V
U22 80C51FA
XTAL1
XTAL2
RESET
P0.0 P0.1 P0.2 P0.3 P0.4 P0.5 P0.6 P0.7
P1.0 P1.1 P1.2 P1.3 P1.4 P1.5 P1.6 P1.7
P2.0 P2.1 P2.2 P2.3 P2.4 P2.5 P2.6 P2.7
P3.0 P3.1 P3.2 P3.3 P3.4 P3.5 P3.6 P3.7
PSEN ALE EA
40=+5V,20=GND
BAT TEST'
H TEST'
W TEST'
METER
SEL1
SEL2
SCALER/DIC.RATE'
SPARE'
50HZ
OVERLOAD'
COUNT'
HOLD'
PULSE'
VOLTS
WR'
RD'
P1 -33 BAT TEST'
P1 -44 H TEST'
P1 -21 W TEST'
P1 -22 OVERLOAD'
P1 -43 COUNT'
P1 -19 HOLD'
P1 -18 PULSE'
P1 -20 VOLTS
P1 -39 SCALER/DIC.RATE'
P1 -41 SPARE'
R34 22K
RD'
U20 CD74HC573
P1 -32 RESPONSE
P1 -9 ZERO
P1 -31 CT1
P1 -8 CT2
P1 -30 CT3
P1 -7 RNG1
P1 -29 RNG2
P1 -6 RNG3
D0 D1 D2 D3 D4 D5 D6 D7
Q0 Q1 Q2 Q3 Q4 Q5 Q6 Q7
CE OE
20=+5V,10=GND
U43 CD74HC238
SEL1 SEL2 HR'
A0 A1 A2
E1 E2 E3
Y0 Y1 Y2 Y3 Y4 Y5 Y6 Y7
SL1 SL2 SL3 SL4
16=+5V,8=GND
U21 87C257 5-261-010
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14
O0 O1 O2 O3 O4 O5 O6 O7
CE ALE OE
BUS0 BUS1 BUS2 BUS3 BUS4 BUS5 BUS6 BUS7
PSEN' ALE GND
28=+5V,14=GND
U13 CD4054
IN1 IN2 IN3 IN4
S1 S2 S3 S4
OUT1 OUT2 OUT3 OUT4
D FREQ
P3 -10 P3 -18 P3 -26 P3 -34 P3 -42 P3 -35 P3 -17
16=+5V,8=GND,7=GND
1/4 U11 CD74HC08
14=+5V,7=GND
50HZ
P3 -2
U14 CD4056
U19 CD4056
U17 CD4056
U18 CD4056
U15 CD4056
U16 CD4056
STB
P3 -49 P3 -50 P3 -48 P3 -46 P3 -44 P3 -47 P3 -45
P3 -41 P3 -43 P3 -40 P3 -38 P3 -36 P3 -39 P3 -37
P3 -31 P3 -33 P3 -32 P3 -30 P3 -28 P3 -29 P3 -27
P3 -23 P3 -25 P3 -24 P3 -22 P3 -20 P3 -21 P3 -19
P3 -13 P3 -15 P3 -16 P3 -14 P3 -12 P3 -11 P3 -9
P3 -5 P3 -7 P3 -8 P3 -6 P3 -4 P3 -3 P3 -1
16=+5V,8=GND,7=GND
1/2 U26 LM358
RCDR
P1 -36
R41 1M RCDR CAL
8=+5V,4=GND
METER
R33 5.6K
C6 22UF 15V
R40 1M METER CAL
R32 2.2K
METER DRIVE
P1 -28
R31 220K
U25 RD0106
DS1 DS2 RES C IN
OUT C OUT
DIV SEL
DIV OUT
P1 -14
P1 -16
PULSE'
P1 -24 +BAT
P1 -2
P1 -27
P1 -5 +5V
C9 100UF 10V
P1 -26
P1 -4
R29 130K
1/2 U10 ICM7556
RESET CV TRTC THR
OUT DIS
14=+5V,7=GND
R28 220K
CR45 1N4148
AUD IN
P1 -15
100V 47PF C1
C2 0.047UF 100V
R30 470K
C3 0.001UF 100V
R27 3.3K
Q36 2N3904
C8 100UF 10V
T37 4275-074
600T
100T
+AUD -AUD
7=PGND,8=PGND
P1 -3 P1 -25 P1 -23 P1 -1
LUDLUM MEASUREMENTS INC.
UPDATED
DR CKD 11/05/13
DSGN LL 03/14/89
APPD RJS
NEXT HIGHER ASSY
TITLE: PROCESSOR BOARD - REV1
BOARD# 5261-136
SIZE C | MODEL 2221 | SERIES 261 | SHEET 91
16:51:04 5-Nov-13 5261136 SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR CKD	11/05/13	TITLE: PROCESSOR BOARD	
		BOARD: 5261-136	
DSGN LL	03/14/91	MODEL: 2221	
APP RSS	6Nov13	FILENAME: BS261136	
		16:46:31	5-Nov-13
COMPONENT	SOLDER	REVISION	SERIES / SHEET
OUTLINE	OUTLINE	1.0	261 / 103



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	
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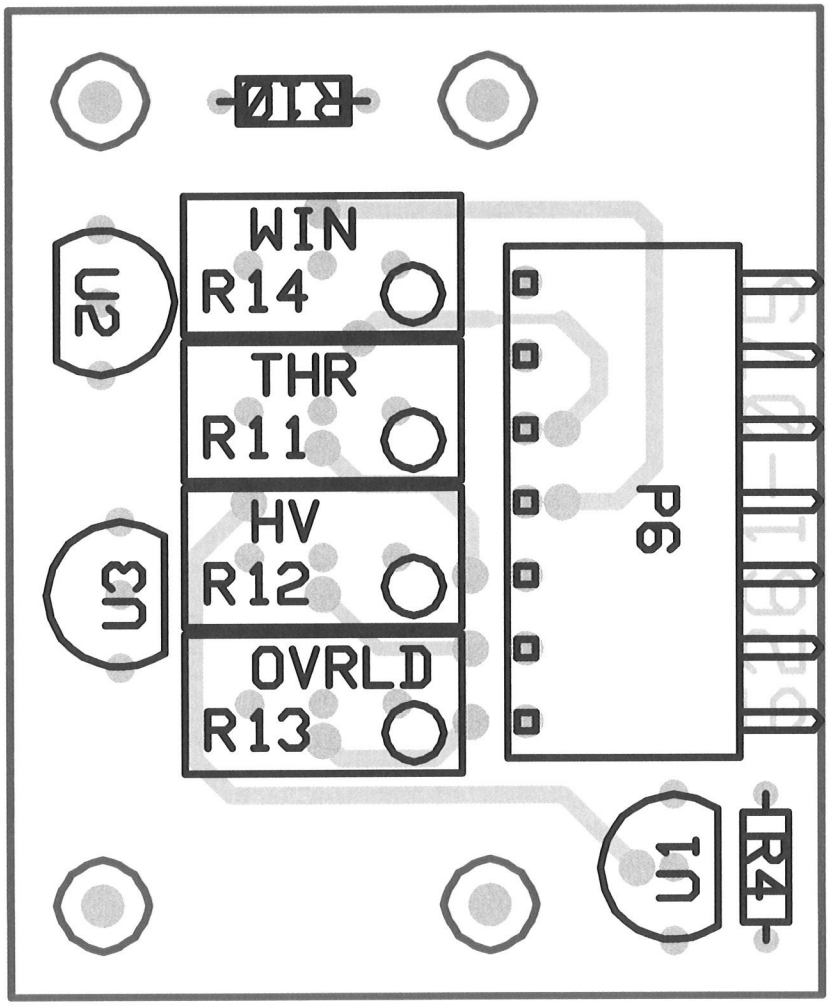
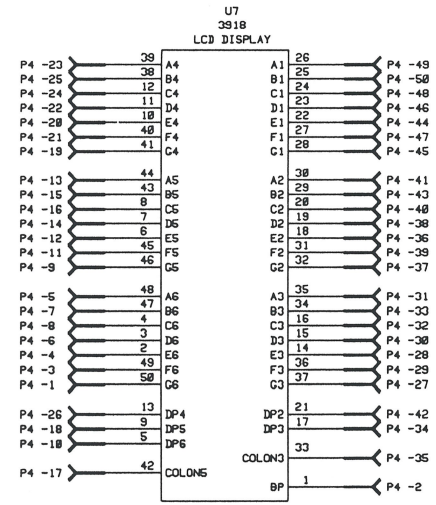
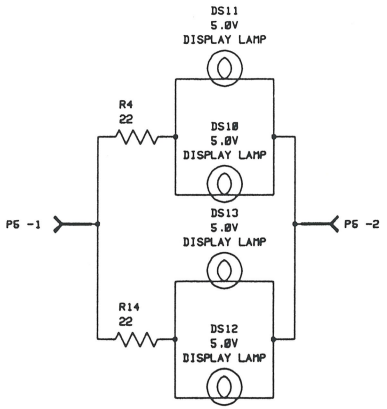


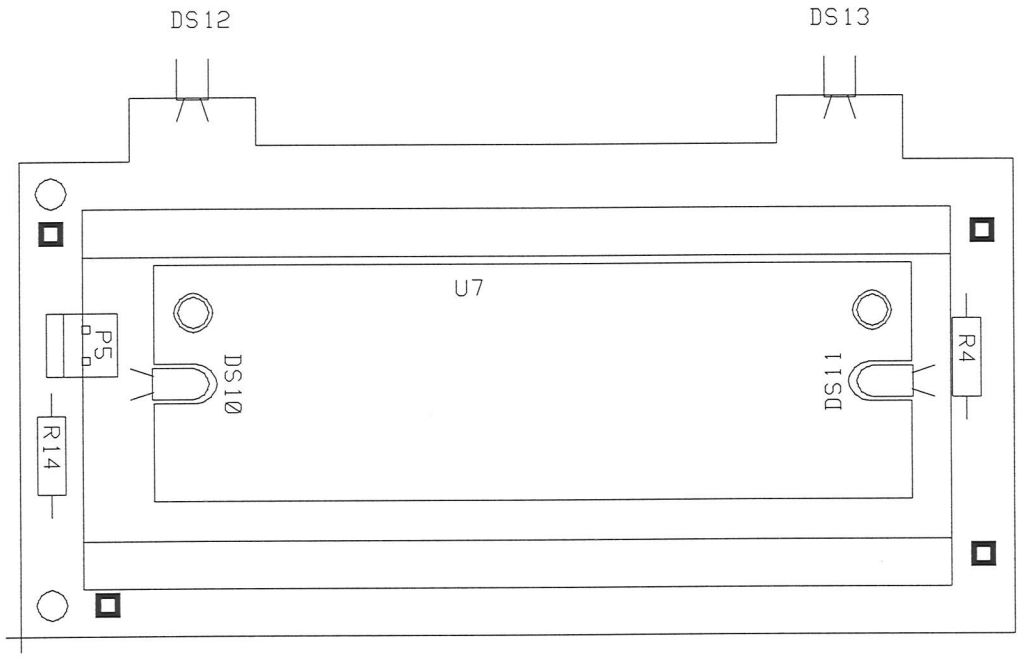
LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828		
Title: Calibration Board				
Drawn: LL	3/16/89	**Model:** 2221		
Design: LL	3/16/89	**Board#:** 5261-075		
Approve: RDS	8 Jul 14	**Rev:** 1		
PCBA Drawing		**SCALE: 1.00**	**Series** 261	**Sheet** 59A
Print 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

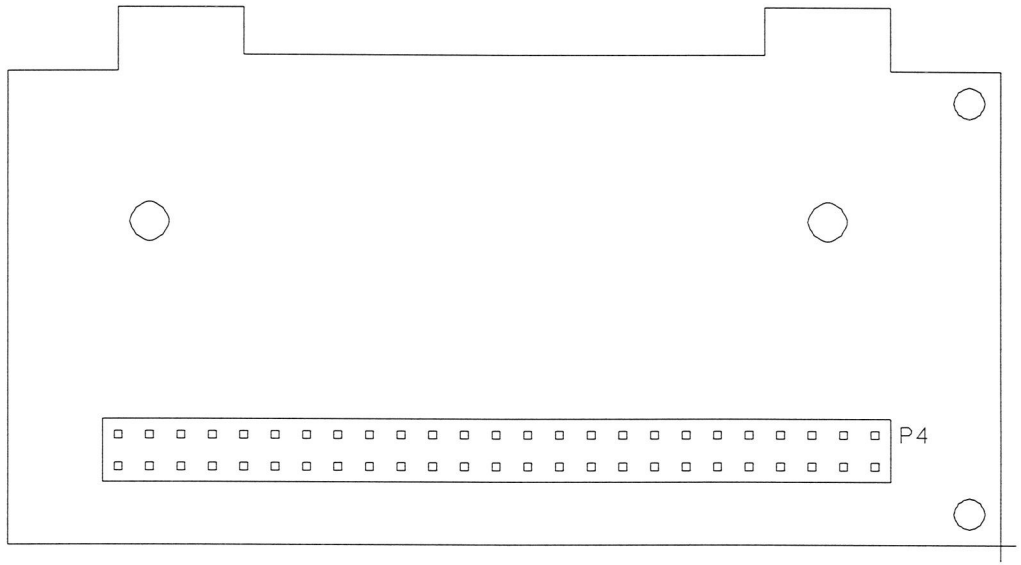




CONTRACT -		LUDLUM MEASUREMENTS INC.	
DR LL	3/16/89	TITLE: LCD DISPLAY	
CHK R.C.	7/13/98		
DSGN LL	3/16/89	BOARD# 5261-074	
APPD [illegible]	7/13/98	SIZE D / MODEL 2221 / SERIES 261 / SHEET 58	
NEXT HIGHER ASSY. -			
15:14:38	06-12-89	5261074.DRW	SHEET 1 OF 1

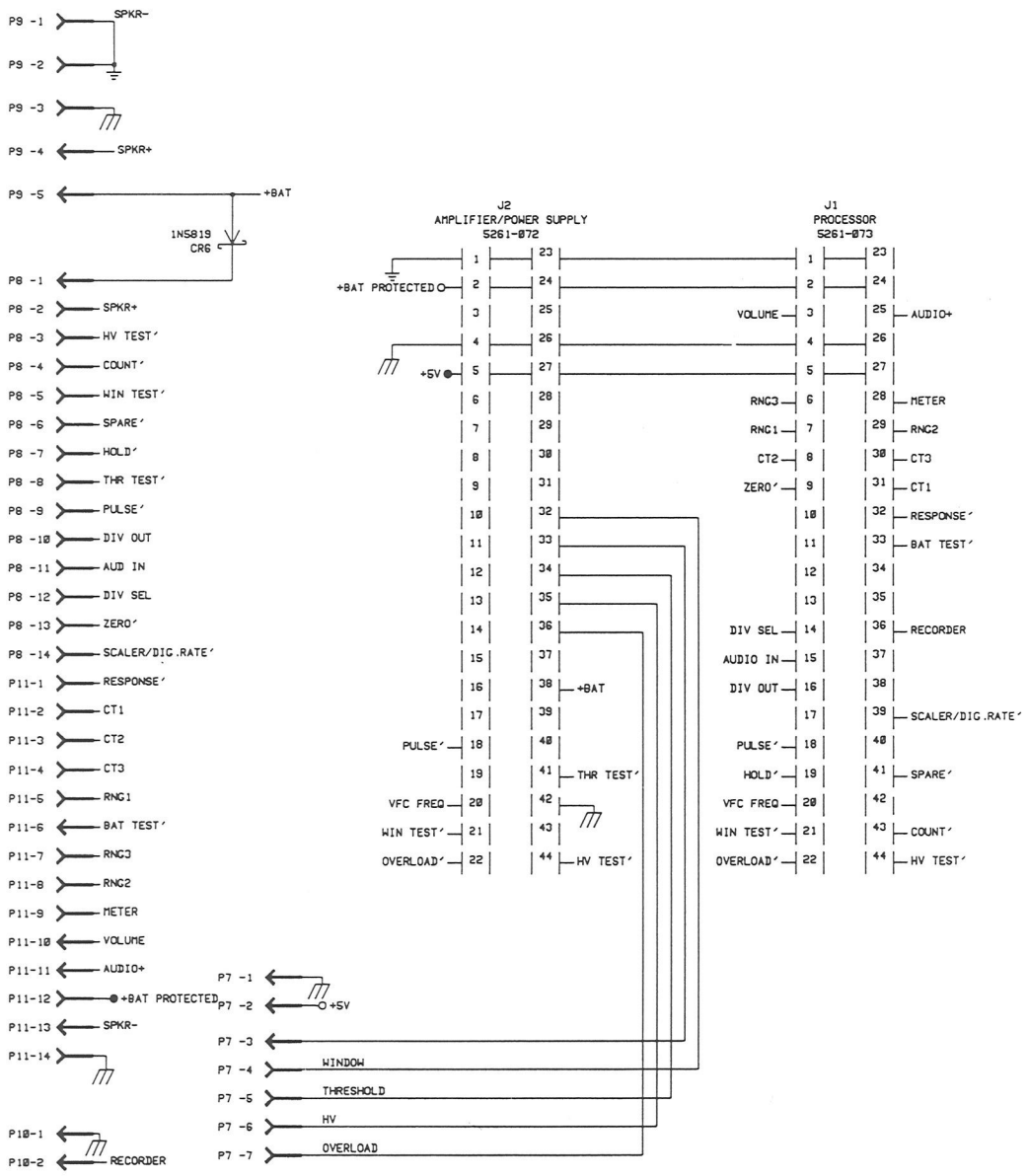


LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR LL	03/27/89	TITLE: DISPLAY BOARD	
		BOARD: 5261-074	
DSGN LL	03/16/89	MODEL: 2221	
APP RJS	7Nov13	FILENAME: BS261074	
		09:51:12	7-Nov-13
COMPONENT	SOLDER	REVISION	SERIES / SHEET
OUTLINE	OUTLINE	1.0	261 / 209

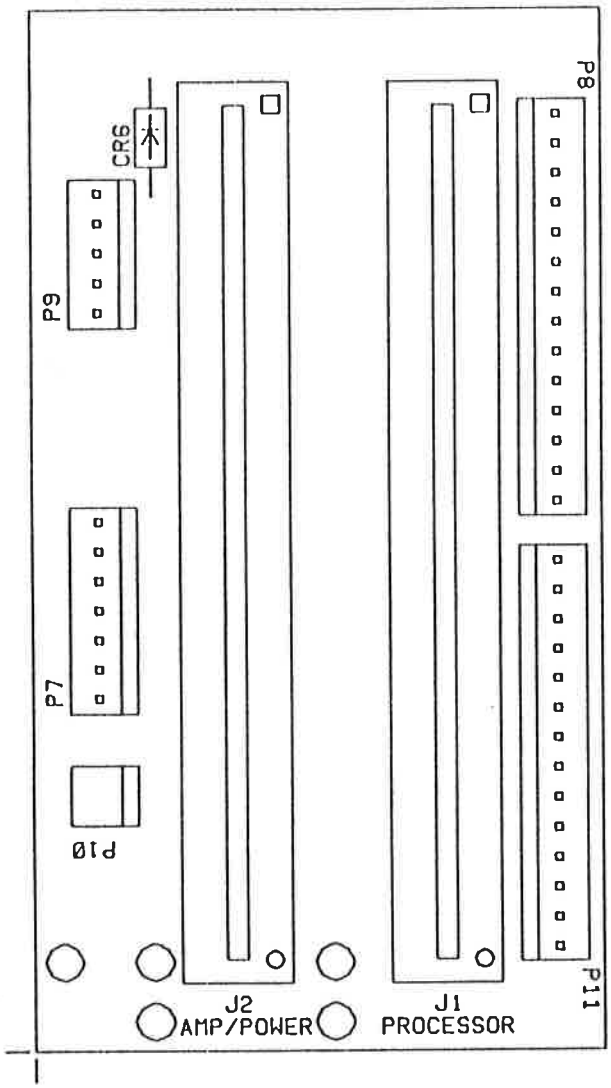


LUDLUM MEASUREMENTS INC. SWEETWATER, TX.				
DR LL	03/27/89	TITLE: DISPLAY BOARD REV 1		
		BOARD# 5261-074 FILE		
DSGN LL	03/16/89	MODEL 2221	SERIES 261	SHEET 209
APP RGS	7Nov13	COMP ARTWORK ☐	SLDR ARTWORK ☐	
00:00:00	00/00/00	COMP OUTLINE ☐	SLDR OUTLINE ☒	
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR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

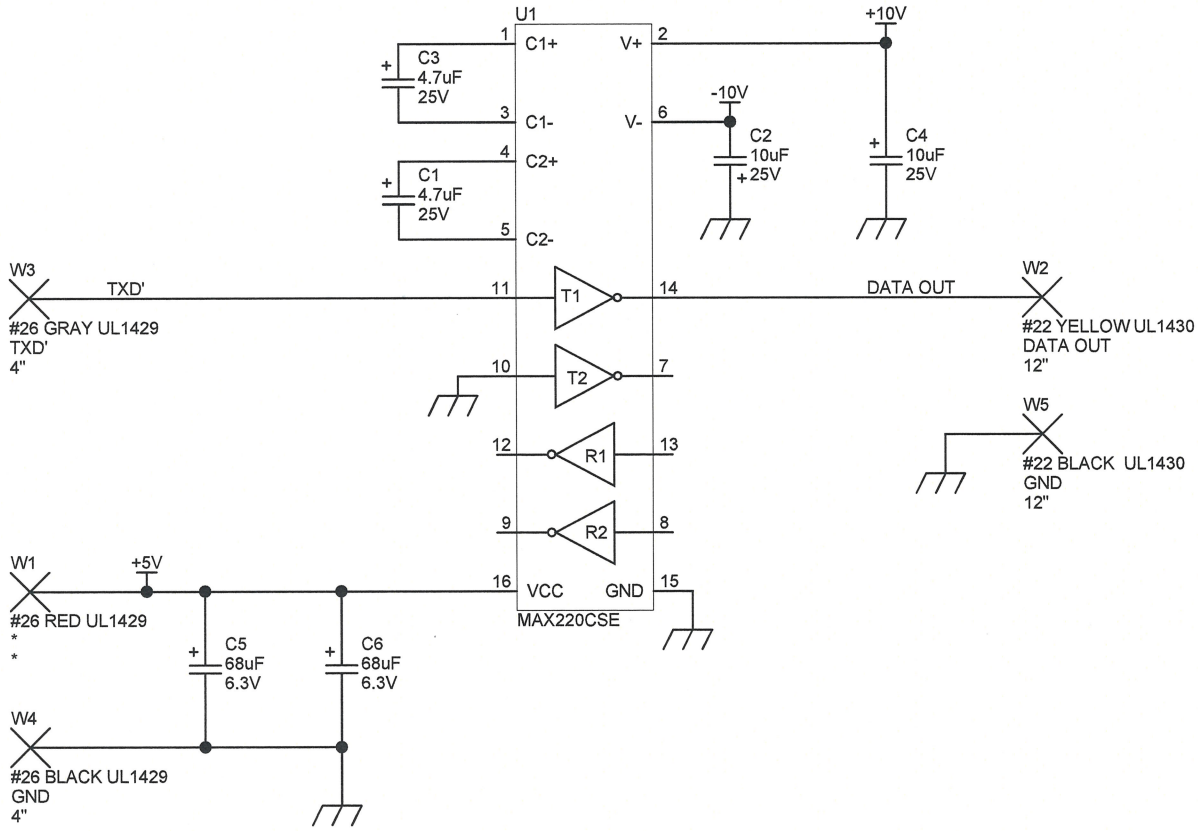
REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



CONTRACT -		LUDLUM MEASUREMENTS INC.	
DR LL	3/16/89	TITLE: BACKPLANE	
CHK R.C.	7/13/98		
DSGN LL	3/16/89	BOARD# 5261-076	
APPD [illegible]	7/13/98	SIZE D / MODEL 2221 / SERIES 261 / SHEET 68	
NEXT HIGHER ASSY. -			
07:45:14	05-24-89	S0261076.DRW	SHEET 1 OF 1



BOARD# 5261-076	
TITLE BACKPLANE	
MODEL 2221	
COMPONENT OUTLINES	
DR RDS	3/28/89
CHK R.C.	7/13/98
DSGN LL	3/16/89
APPD RSS	7/13/98
BS261076.DRW	
05-24-89	15:15:37



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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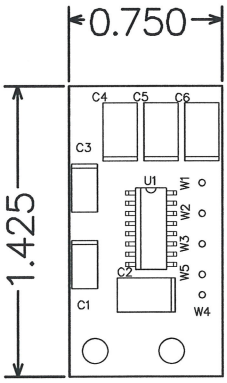

LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828	
Title: RS-232 BOARD			
Drawn: CKB	03/21/2001	**Model:** 2221	
Design: RDS	11/11/1999	**Board#:** 5261-179	
Approve: RDS	11Feb13	**Rev:** 1	
Print Date: 2/8/2013 1:57:39 PM		**SCALE: 1.00** Top Overlay	**Series** 261 / **Sheet** 180
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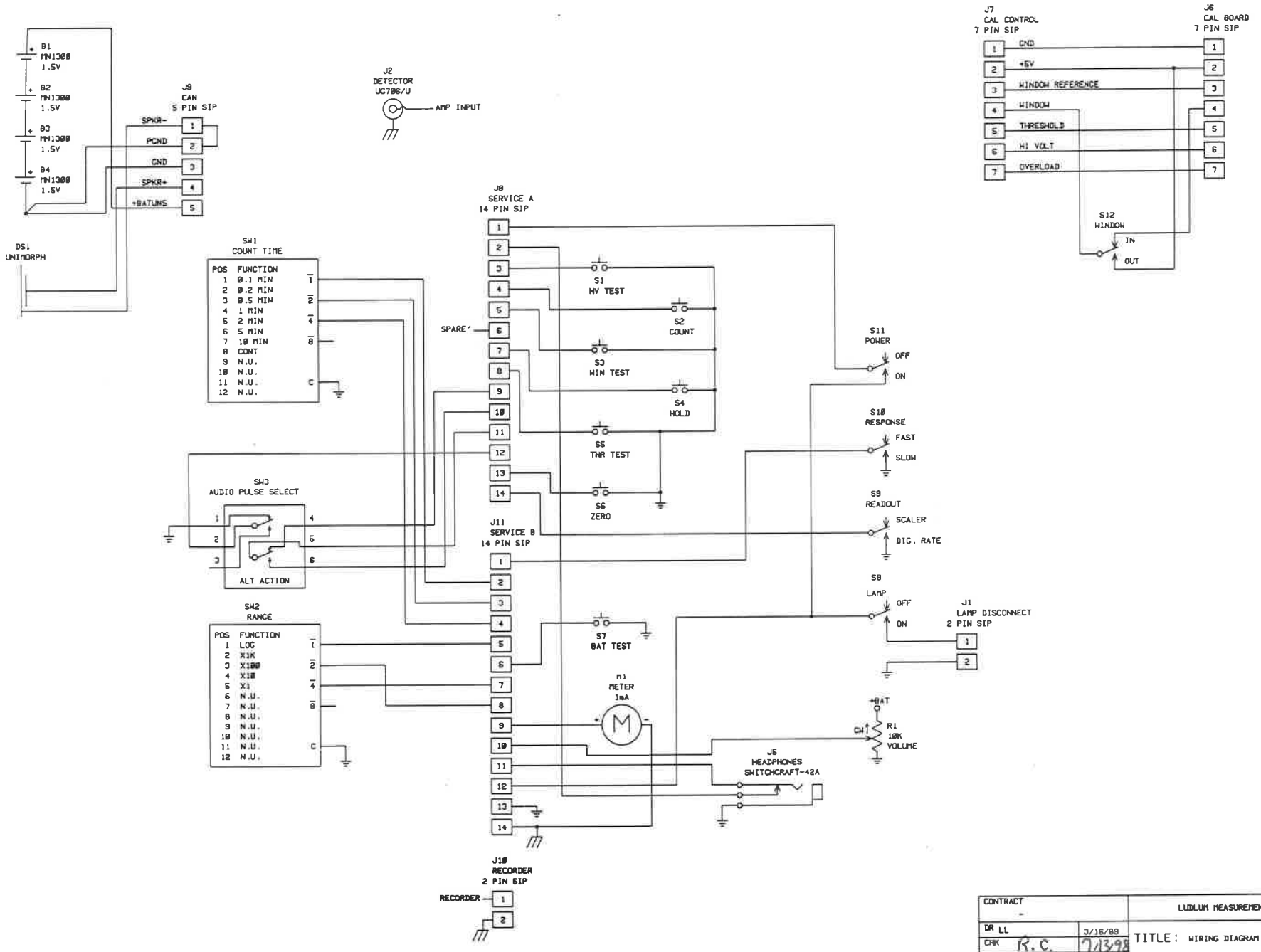
REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



CONTRACT -		LUDLUM MEASUREMENTS INC.	
DR LL	3/16/89	TITLE: WIRING DIAGRAM	
CHK R.C.	7/13/89		
DSGN LL	3/16/89	BOARD# 261-877	
APPD DSS	7/13/89	SIZE D / MODEL 2221 / SERIES 261 / SHEET 61	
NEXT HIGHER ASSY. -			
10:41:06	05-29-89	S0261877.DRW	SHEET 1 OF 1