KEITHLEY

Model 220 Programmable Current Source

Instruction Manual

A GREATER MEASURE OF CONFIDENCE

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Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

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Model 220 Programmable Current Source Instruction Manual

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Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

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All Keithley product names are trademarks or registered trademarks of Keithley Instruments, Inc.
Other brand and product names are trademarks or registered trademarks of their respective holders.

Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a ⏚ screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The ⚠ symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The ⚠ symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

MODEL 220 SPECIFICATIONS

MODEL 220 CURRENT SOURCE

RANGE	MAXIMUM OUTPUT	ACCURACY (1 Year) 18°–28°C	STEP SIZE	TEMPERATURE COEFFICIENT/°C 0°–18°C & 28°–50°C	NOISE (pk-pk of range)	3dB BANDWIDTH
100 mA	±101.00 mA	0.1 % + 50 µA	50 µA	0.01 % + 2 µA	100 ppm	0.1 Hz to 30 kHz
10 mA	±19.995 mA	0.05% + 10 µA	5 µA	0.005% + 200 nA	100 ppm	0.1 Hz to 100 Hz
1 mA	±1.9995 mA	0.05% + 1 µA	500 nA	0.005% + 20 nA	100 ppm	0.1 Hz to 100 Hz
100 µA	±199.95 µA	0.05% + 100 nA	50 nA	0.005% + 2 nA	100 ppm	0.1 Hz to 100 Hz
10 µA	±19.995 µA	0.05% + 1 nA	5 nA	0.005% + 200 pA	100 ppm	0.1 Hz to 100 Hz
1 µA	±1.9995 µA	0.1 % + 1 nA	500 pA	0.01 % + 20 pA	100 ppm	0.1 Hz to 100 Hz
100 nA	±199.95 nA	0.3 % + 100 pA	50 pA	0.02 % + 2 pA	100 ppm	0.1 Hz to 100 Hz
10 nA	±19.995 nA	0.3 % + 10 pA	5 pA	0.02 % + 200 fA	200 ppm	0.1 Hz to 10 Hz
1 nA	±1.9995 nA	0.4 % + 2 pA	500 fA	0.02 % + 200 fA	400 ppm	0.1 Hz to 10 Hz

OUTPUT RESISTANCE: $>10^{14}\Omega$ (on 1nA range).
OUTPUT CAPACITANCE: <20pF.
LINE REGULATION: <0.01% for AC power line changes within specified limits.
VOLTAGE LIMIT: Bipolar, 1V to 105V in 1V programmable steps.
RESPONSE TIME: <3ms to within 0.1% of programmed change.
TRANSIENT RECOVERY TIME: <3ms to rated accuracy following any change in compliance voltage.
GUARD OUTPUT:
Maximum Load Capacitance: 10nF.
Maximum Load Current: Absolute total (Output + Guard) not to exceed 105mA.
Accuracy: ±1mV (excluding output lead voltage drop).
PROGRAM MEMORY:
Number of Locations: 100.
Range of Dwell Times: 3ms to 999.9s.
Accuracy of Dwell Time: ±(0.05%+200µs).
OUTPUT LOAD: Output load must be non-inductive.
EXTERNAL TRIGGER: TTL-compatible EXTERNAL TRIGGER INPUT and OUTPUT.
OUTPUT CONNECTIONS: Teflon® insulated 2-lug triax connector (Specialty Connector #30JR121-1) for output; five-way binding posts for GUARD, OUTPUT COMMON, and CHASSIS; BNC (chassis isolated) connectors for EXTERNAL TRIGGER INPUT and OUTPUT, Amphenol or Cinch Series 87 IEEE and printed circuit digital I/O port. All connections on rear panel.

IEEE-488 BUS IMPLEMENTATION

MULTILINE COMMANDS: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.

UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.

INTERFACE FUNCTIONS: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

INTERNAL PROGRAMMABLE PARAMETERS: Display Mode, Output, Prefix Data Format, EOI, SRQ (including mask for over Limit), Program Mode, Range, Trigger Mode, Terminator Character, Inputs (Source, Limit, Dwell Time, 100-Point Memory Locations), Output Status, Digital Self Test.

DIGITAL I/O PORT: A separate I/O port consisting of four input and four output lines as well as common (IEEE-488) and +5V DC. Outputs will drive one TTL load. Inputs represent one TTL load. The 220 or 230 can be programmed to generate an "SRQ" upon any change in the four bit input data. Mating connector supplied.

GENERAL

DISPLAY: 0.5 in LED digits, 4½-digit signed mantissa, 1-digit signed exponent.
SYSTEMS COMPATIBILITY: IEEE-488-1978.
LIMIT INDICATIONS (Voltage Limit): "V-LIMIT" LED will blink.
MAXIMUM ALLOWABLE COMMON MODE VOLTAGE (OUTPUT or OUTPUT COMMON to CHASSIS): 250V rms, DC to 60Hz.
SELF TEST: Digital RAM, ROM, front panel LEDs upon power ON.
EMC: Conforms to European Union Directive 89/336/EEC.
SAFETY: Conforms to European Union Directive 73/23/EEC (meets EN61010-1/IEC 1010).
WARM-UP: 1 hour to rated accuracy.
POWER: 105–125 or 210–250V AC (internal switch selected), 50 or 60Hz, 60W maximum (80VA maximum). 90–105 or 180–210V AC operation available.
COOLING: Internal fan for forced air cooling.
ENVIRONMENTAL LIMITS: Operating: 0°–50°C; up to 35°C at 70% non-condensing relative humidity. **Storage:** –25° to 70°C.
DIMENSIONS, WEIGHT: 127mm high × 216mm wide × 359mm deep (5 in × 8½ in × 14⅛ in). Net weight 4.4kg (9 lb 11 oz).
ACCESSORIES SUPPLIED: Model 6011 Triaxial Test Lead (3 ft).

Specifications subject to change without notice.

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SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

The Model 220 is a programmable current source with full range current from 2nA to 100mA. The Model 220 has a selectable voltage compliance of up to 105V in one volt increments. The 100 memory locations allow up to 100 storage points for programming source, V-limit, and dwell time. The Model 220 can be used with any measurement system that uses the IEEE-488 interface bus. For detailed operating instructions of the Model 220 and the IEEE-488 bus, refer to the Model 220/230 Programming Manual.

1.2 FEATURES

The Model 220 includes the following features:

- 100 point buffer that is capable of storing up to 100 points of an output waveform.
- Programmable dwell time between the data points in the buffer when used in the single or continuous program modes.
- Input and output connections for external triggering located on the rear panel.
- Selectable voltage compliance allows operator to select the required voltage compliance.
- 4½ digit display with appropriate exponent and decimal point.
- Program modes that control the sequence between the buffer points. This is for either single, step or continuous sequencing.
- Data keyboard to enter data (V-limit, dwell time, source, etc.) into the buffer.
- Program control that has a start, stop and reset control for the buffer and program mode.
- OPERATE button that holds the source in standby until programmed into operate.
- IEEE-488 interface bus operation is standard. This enables the Model 220 to be incorporated into a system that uses programmed control through the IEEE-488 bus.

1.3 WARRANTY INFORMATION

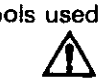
Warranty information is provided on the inside front cover of this manual. If there is a need to exercise the warranty, contact the Keithley representative in your area to determine the proper action to be taken. Keithley maintains complete repair and calibration facilities in the United States, West Germany, Great Britain, France, the Netherlands, Switzerland and Austria. Information concerning the application, operation or service of your instrument may be directed to the applications engineer at any of the above locations. Check the inside front cover of this manual for addresses.

1.4 MANUAL ADDENDA

Improvements or changes to this manual will be explained on an addendum included with this manual.

1.5 SAFETY SYMBOLS AND TERMS

Safety symbols used in this manual are as follows:

The symbol  on the instrument denotes that the user should refer to the operating instructions.

The symbol on the instrument denotes that 1000V or more may be present on the terminal(s).

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

The **CAUTION** used in this manual explains hazards that could damage the instrument.

1 .6 UNPACKING AND INSPECTION

The Model 220 is inspected both mechanically and electrically before shipment. Upon receiving the Model 220 unpack all items from the shipping container and check for any obvious damage that may have occurred during transit. Report any damage to the shipping agent. Retain and use the original packaging materials if reshipment is necessary. The following items are shipped with all Model 220 orders:

- Model 220 Programmable Current Source
- Model 220 Instruction Manual
- Model 6011 Triaxial Test Lead
- Model 220/230 Programming Manual
- Optional accessories per request.

1.7 REPACKAGING FOR SHIPMENT

The Model 220 should be packed in its original carton using the packaging method shown in Figure 1-1. Before packaging, wrap the instrument in plastic. After it is placed in the box, surround the instrument with styrofoam packaging material.

If the Model 220 is to be returned to Keithley Instruments for calibration or repair, include the following:

- ATTENTION REPAIR DEPARTMENT on the address label.
- Warranty status of the instrument.
- Completed service form.

1.8 SPECIFICATIONS

For Model 220 detailed specifications, refer to the specifications that precede this section.

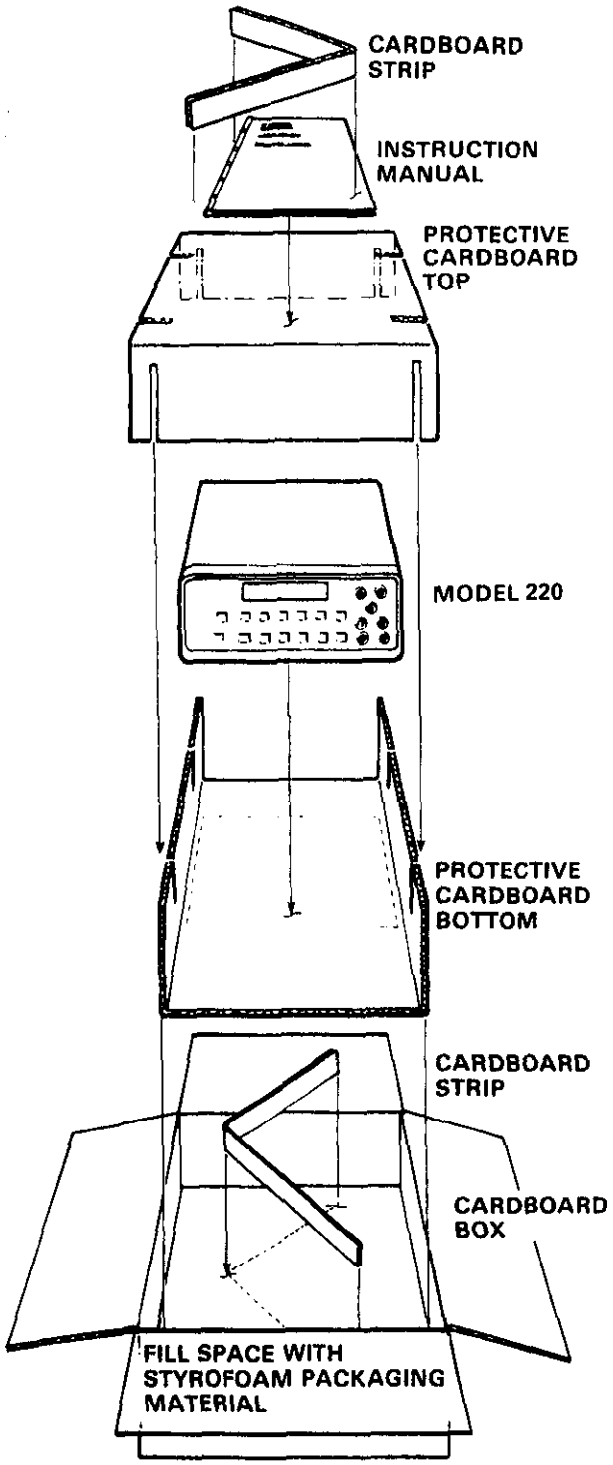


Figure 1-1. Instrument Packaging

1.9 ACCESSORIES

1.9.1 Optional Accessories

The following optional accessories are available from Keithley Instruments to enhance the capabilities of the Model 220.

Model 1019A Universal Rack Mounting Kit-The Model 1019A Universal Rack Mounting Kit can accomodate one or two Model 220's. The dimensions are 133mm × 483mm (5¼ in. × 19in.).

Model 6167 Guarded Adapter-The Model 6167 Guarded Adapter reduces effective cable capacity by driving the inner shield of a triaxial cable at guard potential.

Model 7008-3 IEEE-488 Cable-The Model 7008-3 is a three foot (1 meter) IEEE-488 Cable. The cable has 24 stranded wire conductors and is terminated with IEEE-488 standard connectors.

Model 7008-6 IEEE-488 Cable-The Model 7008-6 is a six foot (2 meter) IEEE-488 Cable. The cable has 24 stranded wire conductors and is terminated with IEEE-488 standard connectors.

Model 7010 Cable Adapter-The Model 7010 is a IEEE-488 cable adapter. The adapter extends the IEEE-488 connector by one connector width for easy access connections.

1.9.2 Supplied Accessories

The following accessory is supplied with each Model 220.

Model 6011 Triax Input Cable-The Model 6011 is a three foot (1 meter) low noise triax cable terminated with alligator clips at one end and a Teflon® insulated triax connector at the other end.

SECTION 2
OPERATION

2.1 INTRODUCTION

This section includes operating instructions such as: preparation for use, environmental conditions, front and rear panel control descriptions, output connections and several examples of uses and applications of the Model 220. For Model 220 front and rear panel illustrations refer to Figure 2-1.

2.2 PREPARATION FOR USE

2.2.1 Power-Up

Plug the Model 220 into the proper power receptacle in accordance with Table 2-1. For fuse replacement or line switch (S102) setting refer to the maintenance section.

WARNING

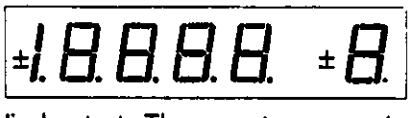
Ground the instrument through a properly earth grounded receptacle before operation. Failure to ground the instrument can result in severe injury or death in the event of short circuit or malfunction.

Table 2-1. Line Voltage Setting

Input Voltage	Switch Setting S102	Fuse (F101)
105V-125V	115VAC	½A, 250V, 3AG
210V-250V	230VAC	¼A, 250V, 3AG
90V-110V*	115VAC	½A, 250V, 3AG
180V-220V*	230VAC	¼A, 250V, 3AG

*For instruments equipped with low voltage transformer TR-187.

Immediately after turning on the Model 220 via the power switch, the display will indicate the following for several seconds:



1. This is a display test. The operator can note inoperative display segments by comparing the Model 220's display with the figure above.
2. In addition, the push button and the TALK, LISTEN, REMOTE indicators will light. All indicators will light simultaneously if operating correctly.

After the display test is complete the Model 220 will display the software revision level for approximately one second.

Example:

After the software revision level is displayed, the Model 220 will display the primary address of the instrument for approximately one second. The primary address of the Model 220 is factory set at 12.

Example:

2.2.2 Warm-Up

To achieve rated accuracy the Model 220 requires one hour for warm-up.

2.3 OPERATING INSTRUCTIONS

2.3.1 Environmental Conditions

Operation of the Model 220 should be at an ambient temperature within the range of 0°C to 50°C, up to 35°C at 70% noncondensing relative humidity. Environmental conditions for storage are from -25°C to +70°C.

2.3.2 Front Panel Controls Description

Power On/Off switch operates on the push-push principle. Depressing this button turns the instrument on. Pushing the button again (releasing) turns the instrument off.

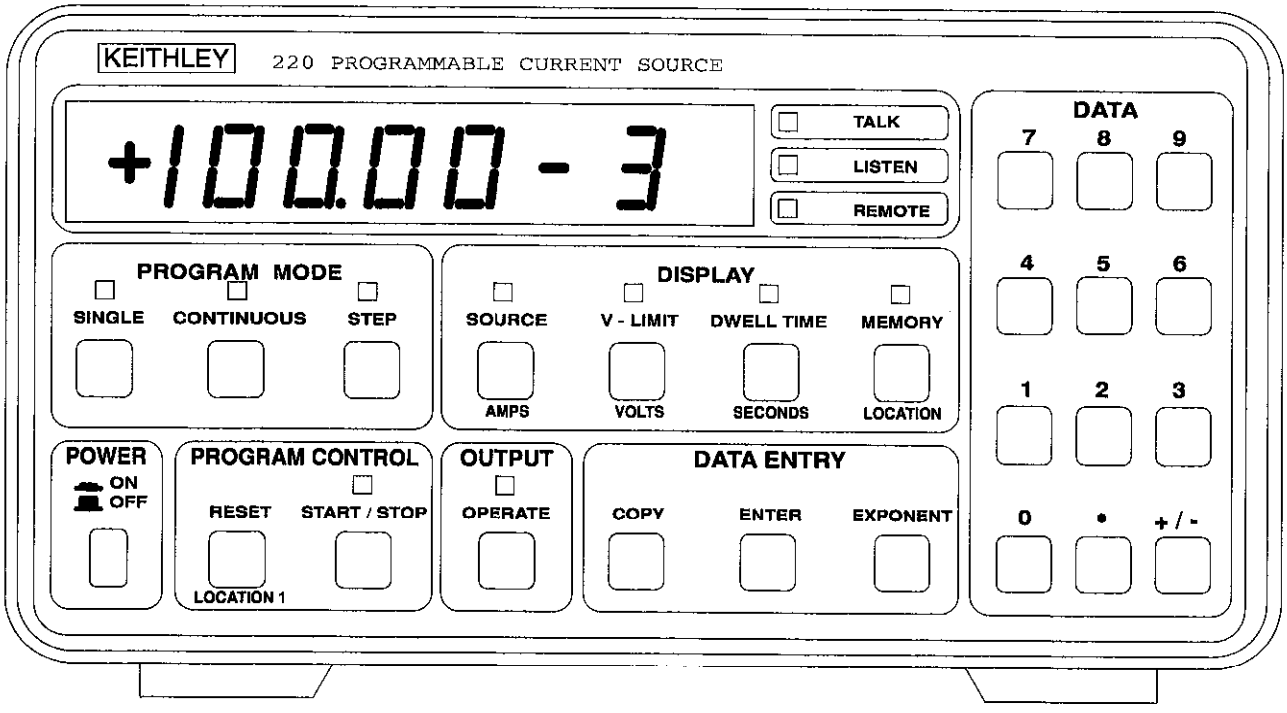
Display—There are four operating functions in the display group. They are described as follows.

SOURCE button selects the source data for display. The full scale range of the available source current is 1.9995nA to 101.00mA. The source current is displayed as a 4½ digit number with a single digit exponent. The least significant digit of the 4½ digit display is truncated to a "0" or a "5" when the ENTER button is pressed. When a 1, 2, 3 or 4 is entered as the least significant digit, it is truncated to a zero when the ENTER button is pressed. When a 6, 7, 8 or 9 is entered as the least significant digit, it is truncated to a five when the ENTER button is pressed.

During the entry of source data onto the display (cursor is flashing), pressing the SOURCE button reverts the display to the previous source data. A different source current can be programmed for each of the 100 memory locations.

V-LIMIT button selects the voltage compliance for display. The compliance voltage ranges from 1V to 105V in 1V increments. The voltage compliance is displayed as a three digit number. The three digit number is right justified when a one or two digit number is entered and the ENTER button is pressed. The voltage compliance limiting is bipolar.

The voltage limit accuracy for output current (I_{out}) greater than 1nA and less than 100μA is ±3%(+0.5V). For I_{out} greater than or equal to 100μA there is an additional error of 1V in the same



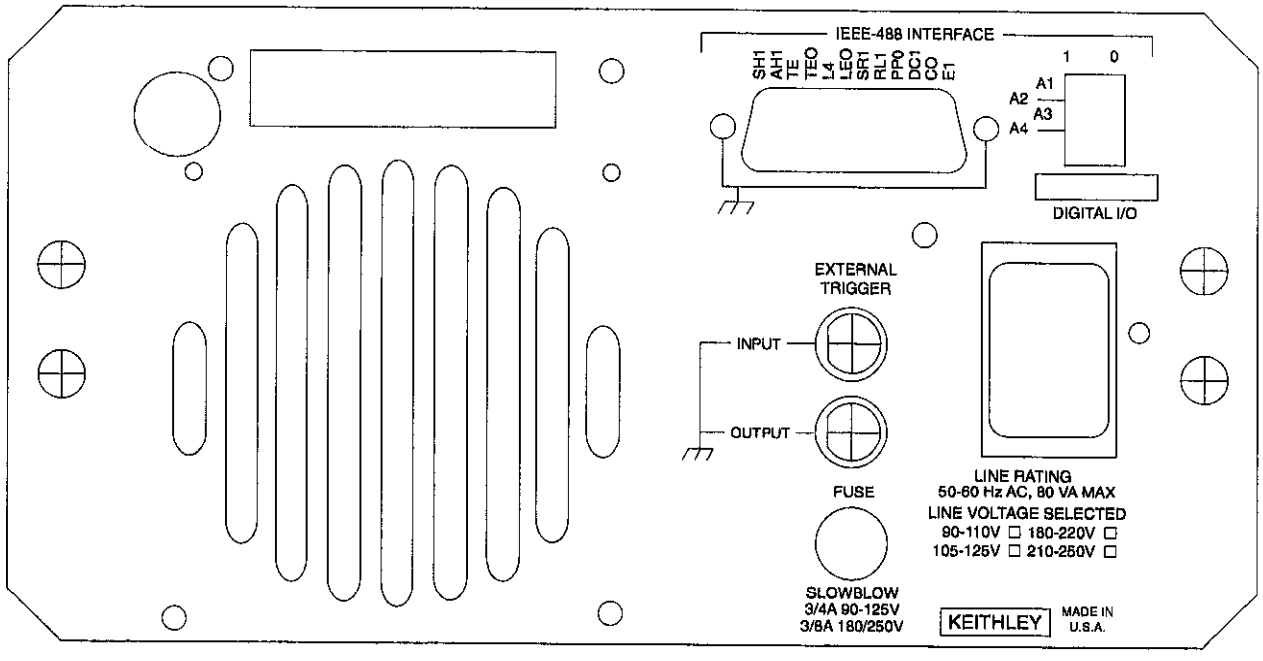


Figure 2-1. Model 220 Front and Rear Panels

polarity of I_{out}. For I_{out} less than or equal to 1nA there is an additional error of 0.5V with the opposite polarity of I_{out}.

A different compliance voltage limit can be programmed for each of the 100 memory locations. During the entry of V-limit data onto the display, (cursor is flashing) pressing the V-LIMIT button reverts the display to the previous V-limit data.

DWELL TIME button selects the dwell time data for display. Dwell time is defined as the programmed time the Model 220 spends on a specific memory location when in the single or continuous program modes. The range of the dwell time is 3msec to 999.9sec. The dwell time is displayed as a 4½ digit number with a single digit exponent. After the data is entered onto the display and the ENTER button is pressed, the exponent is displayed as a -3 or a 0 depending on the data entered. An entry of zero for the dwell time, in any memory location except the first will be interpreted as a reset in the step or continuous program modes to permit short cycling of the programmed memory locations it will be interpreted as a stop in the single program mode. The dwell time accuracy listed in the specifications requires that the IEEE-488 bus to be inactive.

A different dwell time can be programmed for each of the 100 memory locations. During the entry of dwell time data onto the display (cursor is flashing), pressing the DWELL TIME button reverts the display to the previous dwell time data.

MEMORY button selects the present memory location number for display. There are 100 available memory locations. They start at memory location 1 and range up to location 100. The memory location is displayed as a three digit number. The three digit display is right justified when a one or two digit number is enterned onto the display or upon actuation of the RESET button the Model 220 selects memory location 1 as the present memory location.

Each memory location contains the source current data, V-limit data, dwell time data and the number of the memory location. To display any of these parameters contained in a particular memory location simply press the appropriate button (eg. SOURCE, V-LIMIT, DWELL TIME or MEMORY). The data of each of these parameters can vary for each memory location. This means the Model 220 can store up to 100 different values of source current, compliance voltage or dwell time.

During the entry of memory location data onto the display (cursor is flashing), pressing the MEMORY button reverts the display to the previously displayed memory location.

NOTE

The contents of all the memory locations are lost when the power to the Model 220 is turned off.

Data Entry—The three buttons contained in the data entry group consist of the COPY, ENTER and EXPONENT buttons. The three buttons and their functions are described as follows:

EXPONENT button allows entry of exponent data onto the display. The EXPONENT button is active only in the source and dwell time display modes. Once the single digit exponent data has been entered onto the display and the ENTER button is pressed, the Model 220 places the data and the exponent into the proper notation. For example, if 520.0-7 is entered on the display, it is displayed as 52.00-6 after the ENTER button is pressed.

ENTER button loads the displayed data into the present memory location.

COPY button duplicates the source, V-limit, and dwell time data from one memory location into the next memory location. The COPY button is active only in the memory display mode. Refer to example 5.

OUTPUT button is an alternate action control which places the instrument in the displayed output mode. In the operate mode, the OUTPUT LED is turned on and the source data in the present memory location is present at the output connector on the rear panel. When the instrument is not in the operate mode, the output is programmed to .0000-9 amps.

Additionally if the compliance voltage was programmed to >32V it will be reduced (without changing displayed value) to 32V.

Program Mode—The three buttons contained in the program mode group consist of the SINGLE, CONTINUOUS and STEP buttons. These three buttons select the possible modes of scanning the internal 100 memory locations. The buttons are described as follows:

STEP button selects the step program mode. The step program mode allows the user to manually step through the programmed memory locations using the START/STOP button. When the Model 220 is in the step program mode the STEP LED is turned on.

SINGLE button selects the single program mode. The single program mode cycles through the programmed memory locations one time upon the actuation of the START/STOP button. When the Model 220 is in the single program mode the SINGLE LED is turned on.

CONTINUOUS button selects the continuous program mode. The continuous program mode cycles through the programmed memory locations continuously upon the actuation of the START/STOP button. When the Model 220 is in the continuous program mode the CONTINUOUS LED is turned on.

Program Control—The two buttons contained in the program control group are the RESET and START/STOP buttons. These two buttons control the use of the single, continuous and step program modes. The two buttons are described as follows:

RESET button is a momentary control that sets the presently displayed memory location back to memory location 1. If the Model 220 is in the operate mode, pressing the RESET button sets the output to the source data located in memory location 1. Pressing the RESET button during the entry of data onto the display in the Source, V-limit, dwell time or memory display modes sets the display back to the previous displayed data. Once the data is entered onto the display and the ENTER button is pressed, pressing the RESET button reverts the instrument back to the conditions in memory location 1.

START/STOP button is an alternate action control that serves two functions. The two functions are described as follows:

1. When the START/STOP button is pressed the selected program mode (step, single or continuous) is initiated.
2. When the START/STOP button is pressed a second time the START/STOP and the action of the selected program mode is stopped.
3. The START/STOP LED will be on continuously during the execution of the single of continuous program mode. In the step program mode the LED will be on the duration of the programmed dwell time.

NOTE

When the instrument is in the standby mode (OPERATE LED is turned off), and either single or continuous programming mode, the START/STOP button continues to control the buffer with no output present on the Model 220. In the step mode, the START/STOP LED turns on for the duration of the programmed dwell time.

DATA—The 12 buttons in the Data group allow entry of numerical data from 0 to 9 including with decimal point and polarity onto the display.

The **TALK, LISTEN and REMOTE** LED's identify the present status of the IEEE-488 bus. For more information concerning the Model 220 and the IEEE-488 bus refer to the Model 220/230 Programming Manual.

2.3.3 Rear Panel Description

OUTPUT connector is Teflon® insulated female triax connector.

GUARD terminal provides a low impedance voltage source which is equal to the output compliance voltage. The maximum load capcitance for the guard output is 0.01μF. The maximum load current which includes guard and output is not to exceed 105mA. The accuracy of the guard output is $\pm$1mV excluding output lead IR voltage drops.

NOTE

The guard voltage will not equal the output voltage when the instrument is at the programmed V-limit overcompliance level.

OUTPUT COMMON terminal provides easy access to output common which is also the inner shield of the output connector.

CHASSIS GROUND terminal provides a convenient connection to chassis ground (earth ground).

IEEE-488 INTERFACE connector provides bus connection to the Model 220. The connector mates with the Model 7008-3 and 7008-6 IEEE cables.*

ADDRESS switches are used to program the primary address for the IEEE-488 interface bus operation. The primary address is updated only upon power-up.*

DIGITAL I/O port consists of four input and four output lines as well as IEEE-488 common and +5VDC. The outputs will drive one TTL load. The instrument can be programmed to generate an SRQ upon any change in the 4 bit input data.*

EXTERNAL TRIGGER INPUT initiates the selected program mode in the same manner as the START/STOP button upon receiving a TTL level negative transition with a minimum pulse width of 10μsec.

EXTERNAL TRIGGER OUTPUT provides a negative TTL level pulse of greater than 10μsec at the completion of the programmed dwell time.

The line power **fuse** is rated as shown in Tables 5-2 and 5-3.

The **line plug** mates with a 3-wire line cord which provides UL approved connections to line power.

*For more information concerning the IEEE-488 connector, digital I/O port and primary address switches refer to the Model 220/230 Programming Manual.

2.3.4 Output Connector

The output connector is a Teflon® insulated triax connector which is located on the rear panel. The maximum allowable voltage potential between the HI terminal and the LO terminal is $\pm$100V. The maximum allowable common mode voltage between the HI input terminal and the chassis common is 250Vrms DC to 60Hz. See Figure 2-2.

CAUTION

Do not exceed the maximum common mode voltage. Instrument damage may occur.

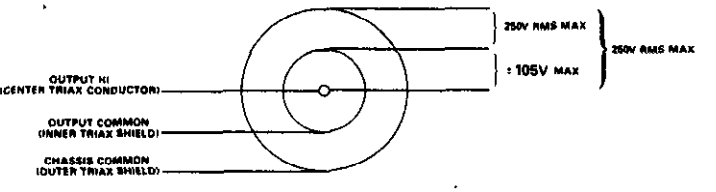


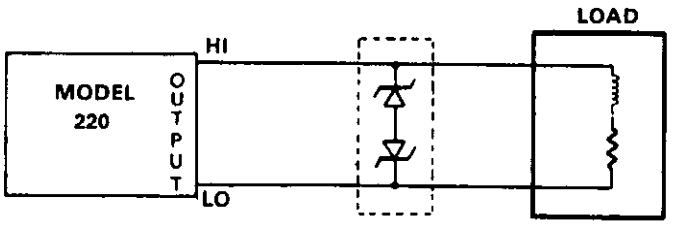
Figure 2-2. Output Connector

2.3.5 Inductive Loads

In general, the output load connected to the Model 220 should be resistive. However, a small amount of inductance in the load can be tolerated but only if the inductive reaction voltage $L\frac{di}{dt}$ is limited to less than 105V. Refer to Figure 2-3 for a suggested method of limiting the inductive reaction voltage.

CAUTION

If the output load connected to the Model 220 is inductive, limit the inductive reaction voltage to less than 105V. Otherwise instrument damage may occur.



TWO BACK TO BACK ZENER DIODES. MOTOROLA 1M1202510

Figure 2-3. Limiting Inductive Reaction Voltage

2.4 OPERATION OF THE MODEL 220

The Model 220 has several different operating parameters. These parameters (step, single continuous, source, V-limit, dwell time etc) are to be programmed using the following general procedure. Several examples of exact programming are given after the following.

2.4.1 Model 220 General Operating Procedure

NOTE

Upon power up or upon actuation of the RESET button the Model 220 is set to memory location 1.

1. Turn on the Model 220 and allow one hour for warm up for rated accuracy operation.
2. Select memory location.
   A. Press MEMORY.
   B. Press the number(s) of the desired memory location (1 to 100).
   C. Press ENTER.
3. Program the desired source.
   A. Press SOURCE.
   B. Press the number(s) of the desired source current (.0000-9mA to 101.00mA). Note that upon power-up the source is set to .0000-9.
   C. Press ENTER.
4. Program the appropriate V-limit.
   A. Press V-limit.
   B. Press the number(s) of the appropriate compliance voltage limit (1 to 105V in one volt increments). Upon power-up the V-limit is set to 1V.
   C. Press ENTER.
5. Program the desired dwell time.
   A. Press DWELL TIME.
   B. Press the number(s) of the appropriate dwell time (3msec to 999.9sec in 1msec increments.) Upon power-up the dwell time of memory location 1 is set to 3.000-3 sec.
   C. Press ENTER.
6. Select the desired program mode (step, single or continuous).
7. Connect appropriate load.

NOTE

The output load must be noninductive. A small amount of inductance in the load can be tolerated if the inductive reaction voltage $L\frac{di}{dt}$ is limited to less than 105V. Refer to paragraph 2.3.5.

8. Program the Output to the operate mode by pressing the OUTPUT button.
9. Select the program control by pressing the START/STOP button.

NOTE

The output is programmed to .0000-9 when not in the operate mode.

2.4.2 Examples of Operation

The following examples depict several operating levels and conditions.

Example 1 Error Message—The Model 220 will display an error message if it is programmed into a parameter value that is outside of the range of the instrument. Table 2-2 lists the conditions that cause an error message. For example program the Model 220 for memory location 102.

1. Press MEMORY.
2. Press 1, 0, 2.
3. Press ENTER.

After the ENTER button is pressed, the Model 220 displays the following for approximately one second. Then the Model 220 returns to the previous display of the memory location.

Table 2-2. Error Message Conditions

Parameters	Limits
Source	Greater than 101.00mA
V-Limit	Greater than 105V or an entry of 000.
Dwell time	Greater than 999.9sec, less than 3msec.
Memory	Greater than 100 or an entry of 000.

Example 2—In this example the Model 220 will be programmed to output a current of 10mA with a 10V compliance limit.

Required Output: 10mA with 10V compliance.

Use the following procedure to program the Model 220 to output the preceding parameters.

1. Select a memory location, if memory location 1 is not desired.
2. Press SOURCE, 1, 0, EXPONENT, 3, ENTER. (Programs a source value of 10mA.)
3. Press V-LIMIT, 1, 0, ENTER. (Programs 10V V-Limit.)
4. Connect load.
5. Press OPERATE.

NOTE

If the ENTER button is not pressed in the sequence indicated, the display data will not be programmed into the appropriate memory location.

Upon the actuation of step 5 the Model 220 outputs 10mA with a 10V compliance limit. Press the SOURCE button to

verify that the 10mA was actually programmed into the Model 220. Press the V-LIMIT button to verify that the 10V limit was actually programmed into the Model 220.

Example 3—In this example the Model 220 will be programmed to output three separate currents, three separate compliance limits, three separate dwell times and three separate memory locations. The three memory locations will be programmed in the step program mode.

Required Output: 100μA, 10V V-limit, 1 second dwell time, memory location 1.
1mA, 20V V-limit, 100msec dwell time, memory location 2.
10mA, 30V V-limit, 2.5 second dwell time, memory location 3.

1. Press MEMORY, 1, ENTER. (Selects memory location 1.)
2. Press SOURCE, 1, 0, 0, EXPONENT, 6, ENTER. (Programs memory location 1 source for 100μA.)
3. Press V-LIMIT, 1, 0, ENTER. (Programs memory location 1 V-limit for 10V.)
4. Press DWELL TIME, 1, EXPONENT, 0, ENTER. (Programs memory location 1 dwell time for one second.)
5. Press MEMORY, 2, ENTER (Selects memory location 2.)
6. Press SOURCE, 1, EXPONENT, 3, ENTER. (Programs memory location 2 source for 1mA.)
7. Press V-LIMIT, 2, 0, ENTER. (Programs memory location 2 V-limit for 20V.)
8. Press DWELL TIME, 1, 0, 0, EXPONENT, +/-, 3, ENTER. (Programs memory location 2 dwell time for 100msec.)
9. Press MEMORY, 3, ENTER. (Selects memory location 3.)
10. Press SOURCE, 1, 0, EXPONENT, 3, ENTER. (Programs memory location 3 source for 10mA.)
11. Press V-LIMIT, 3, 0, ENTER. (Programs memory location 3 V-limit for 30V.)
12. Press DWELL TIME , 2, ., 5, EXPONENT, 0, ENTER. (Programs memory location 3 dwell time for 2.5sec.)
13. Press STEP. (Selects the step program mode.)

After completing step 13 the Model 220 is programmed into the parameters stated. To display any of the three programmed source values, select the desired source value's memory location and press the SOURCE button. To output any of the three source values select the desired source value's memory location, and press the OUTPUT button. Pressing the START/STOP button advances the Model 220 to the next channel. Notice that the START/STOP LED turns on for the programmed dwell time and then turns off. Note that actuation of START/STOP at memory location 3 will put instrument to location 1.

Example 4—In this example the Model 220 will be programmed to output five separate currents, five separate compliance limits, five separate dwell times and five separate memory locations.

Required Output: 100nA, 5V V-limit, 0.5 second dwell time, memory location 1.
1μA, 10V V-limit, 1 second dwell time, memory location 2.
10μA, 15V V-limit, 1.5 second dwell time, memory location 3.
100μA, 20V V-limit, 2 second dwell time, memory location 4.
1mA, 25V V-limit, 2.5 second dwell time, memory location 5.

1. Press MEMORY, 1, ENTER. (Selects memory location 1.)
2. Press SOURCE, 1, 0, 0, EXPONENT, 9, ENTER. (Programs memory location 1 source for 100nA.)
3. Press V-LIMIT, 5, ENTER. (Programs memory location 1 V-limit for 5V.)
4. Press DWELL TIME, ., 5, EXPONENT, 0, ENTER. (Programs memory location 1 dwell time for 0.5 seconds.)
5. Press MEMORY, 2, ENTER. (Selects memory location 2.)
6. Press SOURCE, 1, EXPONENT, 6, ENTER. (Programs memory location 2 source for 1μA.)
7. Press V-LIMIT, 1, 0, ENTER. (Programs memory location 2 V-limit for 10V.)
8. Press DWELL TIME, 1, EXPONENT, 0, ENTER. (Programs memory location 2 dwell time for one second.)
9. Press MEMORY, 3, ENTER. (Selects memory location 3.)
10. Press SOURCE, 1, 0, EXPONENT, 6, ENTER. (Programs memory location 3 source for 10μA.)
11. Press V-LIMIT, 1, 5, ENTER. (Programs memory location 3 V-limit for 15V.)
12. Press DWELL TIME, 1, ., 5, EXPONENT, 0, ENTER. (Programs memory location 3 dwell time for 1.5 seconds.)
13. Press MEMORY, 4, ENTER. (Selects memory location 4.)
14. Press SOURCE, 1, 0, 0, EXPONENT, 6, ENTER. (Programs memory location 4 source for 100μA.)
15. Press V-LIMIT, 2, 0, ENTER. (Programs memory location 4 V-limit for 20V.)
16. Press DWELL TIME, 2, EXPONENT, 0, ENTER. (Programs memory location 4 dwell time for 2 seconds.)
17. Press MEMORY, 5, ENTER. (Selects memory location 5.)
18. Press SOURCE, 1, EXPONENT, 3, ENTER. (Programs memory location 5 source for 1mA.)
19. Press V-LIMIT, 2, 5, ENTER. (Programs memory location 5 V-limit for 25V.)
20. Press DWELL TIME,2, ., 5, EXPONENT, 0, ENTER. (Programs memory location 5 dwell time for 2.5 seconds.)

After completing step 20 the Model 220 is programmed into the parameters stated. To display any of the parameters of any memory location select the desired memory location and then select the desired parameter. To output any of the source values select the desired source value's memory location and press the OUTPUT button.

To scan the five memory locations use the following procedure:

1. Select the program mode of scanning. (Select Single, Continuous, or Step.)
2. Select desired display mode. (Source, V-limit, dwell time or memory.)
3. Press the START/STOP button.

In the step program mode the user can manually step through the programmed memory locations one at a time. Each time it is desired to advance to the next programmed memory location the user presses the START/STOP button. The START/STOP LED turns on for the duration of the programmed dwell time. When the last programmed memory location is selected (memory location 5 in this example) pressing the START/STOP button reverts the instrument to memory location 1.

In the single program mode the Model 220 cycles through all the programmed memory locations one time. To start the single program mode press the START/STOP button. Once the single program mode is activated, the Model 220 starts from the present memory location and advances to each programmed memory location. The instrument remains at each memory location for the programmed dwell time and then advances to the next programmed memory location. After the dwell time of the last programmed location the START/STOP LED turns off and the single program mode is ended. The Model 220 remains at the last programmed location until power is turned off, RESET is pressed, memory location is changed or the single or continuous program modes are activated.

NOTE

An entry of zero for the dwell time for any memory location is interpreted as a reset in the step, single and continuous program modes.

In the continuous program mode the Model 220 cycles through all the programmed memory locations continuously. To start the continuous program mode press the START/STOP button. To stop the continuous program mode press the START/STOP button a second time. When the START/STOP button is pressed the second time the continuous program mode is stopped at the present memory location. Once the continuous program mode is activated, the Model 220 starts from the present memory location and advances to the next memory location. The instrument remains at the present memory location for the programmed dwell time (dwell time can vary for each memory location) and then advances to the next memory location. The cycle continues up to and including the last programmed memory location and then reverts to memory location 1. At this point the cycle starts over again and keeps repeating until the START/STOP button is pressed, power to the instrument is turned off or the single or step program modes are selected.

Example 5—In this example the COPY button will be used to duplicate the data of memory location 1 into memory locations 2, 3, 4 and 5. The COPY button function, when used in the memory display mode, duplicates the source, V-limit, and dwell time data of one memory location, into the next memory location. Program the following parameters into memory location 1 and use the procedure to duplicate these parameters into memory locations 2, 3, 4 and 5.

Required Parameters:

1. 10.05mA Source
2. 25V V-limit
3. 525msec Dwell Time

1. Press MEMORY, 1, ENTER. (Selects memory location 1.)
2. Press SOURCE, 1, 0, ., 0, 5, EXPONENT, 3, ENTER. (Programs memory location 1 source for 10.05mA.)
3. Press V-LIMIT, 2, 5, ENTER. (Programs memory location 1 V-limit for 25V.)
4. Press DWELL TIME, 5, 2, 5, EXPONENT, 3, ENTER. (Programs memory location 1 dwell time for 525msec.)
5. Press MEMORY, COPY, COPY, COY, COPY.

The parameters specified were programmed into the Model 220 by steps 1 through 4. The parameters of memory location 1 were duplicated into memory locations 2, 3, 4 and 5 by step 5. To verify that the data was duplicated into the other memory locations select each memory location and select each parameter for each memory location. For example: To verify that 10.05mA was duplicated into memory location 3 use the following two steps.

1. Press MEMORY, 3, ENTER. (Selects memory location 3.)
2. Press SOURCE. (Displays memory location 3 source data.)

Example 6 Fabricating Output Waveforms—The Model 220 is capable of fabricating output waveforms. With the 100 memory locations the Model 220 can fabricate waveforms with up to 100 individual steps. The following procedure is an example of programming the Model 220 to output a square wave of 10mA to 2mA at 100Hz.

Required Output: 10mA to 2mA square wave at 100Hz with a V-limit of 10V.

NOTE

Cycle power to the instrument before starting this example to avoid confusion of previously programmed memory locations.

1. Press MEMORY, 1, ENTER. (Selects memory location 1.)
2. Press SOURCE, 1, 0, EXPONENT, 3, ENTER. (Programs memory location 1's V-limit for 10V.)
3. Press V-LIMIT, 1, 0, ENTER. (Programs memory location 1's V-limit for 10V.)
4. Press DWELL TIME, 5, EXPONENT, 3, ENTER. (Programs memory location 1 dwell time for 5msec.)
5. Press MEMORY, 2, ENTER. (Selects memory location 2.)
6. Press SOURCE, 2, EXPONENT, 3, ENTER. (Programs memory location 2 source for 2mA).)
7. Press V-LIMIT, 1, 0, ENTER. (Programs memory location 2 V-limit for 10V.)
8. Press DWELL TIME, 5, +/-, EXPONENT, 3, ENTER. (Programs memory location 2 dwell time for 5msec.)
9. Press CONTINUOUS, OPERATE, START/STOP.

Upon completion of step 9 the Model 220 outputs a 10mA to 2mA 100Hz square wave as shown in Figure 2-4.

NOTE

When fabricating output waveforms observe the response time specifications of the Model 220. Also, consider the affect of load impedance on the waveform to be fabricated.

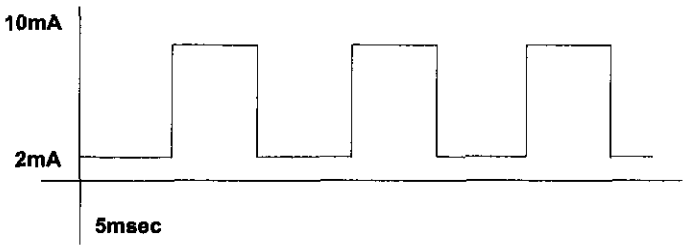


Figure 2-4. 10mA to 2mA Square Wave

NOTE

In this example the Model 220 does not change range. If the Model 220 is programmed to change from one range into another (e.g. 10mA to 1mA), the output drops to zero for approximately 2msec between range changes.

Example 7 Using External Trigger (Input and Output) — The external trigger input initiates the program mode (single, continuous, or step) in the same manner as the START button. To output any programmed values the program mode must be selected, the OPERATE button enabled, and the instrument must receive the external trigger input pulse.

The external trigger output is a pulse signifying the completion of a programmed dwell time. The pulse is present at the external trigger output in any of the three program modes. For the single or continuous program modes there is an output pulse at the end of every programmed dwell time. For the step program mode, there is an output at the end of the programmed dwell time for the one memory location. To go on to the next step (memory location), and therefore output another external trigger output pulse, another external trigger input pulse is required.

Using the Model 619 in conjunction with the Model 220 can help illustrate this example. Like the Model 220, the Model 619 has external trigger input and output (electrometer complete and external trigger) lines. Connect the two instruments as shown in Figure 2-5. In this configuration and with the proper programming, the Model 220 will output the programmed current when the START button is pressed. At the end of the specified dwell time the Model 220 outputs the external trigger pulse. This pulse triggers the Model 619 to take a reading. When the Model 619 measurement cycle is completed it will output a trigger pulse (via the electrometer complete line) to the Model 220. The trigger pulse from the Model 619 to the Model 220, triggers the Model 220 to advance to the next memory location and output the next programmed current.

NOTE

Only the Model 619's with electrometer complete and external trigger can be used for this example.

At this point the cycle repeats itself and keeps on repeating itself by advancing through the programmed memory locations of the Model 220. To stop the cycle, disconnect one of the trigger lines.

NOTE

The Model 619 can be set to the talk-only mode and connected to an IEEE compatible printer. The Model 619 measurement data would then be recorded by the printer automatically. This would free the operator from recording the data manually.

Example 8 Using Guard — Leakage resistance between low current conductors and nearby voltage sources can cause significant error currents. For example, if a printed circuit element has a leakage path with a resistance of $10^9\Omega$ to a nearby 15V supply terminal, a current of 15nA will be generated as shown in Figure 2-6a. In order to keep this current below 1pA, the leakage resistance would have to be above $1.5 \times 10^{12}\Omega$. This high resistance is difficult to maintain in many situations. In order to eliminate such stringent insulation resistance requirements, guarding techniques may be used as shown in Figure 2-6b.

Guarding is surrounding the sensitive input with a conductor (the guard) connected to a low impedance point which is at (virtually) the same potential. The GUARD terminal located on the rear panel provides an easy connection to a low impedance voltage source which is equivalent to the output compliance voltage.

The maximum load capacitance for the guard output is 0.01μF. The maximum load current which includes guard and output is not to exceed 105mA. The accuracy of the guard ±1mV excluding output lead I•R voltage drop.

Example 9 Floating Operation — The Model 220 can be floated off chassis ground. Guard or output common MUST NOT be connected to chassis ground when floating the instrument above chassis ground potential. Chassis ground is connected to earth ground with the line power cord and an appropriate grounded three-wire receptacle. The Model 220 can be floated up to 250Vrms above chassis ground.

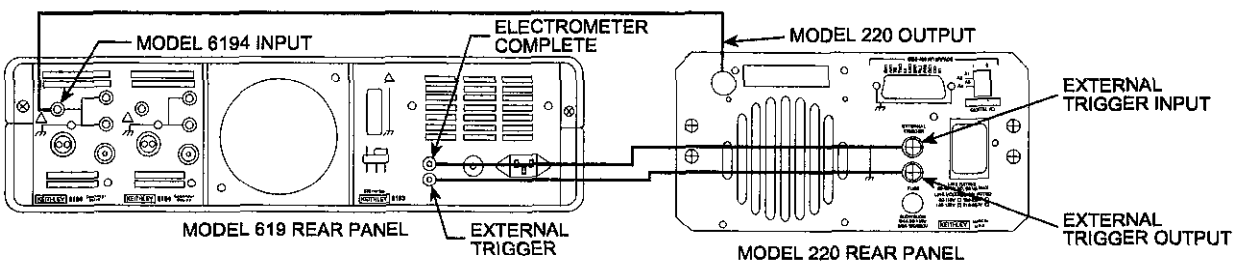
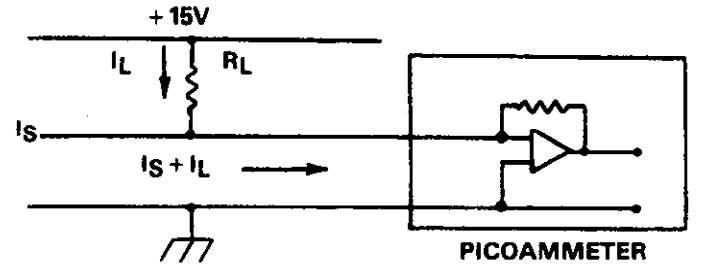
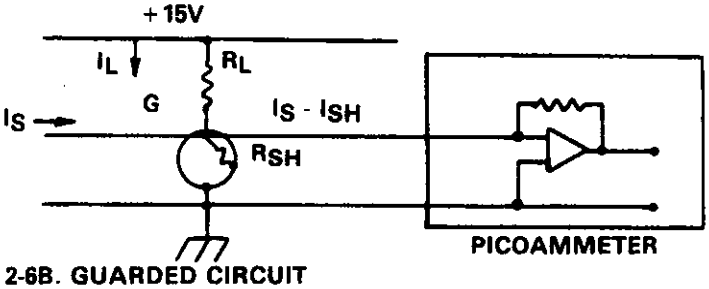


Figure 2-5. Using the Model 220 External Trigger



2-6A. UNGUARDED CIRCUIT



2-6B. GUARDED CIRCUIT

Figure 2-6. Guarding

CAUTION

When an external voltage source is connected in series with the Model 220 output, care should be taken to limit the power delivered to the Model 220. Refer to Figure 2-8 for power limits.

Example 10 Operation as an Active Load (Current Sink)—The Model 220 can be used as an active current sink as shown in Figure 2-7. The output voltage V_o is a function of E, I and R_L where:

$V_o = E + IR_L$

E = External Voltage Source

I = Programmed Current on the Model 220

R_L = Load Resistance

CAUTION

When the Model 220 is connected so as to sink current (that is, power is delivered to the Model 220 by an external power supply), care should be taken to limit the power delivered to the Model 220. Figure 2-8 shows the power limits to the Model 220 used in this configuration.

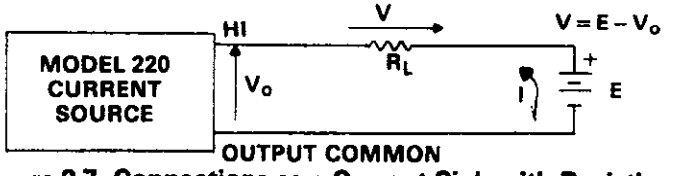


Figure 2-7. Connections as a Current Sink with Resistive Load

For resistive loads the Model 220 will deliver the programmed current up to the compliance voltage ($V_o = V_c$). The output voltage V_o must be within the power limits specified in Figure 2-8.

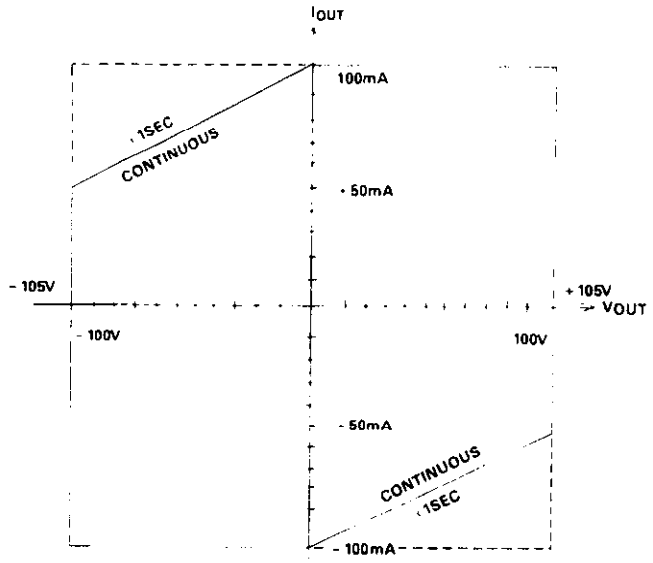


Figure 2-8. Model 220 Recommended Operating Limits

2.5 APPLICATIONS

2.5.1 Calibration

Model 220, with its high accuracy, can be used as current calibration source. The required current values and voltage compliance limits can be programmed into the memory locations. The three different program modes allow the operator to run through the programmed values wether manually (step) or automatically (single or continuous). In the single or continuous program mode different dwell times can be programmed. This allows the operator to tailor the dwell times to his needs. The step program modes may be the best way to run through the calibration steps. In this mode the operator can manually step through the memory locations and therefore, output the current when it is required by the calibration procedure.

2.5.2 Resistivity Measurement

Certain semiconductor materials such as silicon have high resistivities. The measurement of their resistivity can be a difficult measurement. To aid in the measurement, special probes of a hard metal such as tungsten are used. Because contact resistance is so high, a four point probe is usually employed. The outer two contact supply a constant current, the inner two contacts measure the voltage drop across a portion of the sample. With the geometry of the probe and wafer known, resistivity can then be calculated.

The current source used must be stable and accurate. The Model 220 is ideal for this application. The accurate and stable current along with compliance voltage can be easily programmed before making the measurement.

The two voltmeters require a high impedance to overcome lead resistance problems. The Model 614 has the high input impedance (greater than $5 \times 10^{13}\Omega$ in parallel with 20pF) re-

quired to make the measurement accurately. Refer to Figure 2-9.

For most wafers the resistivity is calculated from: $P = kt\frac{V}{I}$

k is a constant based on the geometry of the wafer and probe.
t is the sample thickness.
V is the measured voltage.
I is the current in the sample.

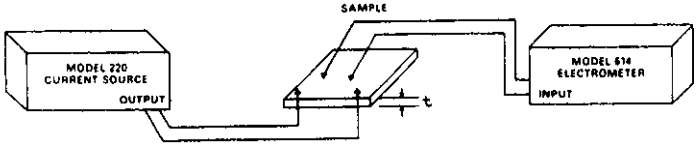


Figure 2-9. Resistivity Measurement Using the Model 220 and Model 614

2.5.3 Diode Characterization

With the Model 220 it is possible to plot I-V (current-voltage) characteristics of a diode over several decades. Figure 2-10 shows the configuration to be used. The Model 614, with its high input resistance in the volts function; will allow the measurement to be made accurately. Figure 2-11 shows several examples of diodes whose curves have been plotted using the configuration of Figure 2-10.

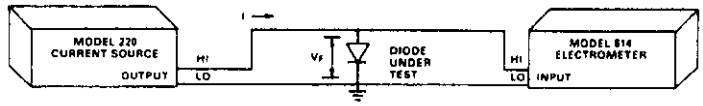


Figure 2-10. Diode Characterization

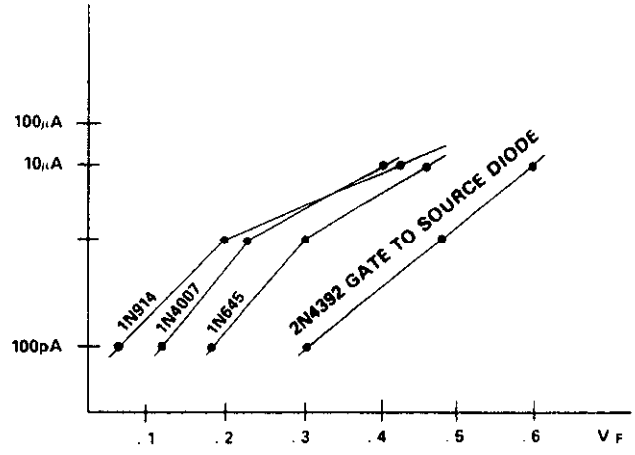


Figure 2-11. Diode Curves

SECTION 3
PERFORMANCE VERIFICATION

3.1 INTRODUCTION

Performance verification may be done upon receipt of the instrument to ensure that no damage or misadjustment has occurred during transit. Verification may also be performed whenever there is question of the instrument's accuracy.

NOTE

For instruments that are still under warranty (less than 12 months since date of shipment), whose performance falls outside specifications at any point, contact your Keithley representative or the factory immediately.

3.2 ENVIRONMENTAL CONDITIONS

Measurements should be made at 18°-28°C and at less than 70% noncondensing relative humidity, unless otherwise indicated.

3.3 RECOMMENDED TEST EQUIPMENT

Table 3-1 lists all the test equipment required for verification. If alternate equipment is used, the alternate test equipment's specifications must be at least as good as the equipment specifications listed in Table 3-1.

3.4 INITIAL CONDITIONS

The Model 220 must be turned on and allowed one hour for warm-up. If the instrument has been subjected to extremes of temperature, allow sufficient time for internal temperatures to reach normal operating conditions as specified in paragraph 3.2. Typically, it takes one hour to stabilize a unit that is 10°C (18°F) out of the specified temperature range.

3.5 PERFORMANCE VERIFICATION PROCEDURE

Use the following procedure to verify the accuracy of the Model 220. If the Model 220 is out of specification, proceed to Section 5 Maintenance, unless the Model 220 is under warranty.

WARNING

Verification should be performed by qualified personnel using accurate and reliable test equipment.

NOTE

The allowable reading for each range includes the tolerances of the recommended test equipment. If different test equipment is used, modify the allowable readings accordingly.

3.5.1 100mA to 1mA Range Verification

1. Connect the Model 220, Model 192 and the 100Ω load resistor as shown in Figure 3-1.
2. Select the 20VDC range on the Model 192.
   a. Program the Model 220 to output +00.00-3. Verify that the reading on the Model 192 does not exceed +5mV.
   b. Program the Model 220 to output +00.000-3. Verify that the reading on the Model 192 does not exceed +1mV.
   c. Select 2V range on the Model 192. Program the Model 220 to output +.0000-3. Verify that the reading on the Model 192 does not exceed +100μV. Select the 20V range on the Model 192.
3. Program the Model 220 for 50mA with a 20V compliance limit.
4. Press the OPERATE button on the Model 220.
5. Verify that the reading on the Model 192 display is within the limits specified in Table 3-2.
6. Repeat steps 2 through 5 for the 10mA and 1mA range.
7. Repeat steps 2 through 6 with negative output current.

NOTE

Because of the power constraints on the 100Ω resistor (1/4W), the 100mA range must be checked with a test current of 50mA. When checking this range, only apply power momentarily to prevent the resistor from overheating.

Table 3-1. Recommended Test Equipment

Item	Description	Specification	Mfr.	Model
A	DMM	0.005% (2V range)	Keithley	192
B	Precision Resistor	100Ω ±0.01%, 1/4W	Keithley	R-196-100Ω
C	Precision Resistor	100kΩ ±0.01%	Caddock	TF020N
D	Precision Resistor	10MΩ ±0.25%	Keithley	R-305-10M
E	Precision Resistor	1GΩ ±2%	Keithley	R-289-1G
F	Tera-Ohmmeter	10MΩ Range; ±0.025%, 1GΩ Range; ±0.05%	Guildline	9520
I	Test Fixture			

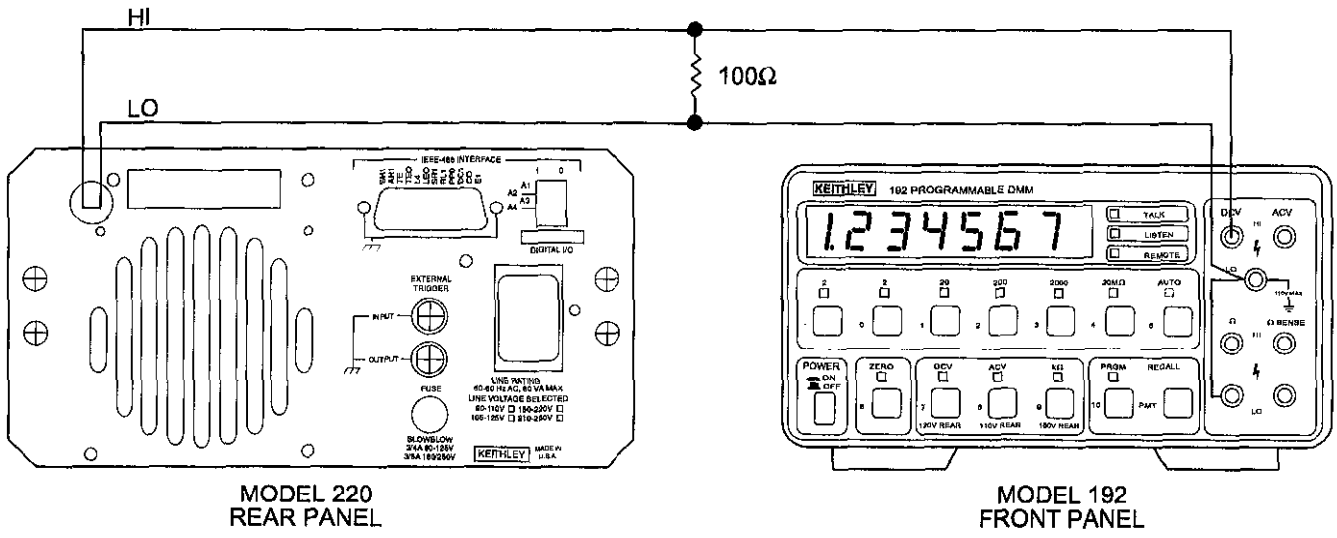


Figure 3-1. 100mA to 1mA Range Verification

Table 3-2. 100mA to 1mA Verification

Model 220 Range	Model 220 Output	Model 192 Range	Model 192* Allowable Reading (18°C to 28°C)
100mA	50.00mA**	20Vdc	5.0090 to 4.9910
10mA	10.000mA	2Vdc	1.00132 to 0.99868
1mA	1.0000mA	2Vdc	0.10013 to 0.09987

*Includes test equipment tolerances.
**Apply momentarily to prevent the resistor from overheating.

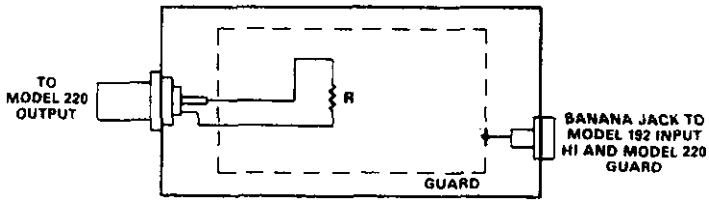
3.5.2 100µA and 10µA Range Verification

1. Replace the 100Ω resistor in Figure 3-1 with the 100kΩ resistor specified in Table 3-1.
2. Select the 20VDC range on the Model 192.
   a. Program the Model 220 to output +00.00-6. Verify that the reading on the Model 192 does not exceed +10mV.
   b. Program the Model 220 to output +0.000-6. Verify that the reading on the Model 192 does not exceed +1mV.
3. Program the Model 220 to output +100.00-6 amps with 20V compliance.
4. Verify the reading on the Model 192 to be between 10.0120 and 9.9880.
5. Select the 2VDC range on the Model 192.
6. Program the Model 220 to output +10.000-6 amps with 20V compliance.
7. Verify the reading on the Model 192 to be between 1.00122 and 0.99878.
8. Repeat steps 2 through 7 with negative output current.

3.5.3 1µA and 100nA Range Verification

1. Construct the test fixture shown in Figure 3-2 using the 10MΩ resistor as R.
2. Measure the 10MΩ resistor with the Guildline 9520 and note the value.
3. Set up the circuit shown in Figure 3-3.
4. Set the Model 192 to the 20VDC range.
5. The GUARD of the Model 220 may input an offset of ±1mV to the Model 192. To cancel this offset, proceed as follows:
   A. Program the Model 220 to output ±0.0000-6A.
   B. Short the 10MΩ resistor.
   C. Zero the display of the Model 192 by pressing the ZERO button.
   D. Remove the short from the 10MΩ resistor.
6. Program the Model 220 to output +1.0000-6A with a 20V compliance.

7. Using the measured value of the 10MΩ resistor, calculate the voltage drop across that resistor.
   Example: (+1.0000-6A) × (10.001MΩ) = 10.0010V.
   (Model 220 Programmed Output) × (Measured Resistance) = (Expected Voltage Drop Across R).
8. Verify that the reading on the Model 192 is the calculated voltage drop ±0.0165V.
9. Place the Model 220 in the standby mode and take the Model 192 out of the zero mode (ZERO annunciator off).
10. Set the Model 192 to the 2VDC range.
11. Cancel the effects of guard offset from the Model 220 as follows:
    A. Program the Model 220 to output +000.0-9A.
    B. Short the 10MΩ resistor.
    C. Zero the display of the Model 192 by pressing the ZERO button.
    D. Remove the short from the 10MΩ resistor.
12. Program the Model 220 to output +100.00-9A with a 20V compliance.
13. Using the measured value of the 10MΩ resistor, calculate the voltage drop across that resistor.
    Example: (+100.00-9A) × (10.001MΩ) = 1.00010V.
    (Model 220 Programmed Output) × (Measured Resistance) = (Expected Voltage Drop Across R).
14. Verify that the reading on the Model 192 is the calculated voltage drop ±0.00367V.
15. Repeat steps 4 through 14 with negative current output
16. Place the Model 220 in the standby mode and take the Model 192 out of the zero mode



Construction Notes:
1. To decrease settling times and to assure accurate calibrations, it is recommended to use an internal guard (as shown in the drawing above). The guard must be insulated from the surrounding case.
2. To further minimize inaccuracies, current leakage paths to ground (or guard) must be minimized. This requires the use of low leakage insulating materials for construction and the use of special cleansing agents such as freon® to clean the components and insulators after construction.

Figure 3-2. Test Fixture

3.5.4 10nA and 1nA Range Verification

1. Construct the test fixture shown in Figure 3-2 using the 1GΩ resistor specified in Table 3-1.
2. Measure the 1GΩ resistor with the Guildline 9520 and note the value.
3. Set up the circuit shown in Figure 3-3.
4. Set the Model 192 to the 20VDC range.
5. Cancel the effects of guard offset from the Model 220 as follows:
   A. Program the Model 220 to output 0.000-9A.
   B. Short the 1GΩ resistor.
   C. Zero the display of the Model 192 by pressing the ZERO button.
   D. Remove the short from the 1GΩ resistor.
6. Program the Model 220 to output +10.000-9A with a 20V compliance.
7. Using the measured value of the 1GΩ resistor, calculate the voltage drop across that resistor.
   Example: (+10.000-9A) × (1.001GΩ) = 10.0100V.
   (Model 220 Programmed Output) × (Measured Resistance) = (Expected Voltage Drop Across R).
8. Verify that the reading on the Model 192 is the calculated voltage drop ±0.0340V.
9. Place the Model 220 in the standby mode and take the Model 192 out of the zero mode.
10. Set the Model 192 to the 2VDC range.
11. Cancel the effects of guard offset from the Model 220 as follows:
    A. Program the Model 220 to output +.0000-9A.
    B. Short the 1GΩ resistor.
    C. Zero the display of the Model 192 by pressing the ZERO button.
    D. Remove the short from the 1GΩ resistor.
12. Program the Model 220 to output +1.0000-9A with a 20V compliance.
13. Using the Measured value of the 1GΩ resistor, calculate the voltage drop across that resistor.
    Example: (+1.0000-9A) × (1.001GΩ) = .00100V.
    (Model 220 Programmed Output) × (Measured Resistance) = (Expected Voltage Drop Across R).
14. Verify that the reading on the Model 192 is the calculated voltage drop ±0.00542V.
15. Repeat steps 4 through 14 with negative current output.

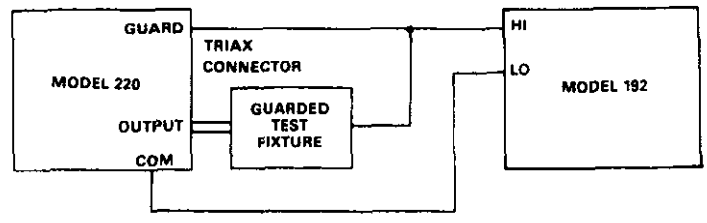


Figure 3-3. 1μA-1nA Range Verification

SECTION 4
THEORY OF OPERATION

4.1 INTRODUCTION

This section contains circuit descriptions for the Model 220. The information is arranged to provide a circuit description of individual functional circuit blocks. To facilitate understanding, the descriptions are keyed to accompany simplified block diagrams and schematics. Detailed schematics of the Model 220 are located in Section 6.

4.2 BLOCK DIAGRAMS

The circuitry of the Model 220 is represented by the two simplified block diagrams in Figures 4-1 and 4-2. Figure 4-1 shows a simplified block diagram of the Model 220's analog circuitry (power supply, range circuitry, amplifiers etc.). Figure 4-2 shows a simplified block diagram of the Model 220's digital circuitry (microprocessor, RAM, ROM, VIA etc.).

4.3 POWER SUPPLY

To facilitate understanding of the following discussion refer to schematic diagram 220-106 (sheet 2 of 2). The power supply is a conventional AC to DC power converter. Transformer T101, has three separate secondaries that are fed into three separate bridge rectifiers CR101, CR108 and the bridge configuration of CR102 through CR105. The output of CR101 is fed into regulator VR101 and is filtered by C107 and C103 producing the +5V digital supply. The output of CR108 is fed into VR102 and VR103 and is filtered by C119 through C122 to produce the positive and negative 15V supplies. The output of CR102 through CR105 is filtered by C117 and C118 to produce the positive and negative 125V supplies. R118 and R119 are bleeder resistors to prevent charge retention after AC power is removed.

A tap off of the primary of the transformer T101 supplies the nominal 115VAC to the fan.

4.4 ANALOG BOARD

To facilitate understanding of the following discussion refer to schematic diagram 220-126 (sheet 1 and 2).

The heart of the analog board is the high voltage electrometer op amp which is centered on U319. The performance of U319 is bootstrapped up to the voltage levels supplying Q318 and Q319 by Q315-Q319, Q313-Q318 and their associated circuitry. Q301, Q302, R344, R348, R349, C313 and C320 establish frequency stability for U319. R343 is an input voltage offset adjustment for U319.

A constant current source can be derived by a series voltage source and resistance from the output (analog common/guard) to the amplifier input. The amplifier input to the common of the high voltage supplies of Q318/Q319 (output common) comprises a current source. Range resistors R358, R361, R362, R378, R375, R376, R380 and R381 along with their associated calibration potentiometers, comprise the series resistance section of the current source. These resistances connect to the input node of the amplifier through relays K301-K305. When several resistances are connected through a common relay, JFET switches Q303 through Q310 are used to distinguish which resistor is being used. Several JFETs are organized in pairs for voltage sensing at the resistor to compensate for the voltage drop in the current carrying JFET.

U315 serves as a sense amplifier with Q311, Q312, R344 and R345 as a high current buffer for the higher current ranges. U314, U318A and U320 B, C, D, E and F drive the range relays. U318B, U317 and U313 A, B, C and D drive the JFET switches. U313 and U317 are voltage comparators with open collector outputs. Combined with R350, this circuitry provides the voltage drive for the switching JFETs.

The voltage source section centers around U311, the 12 bit digital to analog converter (DAC). Associated circuitry R301 through R307 and R316, are used to adjust offset and positive gain. Gain is set on the 1mA range and therefore R376 does not have an adjustment. Following this circuitry is a network providing a +/- operator to the output of U311. U312 provides the active portion while switches on U306 along with resistors R317, R318, R320 and R323 provide a selectable gain of +1 or -1.

R318 provides a gain adjust (-1mA) for this operator. The output is fed to the sense amplifier U315. R392 is an offset voltage adjustment potentiometer for U312 and U315.

Serial to parallel shift/store registers U301, U302 and U303 provide digital control from the serial data link. Data is inputted via the clock and latch lines. Latch selects the data in mode as either recirculated data out (latch = logic 0) or the overcompliance (V-limit) information (latch = logic 1). This selection is performed by U304A and B, U316B and C and U305A.

Gates U305B, C and D form a flip-flop for controlling the tri-state mode of the outputs of U301, U302 and U303. This circuitry, along with R351, R352, CR307, C305, etc., prevents erroneous current source outputs both on acquisition and loss of AC line power.

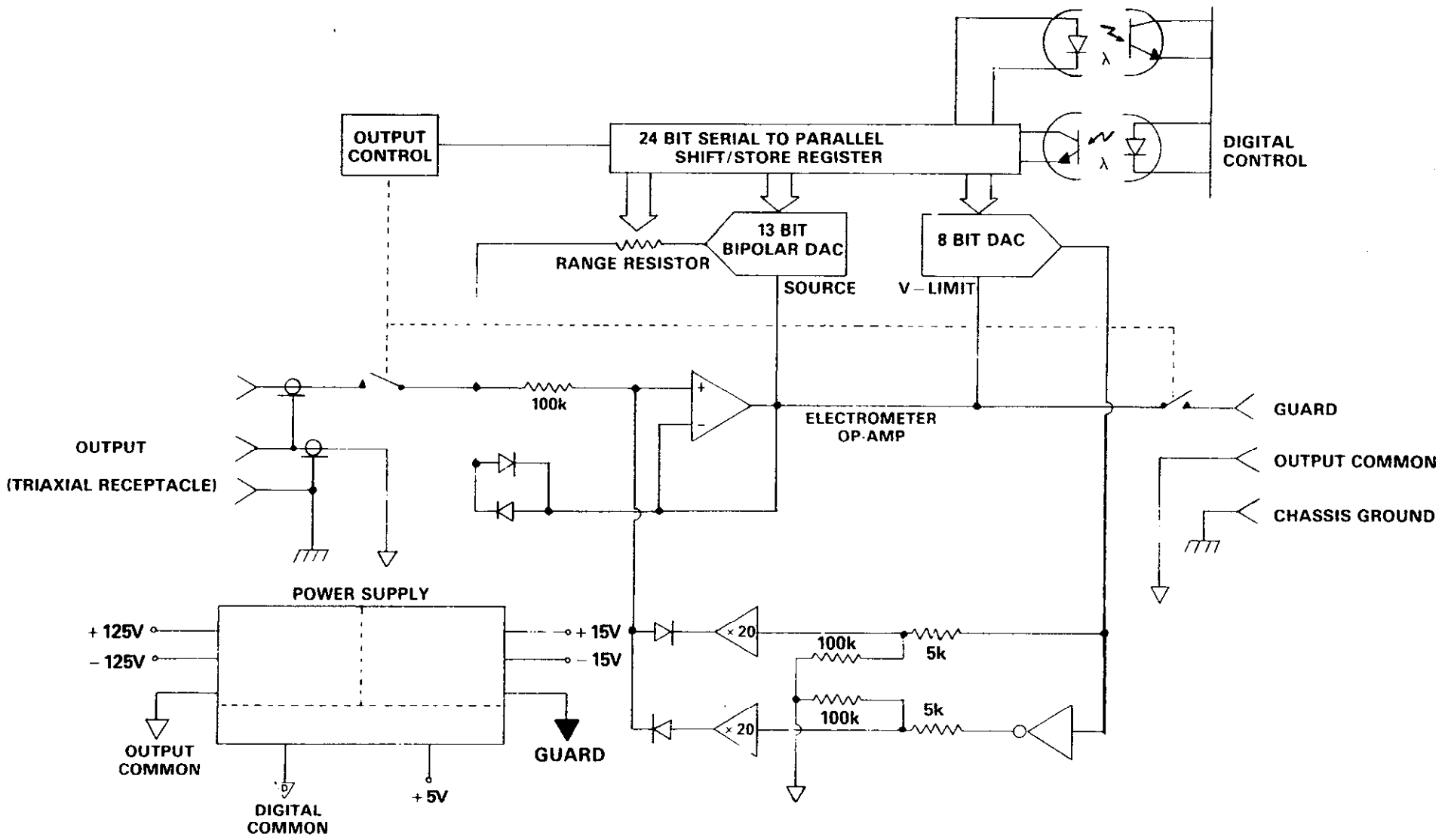
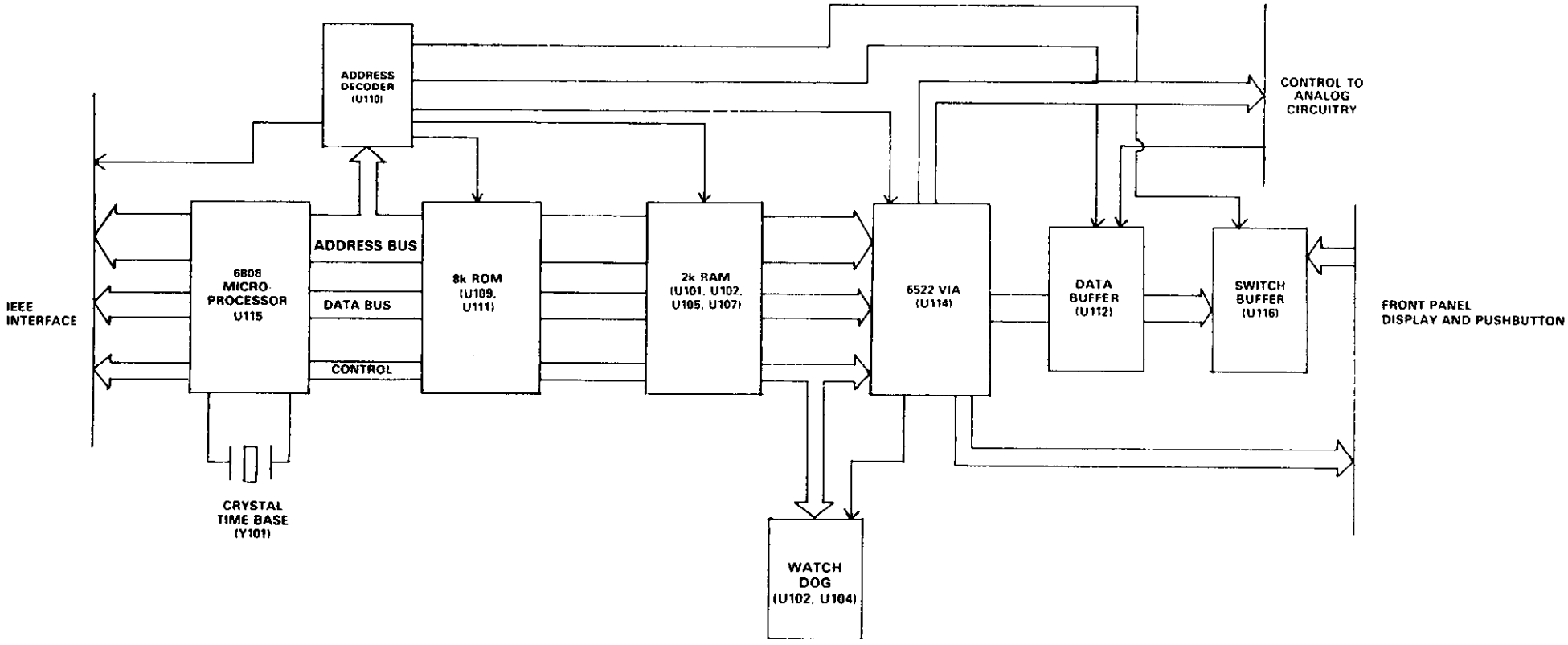


Figure 4-1. Analog Circuitry Block Diagram



FOR DETAILED INFORMATION ON THE IEEE-488 INTERFACE REFER TO THE 220/230 PROGRAMMING MANUAL

Figure 4-2. Digital Circuitry Block Diagram

The remaining portion of the analog circuitry produces the selectable compliance voltage limit. An 8 bit digital-to-analog converter (DAC) U308 starts this process. With 128 combinations, each step is scaled to represent one volt of compliance. Since U308 is a current output DAC, U309 is required to revert back to a voltage level. The output of U309 then represents the selected compliance voltage scaled down by a factor of 20.

This signal and its inverse (U309A, R324 and R327) are applied to divider network R331 and R336 which are referenced to output common. At the junction of each divider network is an amplifier which reverses the previous scaling factor. Resulting from this is an error voltage approximately equal to the difference between the actual compliance voltage level and the programmed level. Each amplifier U307A and B and the associated circuitry, is coupled through diodes CR303 and CR302 on R333. The polarity of the diodes is arranged such that a voltage is impressed on R333 only when the actual voltage compliance exceeds + /- the programmed value. This result is applied to the output node via low leakage diode CR304 preventing any further compliance voltage excursion. Current from the range resistors is shunted through diodes CR305 and CR306 when this operation limit occurs. Resistors R330 and R332 add an offset to compensate for diode drops in CR302 through CR304.

The circuit configuration of U313A and B comprise a window comparator to detect a V-limit condition across R333. The comparator limits are set by resistor divider network R338 through R341. U313A and B open collector outputs are configured in a "wire ORed" fashion through pull up resistor R346. Whenever the voltage across R333 exceeds the comparator limits, a logic 1 is developed through current limiting resistor R347 to the output of inverter U316E. C311 is used for stabilization.

VR301 supplies the digital circuitry with the required +5V. This voltage is also supplied to the digital board for use by the optically isolated portion of the circuitry.

4.5 DIGITAL BOARD (Microcomputer)

To facilitate understanding of the following discussion refer to schematic diagram 220-106 (sheet 1 of 2). For an overall block diagram of the digital circuitry refer to Figure 4-2.

The microcomputer and its associated logic circuitry, controls front panel functions (source, dwell time, program control etc.), operation of the front panel display and data through the IEEE-488 interface circuitry.

The microcomputer includes a 6808 microprocessing unit U115; a 6522 versatile interface adapter U114; two 2732 ROMs U109 and U111; four 2114 RAMs U101, U103, U105 and U107; an address decoder U110; a data bus driver U116 and the necessary reset logic. The memory utilized in this system is shown in the memory map (Figure 4-3). Using address lines A13, A14 and A15; U110 sections the 64k of memory space into 8k and 4k segments. The total memory used is a small portion of the entire addressing capabilities of the 6808 microprocessor U115. Memory locations for the 64k addresses are assigned the values 0000_{16} through $FFFF_{16}$.

Interfacing of the microprocessor with the RAMs, ROMs, Front Panel, VIA or the IEEE-488 interface is controlled by the address decoder, U110.

Partial address decoding is used in this system. The function selected is determined by the state of the address lines A13, A14 and A15. These address lines determine which output is selected at the decoder U110 in accordance with the memory map. Only one of the devices (RAM, ROM, VIA, etc.) will have access to the data bus at any time. The address decoder selects one of the devices only after a Valid Memory Address VMA has been asserted at the decoders input EN (pin 6). The VMA signal is generated by the 6808 microprocessor.

Timing for the computing sequence is provided by the 4MHz crystal Y101. The 6808 microprocessor divides this signal by four to produce a 1MHz signal at the Φ2 output (pin 37).

U102, U104, U106C, U108C and their associated circuitry, forms a reset network (watchdog) which resets the microprocessor, VIA and the IEEE-488 interface. The circuit actuates in the event the front panel display is not updated after a specific period of time has elapsed due to a lost program or power line transient.

The digital circuitry is optically isolated from the analog circuitry by AT101 through AT104, U113A, B, U117 and their associated circuitry. The output signals consist of latch, clock and data out. These signal lines permit serial communication to the analog circuitry. The data in signal line is received from the analog circuitry and is either the recirculated data or the overcompliance (V-limit) data depending on the state of the latch line. When the latch line is a logic 1, the data in line will represent the compliance state (logic 1 implies an overcompliance or V-limit). When the latch line is a logic 0, the data in line will be the recirculated data sent out to the analog side as data out. This data is inverted on the digital side of the isolation.

The remaining circuitry on the digital board consists of external trigger inputs and outputs. C123, CR112, CR111, R121 and R128 comprise an input protection network for triggering input to PB6 of the VIA (U114). V113D, CR109, CR110, R127 and R122 buffer a triggered output originated on PB3 of the VIA (U114).

4.6 DISPLAY CIRCUIT

The display information is outputted on PA0 through PA7 on the VIA (I/O) bus. The information is updated at a 1kHz

rate which means, each digit is on for 1ms. Each update begins by presenting new segment information on the VIA (I/O) bus (PA0-PA7) and outputting a clock pulse on CA2. The clock pulse inputs to U203 and shifts a digit enable bit to the next digit to be enabled. Every eight times the display is updated, a digit enable bit is generated at PB5 and goes to the enable data input of the shift register.

The first four digit drivers drive the rows of the switch matrix. The switches are arranged in a four by six matrix. The segment drivers are Q201 through Q208. In addition to driving the various segments, they also activate the appropriate LEDs.

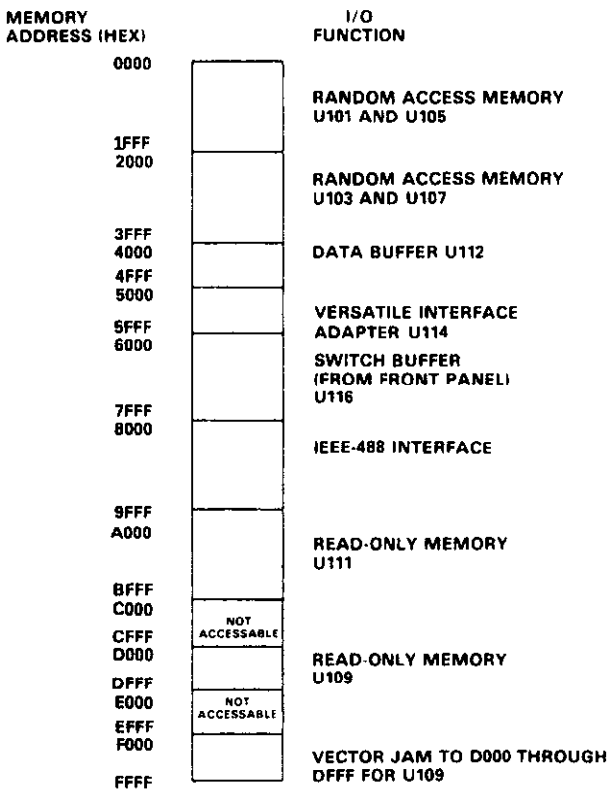


Figure 4-3. Memory Map

SECTION 5
MAINTENANCE

5.1 INTRODUCTION

This section contains information necessary to maintain the Model 220. Calibration adjustment, troubleshooting, fuse replacement, line voltage selection, fan filter cleaning and all information pertinent to maintenance is provided.

5.2 CALIBRATION

Calibration should be performed yearly (every 12 months) or whenever performance verification (see Section 3) indicates that the Model 220 is out of specification. If any step in the calibration procedure cannot be performed properly, refer to paragraph 5.4 for troubleshooting information or contact your Keithley representative or the factory.

WARNING

All service information is intended for qualified electronic maintenance personnel only.

5.2.1 Recommended Test Equipment

Recommended test equipment for calibration is listed in Table 5-1. Alternate test equipment may be used. However, the accuracy of the alternate test equipment must at least be equal to the specifications in Table 5-1.

5.2.2 Environmental Conditions

Calibration should be performed under laboratory conditions having an ambient temperature of 23°C ±1°C and a relative humidity of less than 50%.

5.2.3 Warm-Up

The Model 220 must be turned on and allowed one hour for warm-up. If the instrument has been subjected to extremes of temperature, allow sufficient time for internal temperatures to reach normal operating conditions. Typically, it takes one hour to stabilize a unit that is 10°C (18°F) out of the specified temperature range.

5.2.4 Calibration Fixtures

In order to meet the specifications of the Model 220, the 10MΩand 1GΩ resistors used to calibrate the Model 220 must be enclosed in a guarded fixture. The guarded fixture must be constructed. The following items are necessary for proper construction of the calibration fixture:

1. 10MΩ Resistor, Keithley Part Number R-305-10M
2. 1GΩ Resistor, Keithley Part Number R-289-1G
3. Two enclosed chassis boxes, one to be placed inside the other and insulated from each other.
4. One Triax Connector, Keithley Part Number CS-181
5. One Banana Jack, Keithley Part Number BJ-11

The test fixture shown in Figure 5-2 is to be used to calibrate the 1μA and 100nA ranges. A duplicate test fixture must be constructed with the 1GΩ resistor in order to calibrate the 10nA and 1nA ranges.

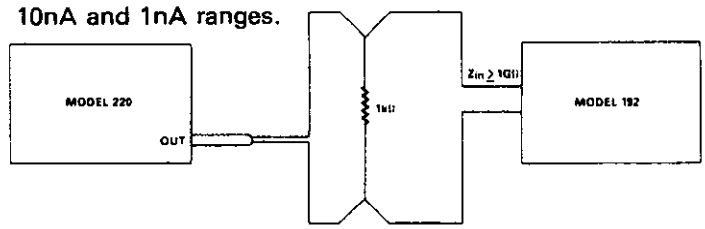


Figure 5-1. Calibration Setup

Table 5-1 Recommended Test Equipment

Item	Description	Specification	Mfr.	Model
A	DMM	±0.005% to 10μV	Keithley	192
B	Resistor*	10Ω ±.1%	Keithley	R-185-10
C	Resistor*	100Ω ±.1%	Keithley	R-308-100Ω
D	Resistor*	1kΩ ±.1%	Keithley	R-315-1k
E	Resistor*	100kΩ ±.02%	Keithley	R-182-100k
F	Resistor*	10MΩ ±.25%	Keithley	R-305-10M
G	Resistor*	1GΩ ±2%	Keithley	R-289-1G
H	Teraohmeter		Guildline	9520
I	Calibration Fixture			

NOTE*

Before placing the resistors in the test configurations, measure them and note the value. Zero the Model 192 before measuring the 10Ω, 100Ω, 1kΩ and the 100kΩ resistors with the Model 192. Measure the 10MΩ and 1GΩ resistors with the Guildline 9520. These values will be used later in the calibration procedure.

5.2.5 Calibration Adjustments

Use the following procedure and make the adjustments indicated to calibrate the Model 220. To locate adjustment points, remove the top cover and refer to the analog board shield.

WARNING

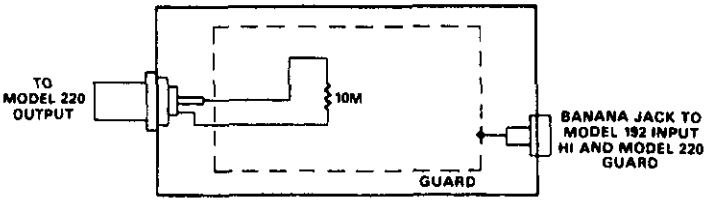
To prevent a shock hazard, turn the instrument off, remove the line cord and all test leads from the instrument before removing the top cover.

1. Remove the top cover (see paragraph 5.5, step 1). Warm-up with top cover in place. Minimize the time the cover is removed.
2. Short the output of the Model 220 (HI to LO). Monitor the guard output with the Model 192 (Item A Table 5-1) on the .2VDC range. Program the Model 220 for an output of +.0000-3 amps and a compliance of 10V. Locate and adjust R343 for a reading on the Model 192 of .000000 ± 20μV.
3. Remove the short from the output and connect the Model 220 and Model 192 as shown in Figure 5-1. Program the Model 220 output +.0000-3 amps. Monitor the Model 220 output on the Model 192. Invert the Model 220 output (press ± and ENTER on the Model 220) and note the change in current. Calculate the average reading when the output is changed from positive to negative and adjust R304 for the calculated value. Then adjust R392 for a reading of less than ± 100nA (100μV across 1kΩ).
4. Set up the circuit shown in Figure 5-1 and 5-3. Follow Table 5-2 to calibrate the ranges of the Model 220.

NOTE

The allowable reading on the Model 192 is the product of the measured shunt resistance times the Model 220 output. For example in Table 5-2, step a:
measured shunt resistance = 1kΩ
Model 220 output = 1.9mA
calculated output = 1.9V ± 300ppm or 570μV

5. Remove the current measurement test configuration and monitor the Model 220 output with the Model 192 on the 200VDC range. Program the Model 220 to +19.000E-6 amps and a compliance of 100V. Adjust R319 for a reading of 100.000 ± 0.2V.
6. This completes the calibration of the Model 220. To verify correct calibration refer to Section 3.



Construction Notes:
1. To decrease settling times and to assure accurate calibrations, it is recommended to use an internal guard (as shown in the drawing above). The guard must be insulated from the surrounding case.
2. To further minimize inaccuracies, current leakage paths to ground (or guard) must be minimized. This requires the use of low leakage insulating materials for construction and the use of special cleansing agents such as freon® to clean the components and insulators after construction.

Figure 5-2. Calibration Fixture

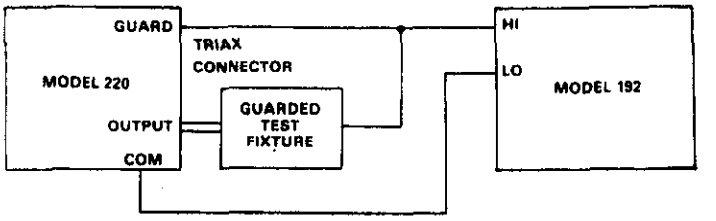


Figure 5-3. 1μA to 1nA Calibration

5.3 FUSE REPLACEMENT

If power fails, first verify that the fuse (F101) is not defective before disassembling the Model 220. If the line voltage setting is changed (S102) the fuse must be replaced according to Tables 5-3 and 5-4. The fuse is accessible from the rear panel. To replace the fuse proceed as follows:

1. Turn power off and disconnect the line cord.

Table 5-2. Calibration

Step	220 Setting (Range)	Compliance	Adjustment Point	Shunt R	Model 192 Range	Allowable Reading on the Model 192 at 5½ Digit Resolution
a	1.9E-3	30V	R303	1kΩ	2VDC	(1kΩ)(1.9E-3) = Calculated Output ±300ppm or 570μV
b	-1.9E-3	30V	R318	1kΩ	2VDC	(1kΩ)(-1.9E-3) = Calculated Output ±300ppm or 570μV
c	100E-3	30V	R381	10Ω	2VDC	(10Ω)(100E-3) = Calculated Output ±750ppm or 750μV
d	19E-3	30V	R386	100Ω	2VDC	(100Ω)(19E-3) = Calculated Output ±300ppm or 570μV
e	190E-6	30V	R385	100kΩ	20VDC	(100kΩ)(190E-6) = Calculated Output ±250ppm or 4.8mV
f	19E-6	30V	R384	100kΩ	2VDC	(100kΩ)(19E-6) = Calculated Output ±300ppm or 570μV
			†Shunt Measurement Technique†			
			‡User of Guarded Fixtures‡			
g	1.9E-6*	30V	R354	10MΩ	20VDC	(10MΩ)(1.9E-6) = Calculated Output ±600ppm or 11.4mV
h	190E-9*	30V	R355	10MΩ	2VDC	(10MΩ)(19E-9) = Calculated Output ±2500ppm or 4.75mV
i	19E-9**	30V	R356	1GΩ	20VDC	(1GΩ)(19E-9) = Calculated Output ±2250ppm or 42.8mV
j	1.9E-9**	30V	R357	1GΩ	2VDC	(1GΩ)(1.9E-9) = Calculated Output ±2250ppm or 4.28mV

*Use the constructed 10MΩGuarded Fixture in the circuit shown in Figure 5-3.
**Use the constructed 1GΩ Guarded Fixture in the circuit shown in Figure 5-3.

2. The fuse carrier is spring loaded. Using a slotted screwdriver, push the fuse carrier in and rotate ¼-turn counterclockwise. The carrier and fuse will eject from the holder.
3. Remove the fuse from the carrier and replace per Table 5-3 or Table 5-4.

WARNING

To prevent a shock hazard, always turn the instrument off and disconnect the line cord before replacing the line fuse.

CAUTION

Do not install a fuse with a higher rating than specified in Table 5-3 or 5-4. Instrument damage may result.

4. To install the fuse and carrier into the holder, reverse the procedure in step 2.

Table 5-3. Fuse Replacement, 3AG Size

Line Voltage	Fuse F101	Keithley Part No.
90V-110V*	3/4A, 250V, 3AG, SLO BLO	FU-19
105V-125V	3/4A, 250V, 3AG, SLO BLO	FU-19
180V-220V*	3/8A, 250V, 3AG, SLO BLO	FU-18
210V-250V	3/8A, 250V, 3AG, SLO BLO	FU-18

*Requires special factory installed transformer TR-187.

Table 5-4. Fuse Replacement, 5mm Size

Line Voltage	Fuse F101	Keithley Part No.
90V-110V*	0.8A, 250V, SLO BLO	FU-52
105V-125V	0.8A, 250V, SLO BLO	FU-52
180V-220V*	0.4A, 250V, SLO BLO	FU-53
210V-250V	0.4A, 250V, SLO BLO	FU-53

*Requires special factory installed transformer TR-187.

5.4 LINE VOLTAGE SELECTION

Set up the Model 220 to operate on the available AC line voltage as follows:

WARNING

To prevent a shock hazard, turn the instrument off and disconnect the line cord. Also, remove all test leads from the instrument before removing the top cover.

1. Remove the top cover (see paragraph 5.5 step 1).
2. Refer to Table 5-5 and set switch S102 (located near the transformer, underneath the IEEE-488 interface board) accordingly.
3. Install proper fuse per paragraph 5.3.

NOTE

The line voltage setting of the instrument is marked on the rear panel. The following procedure can be used either to confirm the factory setting, or to set up the instrument for operating on another voltage range. If the line voltage range is changed, the box next to the selected line voltage should be appropriately marked as an external reminder of the setting. Use a water soluble marking pen.

Table 5-5. Line Voltage Selection

Line Voltage	Line Frequency	Switch S102
90V-110V*	50Hz-60Hz	115V
105V-125V	50Hz-60Hz	115V
195V-235V*	50Hz-60Hz	230V
210V-250V	50Hz-60Hz	230V

*Requires special factory installed transformer TR-187.

5.5 DISASSEMBLY

If it is necessary to remove or replace a component, use the following procedure to aid in disassembly of the Model 220.

1. Remove the top cover as follows:

WARNING

Turn the instrument off, remove all test leads from the instrument and disconnect the power cord before removing the top cover.

   a. Remove the two retaining screws located at the rear of the instrument.
   b. Grasping the top cover at the rear, carefully lift it off the instrument.
   c. When installing the top cover, make sure that the three tabs located at the front of the cover engage in the front panel assembly.
2. Remove the IEEE-488 interface board.
   a. Unplug ribbon cable (J/P1004) at the mother board.
   b. Remove the phillips head retaining screw located near J1004 on the interface board.
   c. Remove the two retaining bolts that secure the interface board and IEEE-488 connector to the rear panel.
   d. Lift the interface board out of the mainframe.
3. Remove the analog board shield.
   a. Remove the four slot head screws that secure the shield to the analog board.
   b. Lift the shield and the four slot head screws away from the analog board.
4. Remove the input node and relay analog shields.
   a. Remove the single phillips head screw located in the middle of the shield.
   b. Lift both shields away from the analog board.

NOTE

The circuitry located beneath the analog board shields is extremely sensitive. Do not touch any of the range resistors or input cable.

5. Remove the analog board.
   a. Remove the phillips head screw located directly behind the two power transistors with heat sinks.

b. Unplug the ribbon cable (J/P1003) from the analog board.
c. Remove the bottom shield of the analog board by removing the two phillips head screws that secure the shield to the board.

NOTE

Do not remove the input cable.

6. Place the analog board along the side of the Model 220.
7. Remove the mother board from the case.
   a. Remove the four plastic standoffs.
   b. Remove the two phillips head screws that secure the mother board to the case. They are located at the rear of the mother board one by the fan and the other is by the line voltage selector switch S102.
   c. Remove the two phillips head screws that secure the case to the rear panel.
   d. Unplug the display ribbon cable (J/P1002) from the mother board.
   e. Grasp the mother board and the rear panel simultaneously. Lift the mother board and rear panel up and toward the rear of the instrument. Then lift the mother board and rear panel out of the case.
8. Remove the display board.
   a. Remove the two phillips head screws that secure the display board to the front panel.
   b. Remove the front panel buttons.
   c. Lift the display board out of the case.
9. For reassembly, perform steps 1-8 in reverse order.

NOTE

When installing connectors J/P1004, J/P1003 and J/P1002 be sure to align pin one of the connector to pin one of the cable.

5.6 FAN FILTER MAINTENANCE

The internal temperature generated by the Model 220 necessitates the forced air cooling provided by the fan. The fan has an air filter which keeps the Model 220 relatively free of dust and dirt. Dust and dirt collect on the filter and impede the air flow through the instrument. Lack of air flow will cause overheating. Therefore, the filter must be kept clean in order for the Model 220 to achieve optimum performance. To clean the filter:

1. Remove the filter from the fan.
2. Use compressed air to remove the dust and dirt from the filter. If the filter is excessively dirty wash it in mild soap and water and dry it with compressed air.
3. Reinstall the filter.

5.7 SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

MOS devices are designed to function at high impedance levels. Normal static charge can destroy these devices. Table 5-6 lists all the static sensitive devices of the Model 220. Steps 1 through 7 provide instruction on how to avoid damaging these devices.

Table 5-6. Model 220 Static Sensitive Devices

Reference Designation	Keithley Part No.
U101, U103, U105, U107	LSI-15
U102	IC-197
U109	220-800-B5
U111	220-801-B5
U112, U301, U302, U303	IC-251
U114	LSI-28
U115	LSI-27
U116	IC-250
U304	IC-138
U305, U314	IC-102
U306	IC-320
U308	IC-321
U311	IC-323
U316	IC-106
Q302	TG-139

1. Devices should be handled and transported in protective containers, antistatic tubes or conductive foam.
2. Use a properly grounded work bench and a grounding wriststrap.
3. Handle devices by the body only.
4. PC boards must be grounded to bench while inserting devices.
5. Use antistatic solder suckers.
6. Use grounded tip soldering irons.
7. After devices are soldered or inserted into sockets they are protected and normal handling can resume.

5.8 TROUBLESHOOTING

The troubleshooting information in this section is intended for use by qualified personnel who have a basic understanding of the analog and digital circuitry used in a precision test instrument. Instructions have been written to assist in isolating the defective circuit. Isolating the defective component has been left up to the troubleshooter. Refer to Table 5-7 for power supply checks. Refer to Table 5-8 for Analog board checks. Refer to Table 5-9 for digital circuitry checks. Refer to Table 5-10 for display board checks. Refer to Table 5-11. for IEEE-488 interface board checks.

NOTE

For instruments that are still under warranty (less than 12 months since date of shipment), whose performance falls outside specification at any point, contact your Keithley representative or the factory before attempting troubleshooting or repair.

5.8.1 Servicing High Impedance Circuitry

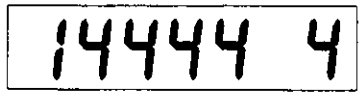
High impedance circuitry is extremely sensitive and must be kept clean of oil, dirt, dust and contaminants. Replacing a component or components within a high impedance circuit requires special cleaning and handling to maintain the high impedance level of the circuit. After replacing any compo-

nent in the high impedance circuitry, or if the high impedance circuitry (1nA-1μA range resistors) are contaminated, use the following procedure to clean the circuit:

1. Clean the entire high impedance circuit with methanol and a clean cotton swab.
2. Blow dry the circuit with dry nitrogen gas.
3. Inspect the circuit for any residue (contamination) and repeat steps 1 and 2 if any residue is found.
4. Reassemble taking care not to touch the clean components.

5.8.2 Digital Self Test

Upon power-up the Model 220 performs a digital self test of the RAM (2114's) chips and a cyclic redundancy check (CRC) of the ROM (2732's) chips. If the self test or the CRC reveals a problem with any of the memory chips, the Model 220 will display an error message corresponding to the defective chip. For example; the digital self test reveals that RAM chip number four is defective. The Model 220 displays a flashing:



This informs the operator the RAM chip number four is defective. Refer to Figure 5-4 for chip number assignment.

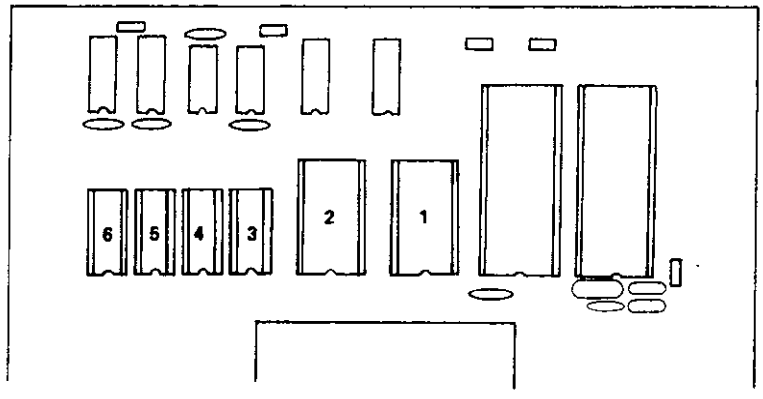


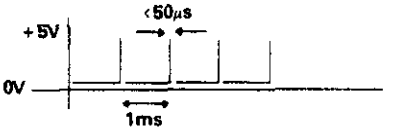
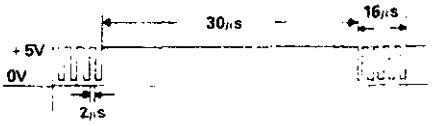
Figure 5-4. Memory Chip Number Assignment

Table 5-7. Power Supply Checks

Step	Item/Component	Required Condition	Remarks
		Unit turned on, properly rated F101 has continuity. Line selector switch S102 verified in correct position.	
1	Q319 Collector	+130VDC ± 15%	+125 Volt Supply*
2	Q318 Collector	−130VDC ± 15%	−125 Volt Supply*
3	VR301 Input	+15VDC ± 15%	+15 Volt Supply**
4	V311 pin 14	−15VDC ± 15%	−15 Volt Supply**
5	TP2	+5VDC ± 5%	+5 Volt Digital Supply***

*Referenced to output common.
**Referenced to analog common.
***Referenced to digital common.

Table 5-8. Analog Board Checks

Step	Item/Component	Required Condition	Remarks
		Program the Model 220 for 100mA at a 100V compliance. Press Operate	Connect a 100Ω, 1W load resistor across the output.
1	U320 pin 11	+0.7V ±.1V	100mA range relay and output relay are energized.
2	U315 pin 2	+9.8V ±0.1V	Output of sense amplifier.
		Program the Model 220 to output 10mA.	
3	U320 pin 15	+0.7V ±.1V	10mA range relay is energized.
		Program the Model 220 to output 1mA.	
4	U320 pin 15	+0.7V ±.1V	1mA range relay is energized.
		Program the Model 220 to output 100μA.	
5	U320 pin 15	+0.7V ±.1V	100μA range relay is energized.
		Program the Model 220 to output 10μA.	
6	U320 pin 15	0.7V ±.1V	10μA range relay is energized.
		Program the Model 220 to output 1μA.	
7	U320 pin 12	0.7V ±.1V	1μA range relay is energized.
		Program the Model 220 to output 100μA.	
8	U320 pin 13	0.7V ±.1V	100nA range relay is energized.
		Program the Model 220 to output 10nA.	
9	U320 pin 14	+0.7V ±.1V	10nA range relay is energized.
		Program the Model 220 to output 1nA.	
10	U320 pins 11, 12 13,14 and 15.	+5V ±.5V	All other range relays are denergized.
11	U309 pin 1	−5V (For a programmed compliance voltage of 100V.)	
12	U311 pins 24 and 16	+6.3V ±.1V	12 Bit DAC Reference
13	U310 pin 6	−6.3V ±.1V	8 Bit DAC Reference
14	U316 pin 9		Latch Line
15	U304 pin 12		Clock Line

NOTE

All measurements in Table 5-8 are referenced to analog common (guard).

Table 5-9. Digital Circuitry

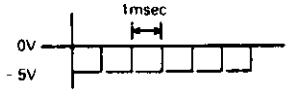
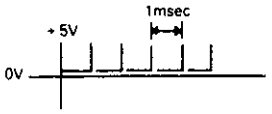
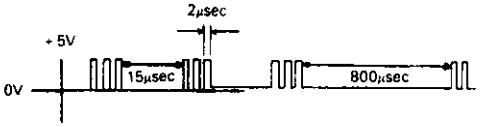
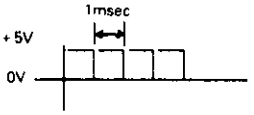
Step	Item/Component	Required Condition	Remarks
1	J1004 pins 1, 2 and 4 (referenced to pins 24, 25 and 26)	+5V ±5%	+5 Volt Digital Supply
2	U315 pin 37 (Φ2)	0V to 4V squarewave at 1MHz	1MHz Clock
3	U115 pin 40 (reset)	+5V ±5%	Reset Line
4	U114 pin 15	Negative going pulse (+5V to 0V) occurring every 8msec.	Strobe for display board.
5	U114 pin 39	Negative going pulse (+5V to 0V) occuring every 1msec	Clock input for Display Board
6	U115 pin 4, U114 pin 21	1kHz clock	IRQ Line
7	U111, U110, U103, U105 U101 and U107	RAM and ROM (see paragraph 5.8.3 Digital Self Test)	Digital Self Test
8	U117 pin 6 (referenced to Analog Common)		Data Out Line (Analog Side)
9	U117 pin 4 (referenced to Analog Common)		Data in Line (Analog Side)
10	U113 pin 3 (referenced to Digital Common)		Clock to Analog Side
11	U113 pin 6 (referenced to Digital Common)		Latch Enable

Table 5-10. Display Checks

Step	Item/Component	Required Condition	Remarks
1	Display	Turn on Power +1.8.8.8.8+1.8	All display segments and LED's will light for several seconds.
2	P1002 pins 9 and 14	+5V±5%	If low, check per Table 5-7.
3	U203 pin 1		Update Data
4	U203 pin 8		Clock.

Table 5-11. IEEE-488 Interface Board Checks

Step	Item/Component	Required Condition	Remarks
1	P1004 pins 1, 2, 3 and 4 referenced to P1004 pins 24, 25 and 26	+5V ±10% referenced to Digital Common	+5V Digital Supply
2	S401 (A1-A5)	In the "1" position the switch is pulled up to +5V±10%	Primary Address
3	U404 pin 18 (ΦE)	1MHz square wave at 0V to +5V	Clock to U404
4	U404 pin 9	+5V signal being pulsed to 0V every 1msec	IRQ Line
5	U404 pin 19	+5V (logic "1") Program the Model 220 into Remote (primary address 12)	RESET Line
6	U405 pins 19 and 2 (D1 and B1)	Logic "1" (≈ +5V)	Information across bus transceiver.
7	U405 pins 18 and 3 (D2 and B2)	Logic "1" (≈5V)	Information across bus transceiver.
8	U405 pins 17 and 4 (D3 and B3)	Logic "0" (≈0V)	Information across bus transceiver.
9	U405 pins 16 and 5 (D4 and B4)	Logic "0" (≈0V)	Information across bus transceiver.
10	U405 pins 15 and 6 (D5 and B5)	Logic "1" (≈ +5V)	Information across bus transceiver.
11	U405 pins 14 and 7 (D6 and B6)	Logic "0" (≈0V)	Information across bus transceiver.
12	U405 pins 13 and 8 (D7 and B7)	Logic "1" (≈ +5V)	Information across bus transceiver.
13	U405 pins 12 and 9 (D8 and B8)	Logic "1" (≈ +5V)	Information across bus transceiver.

NOTE
All measurements in Table 5-11 are referenced to digital common.

SECTION 6
REPLACEABLE PARTS

6.1 INTRODUCTION

This section contains replacement parts information, schematic diagrams, and component location drawings for the Model 220. An exploded view of the Model 220 is shown in Figure 6-1, while an illustration of the Fan Assembly is shown in Figure 6-2.

6.2 PARTS LIST

Parts are listed alphabetically in order of their circuit designations. Table 6-1 contains an index of the schematic diagrams and component location drawings included at the end of this section. Table 6-2 contains a parts list for the Model 220 motherboard. Table 6-3 contains a parts list for the display board. Table 6-4 contains a parts list for the analog board. Table 6-5 contains a parts list for the IEEE interface board.

Table 6-1. Index of Model 220 Schematics and Component Layouts

Title	Figure
Display Board Component Layout	6-3
Mother Board Component Layout	6-4
Analog Board Component Layout	6-5
IEEE Interface Board Component Layout	6-6
Display Board Schematic	6-7
Mother Board Schematic	6-8
Analog Board Schematic	6-9
IEEE Interface Schematic	6-10

6.3 ORDERING INFORMATION

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory. See the inside front cover for addresses. When ordering include the following information:

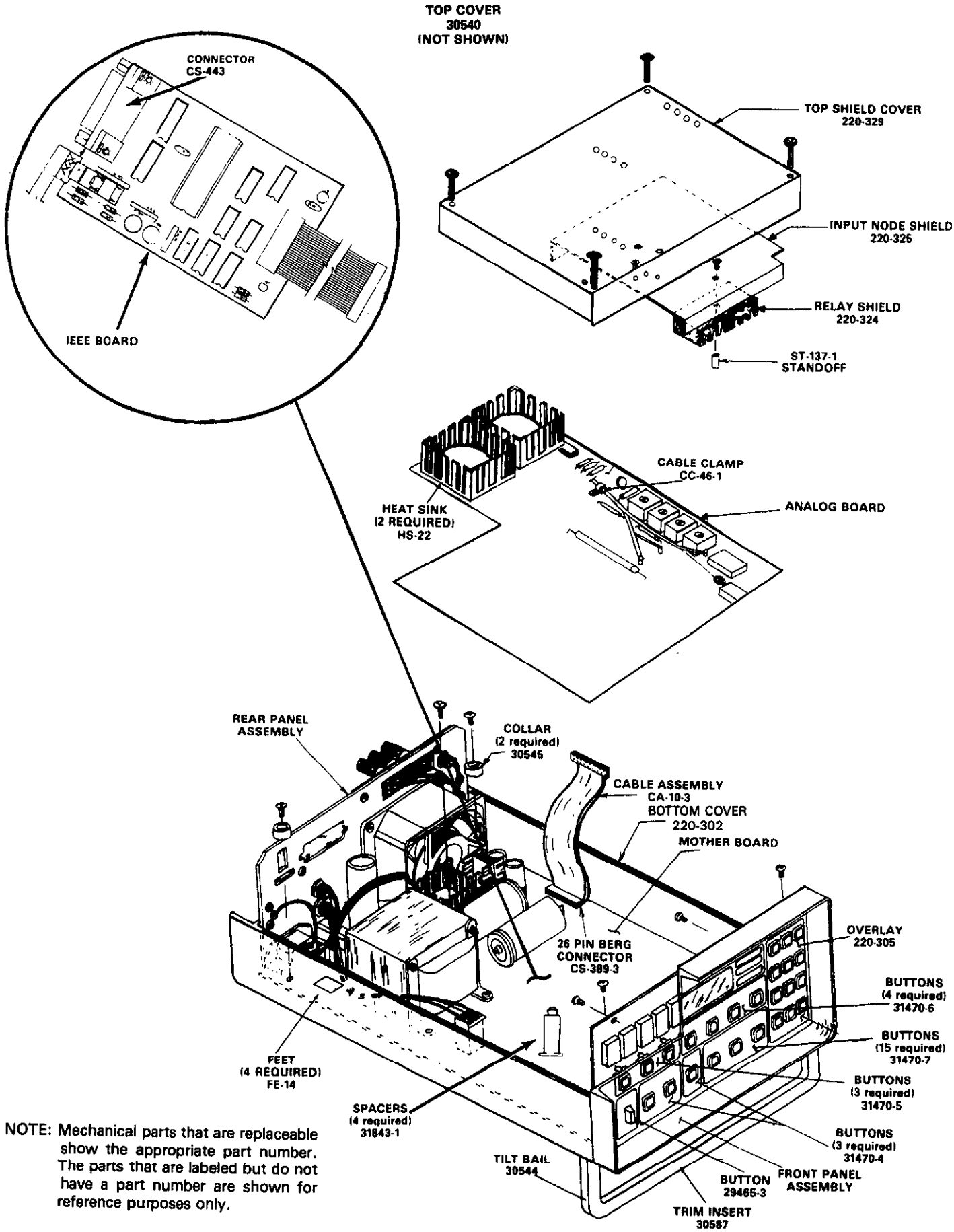
1. Instrument Model Number
2. Instrument Serial Number
3. Part Description
4. Circuit Description (if applicable)
5. Keithley Part Number

6.4 FACTORY SERVICE

If the instrument is to be returned to the factory for service, complete the service form which follows this section and return it with the instrument.

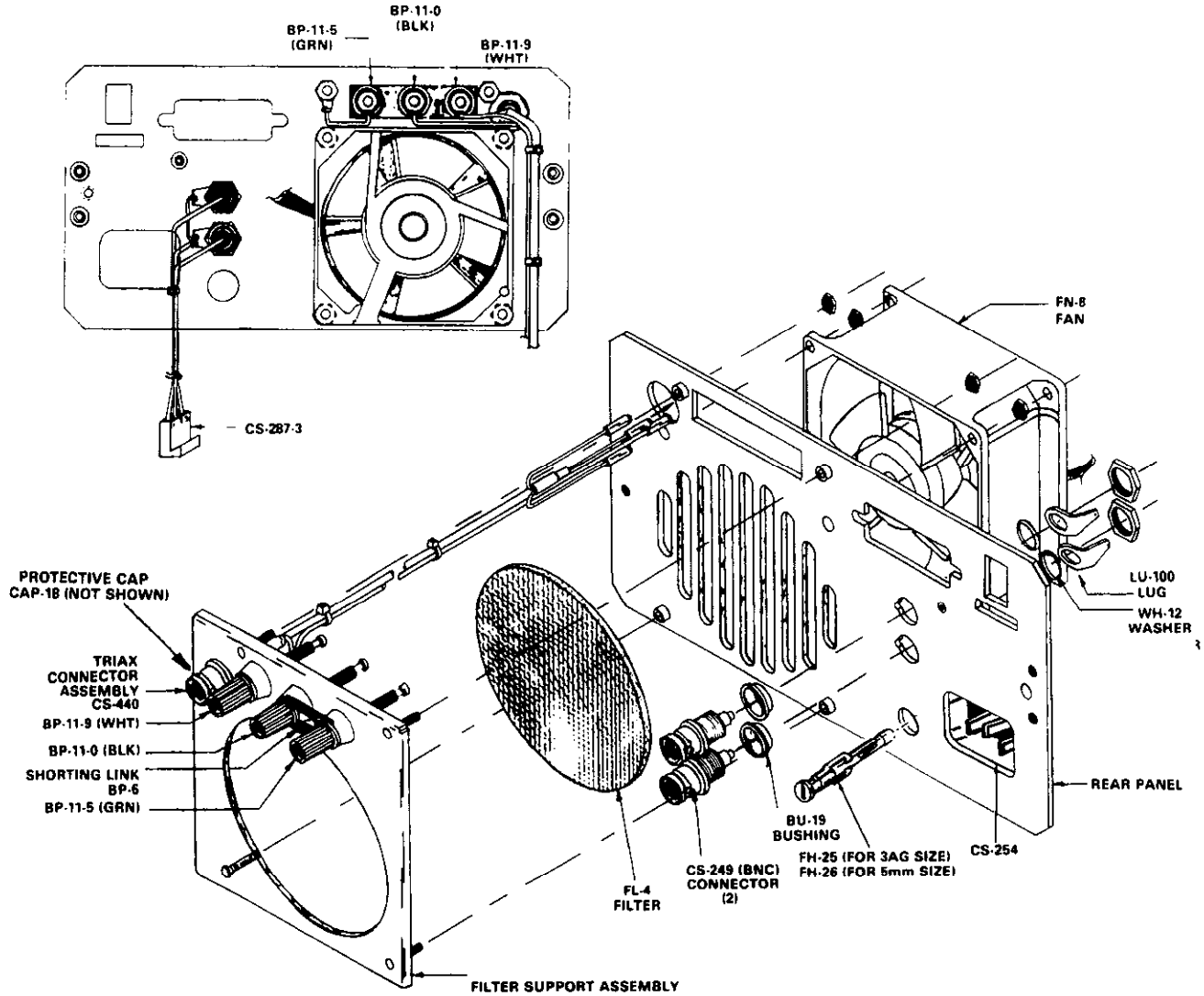
6.5 SCHEMATIC DIAGRAMS AND COMPONENT LOCATION DRAWINGS

Schematic diagrams and component location drawings follow the replaceable parts list information in the order listed in Table 6-1.



NOTE: Mechanical parts that are replaceable show the appropriate part number. The parts that are labeled but do not have a part number are shown for reference purposes only.

Figure 6-1. Model 220 Exploded View



NOTE: Mechanical parts that are replaceable show the appropriate part number. The parts that are labeled but do not have a part number are shown for reference purposes only.

Figure 6-2. Model 220 Fan Assembly

Table 6-2. Mother Board D220-103, Parts List

Circuit Desig.	Description	Location Sch.	Location Pcb.	Keithley Part No.
AT101	Optical Isolator, 6N137	G1	D4	IC-292
AT102	Optical Isolator, 6N137	G3	D4	IC-292
AT103	Optical Isolator, 6N137	G2	D5	IC-292
AT104	Optical Isolator, 6N137	G3	D5	IC-292
C101	.1μF, 16V, Ceramic Disc	E4	D2	C-238-.1
C102	.1μF, 16V, Ceramic Disc	G4	D2	C-238-.1
C103	10μF, 25V, Aluminum Electrolytic	D4	D2	C-314-10
C104	6800pF, 500V, Ceramic Disc	F5	D2	C-22-.0068
C105	.1μF, 16V, Ceramic Disc	E5	D2	C-238-.1
C106	.01μF, 500V, Ceramic Disc	B4	G3	C-22-.01
C107	10,000μF, 25V, Aluminum Electrolytic	C4	G3	C-342-10000
C108	.1μF, 16V, Ceramic Disc	F2	D3	C-238-.1
C109	.1μF, 16V, Ceramic Disc	F1	D4	C-238-.1
C110	.1μF, 16V, Ceramic Disc	C1	C4	C-238-.1
C111	.1μF, 16V, Ceramic Disc	G3	E4	C-238-.1
C112	.1μF, 16V, Ceramic Disc	G2	E5	C-238-.1
C113	.1μF, 16V, Ceramic Disc	B1	C5	C-238-.1
C114	22pF, 1000V, Ceramic Disc	B3	C5	C-64-22p
C115	22pF, 1000V, Ceramic Disc	B3	C5	C-64-22p
C116	.1μF, 16V, Ceramic Disc	G3	E5	C-238-.1
C117	330μF, 160V, Aluminum Electrolytic	D2	E5	C-337-330
C118	330μF, 160V, Aluminum Electrolytic	C2	E5	C-337-330
C119	10μF, 25V, Aluminum Electrolytic	D3	F5	C-314-10
C120	10μF, 25V, Aluminum Electrolytic	D3	F6	C-314-10
C121-C122	1000μF, 35V, Aluminum Electrolytic		F6	C-309-1000
C123	330pF, 500V, Ceramic Disc	F5	E3	C-22-330p
C124				C-178-.1
CR101	Rectifier Bridge (5A), PEO5	C4	G3	RF-64
CR102	Rectifier, 1N4006	C2	E4	RF-38
CR103	Rectifier, 1N4006	C2	E4	RF-38
CR104	Rectifier, 1N4006	C2	E4	RF-38
CR105	Rectifier, 1N4006	C2	E4	RF-38
CR106	Rectifier, 1N4006	C3	F5	RF-38
CR107	Rectifier, 1N4006	C3	F5	RF-38
CR108	Rectifier Bridge (1.5A), PF-40	C3	F5	RF-46
CR109	Rectifier, 1N4006	G5	E3	RF-38
CR110	Rectifier, 1N4006	G5	E3	RF-38
CR111	Rectifier, 1N4006	G5	E3	RF-38
CR112	Rectifier, 1N4006	G5	—	RF-38
F101	Fuse, 3/8 Amp, 250V, Slo-Blo	A4	H3	FU-18
F101	Fuse, 3/4 Amp, 250V, Slo-Blo	A4	H3	FU-19
F101	Fuse, 8/10 Amp, 250V, Slo-Blo	A4	H3	FU-52
F101	Fuse, 4/10 Amp, 250V, Slo-Blo	A4	H3	FU-53
J1001	Power Connector	A4	G2	CS-388
J1003	Cable Assembly (26-pin)	—	E5	CA-10-3
J1008	Socket 16-pin	H5	—	SO-65
P1004	500V, Connector Male	—	B3	CS-389-3
P1005	2 pin, Connector	A1,B1	G2	CS-288-2
P1006	3 pin, Molex Connector	H5	D2	CS-288-3
R101	18k, 5%, 1/4W, Composition	E4	D2	R-76-18k
R102	4.7k, 5%, 1/4W, Composition	F1	D3	R-76-4.7k
R103	220k, 5%, 1/4W, Composition	C4	F3	R-76-220k
R104	4.7k, 5% 1/4W, Composition	F2	E4	R-76-4.7k
R105	390Ω, 5%, 1/4W, Composition	F1	E4	R-76-390
R106	220Ω, 5%, 1/4W, Composition	G3	D4	R-76-220
R107	2.4k, 5%, 1/4W, Composition	G3	E4	R-76-2.4k
R108	220Ω, 5%, 1/4W, Composition	G2	D5	R-76-220
R109	2.4k, 5%, 1/4W, Composition	G2	E5	R-76-2.4k

Table 6-2. Mother Board D220-103, Parts List (Cont.)

Circuit Desig.	Description	Location Sch.	Location Pcb.	Keithley Part No.
R110	220Ω, 5%, 1/4W, Composition	G2	D5	R-76-220
R111	2.4k, 5%, 1/4W, Composition	G2	E5	R-76-2.4k
R112	4.7k, 5%, 1/4W, Composition	H1	E5	R-76-4.7k
R113	220Ω, 5%, 1/4W, Composition	G1	E5	R-76-220
R114	Thick Film Resistor Network	E5	B5	TF-140
R115	4.7k, 5%, 1/4W, Composition	F3	C5	R-76-4.7k
R118	100k, ±10%, 1/2W, Composition	D2	E5	R-1-100k
R119	100k, ±10%, 1/2W, Composition	D2	E5	R-1-100k
R121	100Ω, ±10%, 1/2W, Composition	G5	E3	R-1-100
R122	100Ω, ±10%, 1/2W, Composition	G4	E3	R-1-100
R125	4.7k, 5%, 1/4W, Composition	E2	D4	R-76-4.7k
R126	10k, 5%, 1/4W, Composition	F1	D5	R-76-10k
R127	4.7k, 5%, 1/4W, Composition	G4	E3	R-76-4.7k
R128	47kΩ, 10%, 0.25W, Composition	G5	E3	R-76-47k
S101	Switch, Power	A3	B2	SW-466
S102	Switch, Line	A3	G2	SW-397
T101	Transformer	B2	F2	TR-186
T101	Transformer (special for 90V-110V 180V-220V operation)	B2	F2	TR-187
U101	1024 X 4-bit Static Ram, 2114	D5	C2	LSI-15
U102	Oscillator/Clock, 4060	E4	D2	IC-197
U103	1024 X 4-bit Static Ram, 2114	C5	C2	LSI-15
U104	Up/Down Counter, 74LS193	F4	D2	IC-214
U105	1024 X 4-bit Static Ram, 2114	D6	C2	LSI-15
U106	Quad 2-In. Nand Gate,74 LS00	SEV	D2	IC-163
U107	1024 X 4-bit Static Ram, 2114	SEV	C3	LSI-15
U108	Quad 2-In. NOR Gate, 74LS02	SEV	D3	IC-179
U109	Erasable Prom, 2732	B5	C3	220-800-B5
U110	Decoder/Demultiplexer, 74LS138	F3	D3	IC-182
U111	Erasable Prom, 2732	A5	C4	220-801-B5
U112	8-bit Shift Register, 14094	E1	D4	IC-251
U113	Quad Exclusive OR Gate, 7486	Sev	D4	IC-116
U114	Interface Adapter, SY6522	C2	C4	LSI-28
U115	Microprocessor, MC6808	B2	C5	LSI-27
U116	Bus Driver, 14503	E6	C5	IC-250
U117	Hex Inverter, 16-pin DIP, 4049	SEV	E5	IC-106
VR101	5 Volt Regulator, LM309K	D4	F4	IC-34
VR102	±15V, 3-term, 7915	D3	F5	IC-174
VR103	3-term Positive Voltage Regulator, 7815	D3	F5	IC-96
W101	Jumper	B6	D2	J-3
W102	Jumper	B6	D2	J-3
Y101	4.0 MHZ Crystal	—	C5	CR-10

Table 6-3. Display Board D220-113, Parts List

Circuit Desig.	Description	Location Sch.	Location Pcb.	Keithley Part No.
C201	10μF, 25V, Aluminum Electrolytic	D5	C3	C-314-10
DS201	±1, Digital Display	B1	B2	DD-31
DS202	"8" Digital Display	C1	B2	DD-30
DS203	"8" Digital Display	C1	C2	DD-30
DS204	"8" Digital Display	D1	C2	DD-30
DS205	"8" Digital Display	D1	D2	DD-30
DS206	±1, Digital Display	E1	D2	DD-31
DS207	"8" Digital Display	E1	E2	DD-30
DS208	Pilot Light	G3	E1	PL-67
DS209	Pilot Light	G2	E2	PL-67
DS210	Pilot Light	E2	E2	PL-67
DS211	Pilot Light	G3	B2	PL-67
DS212	Pilot Light	H3	B2	PL-67
DS213	Pilot Light	H3	C2	PL-67
DS214	Pilot Light	F3	D2	PL-67
DS215	Pilot Light	F3	D2	PL-67
DS216	Pilot Light	G3	E2	PL-67
DS217	Pilot Light	G3	E2	PL-67
DS218	Pilot Light	H3	C3	PL-67
DS219	Pilot Light	F3	D3	PL-67
P1002	Cable Assembly	A6	E4	CA-15-1
Q201	PNP Silicon Transistor, 2N4355	F5	E1	TG-90
Q202	PNP Silicon Transistor, 2N4355	H5	E1	TG-90
Q203	PNP Silicon Transistor, 2N4355	H5	E1	TG-90
Q204	PNP Silicon Transistor, 2N4355	H5	E1	TG-90
Q205	PNP Silicon Transistor, 2N4355	F5	E2	TG-90
Q206	PNP Silicon Transistor, 2N4355	G5	E2	TG-90
Q207	PNP Silicon Transistor, 2N4355	G5	E2	TG-90
Q208	PNP Silicon Transistor, 2N4355	G5	E2	TG-90
R201	Thick Film	SEV	D2	TF-165-.1
R202	Thick Film	SEV	F1	TF-77
S201	Pushbutton Switch	A3	B2	SW-435
S202	Pushbutton Switch	B3	B2	SW-435
S203	Pushbutton Switch	B3	C2	SW-435
S204	Pushbutton Switch	A3	D2	SW-435
S205	Pushbutton Switch	A3	D2	SW-435
S206	Pushbutton Switch	B4	E2	SW-435
S207	Pushbutton Switch	B4	E2	SW-435
S208	Pushbutton Switch	A4	B3	SW-435
S209	Pushbutton Switch	A4	C3	SW-435
S210	Pushbutton Switch	B4	D3	SW-435
S211	Pushbutton Switch	B4	D3	SW-435
S212	Pushbutton Switch	A4	E3	SW-435
S213	Pushbutton Switch	A4	E3	SW-435
S214	Pushbutton Switch	B5	F2	SW-435
S215	Pushbutton Switch	B5	F2	SW-435
S216	Pushbutton Switch	A5	G2	SW-435
S217	Pushbutton Switch	A5	F2	SW-435
S218	Pushbutton Switch	A3	F2	SW-435
S219	Pushbutton Switch	B3	G2	SW-435
S220	Pushbutton Switch	B3	F3	SW-435
S221	Pushbutton Switch	A2	F3	SW-435
S222	Pushbutton Switch	A2	G3	SW-435
S223	Pushbutton Switch	B2	F3	SW-435
S224	Pushbutton Switch	B2	F3	SW-435
S225	Pushbutton Switch	A2	G3	SW-435
U201	MOS to LED Segment Driver, 75492	SEV	B3	IC-169
U202	MOS to LED Segment Driver, 75492	SEV	C3	IC-169
U203	8-bit Shift Register, 74LS164	C5	D3	IC-127
U204	MOS to LED Segement Driver, 75492	SEV	E3	IC-169

Table 6-4. Analog Board D220-123, Parts List

Circuit Desig.	Description	Location Sch.	Location Pcb.	Keithley Part No.
C301	.1μF, 16V, Ceramic Disc	F3	B2	C-238-.1
C302	.1μF, 16V, Ceramic Disc	E3	B2	C-238-.1
C303	.1μF, 16V, Ceramic Disc	C2	D1	C-238-.1
C304	.01μF, 500V, Ceramic Disc	B4	D1	C-22-.01
C305	.47μF, 50V, Ceramic Film	A4	D2	C-237-.47
C306	470pF, 500V, Ceramic Disc	C3	D2	C-22-470p
C307	.01μF, 500V, Ceramic Disc	F5	B2	C-22-.01
C308	.02μF, 500V, Ceramic Disc	F4	B2	C-22-.02
C309	.02μF, 500V, Ceramic Disc	E2	C2	C-22-.02
C310	470pF, 500V, Ceramic Disc	C2	C3	C-22-470p
C311	.001μF, 500V, Ceramic Disc	B1	B3	C-22-.001
C312	10μF, 25V, Aluminum Electrolytic	D1	B3	C-314-10
C313	220pF, 500V, Ceramic Disc	D2	B3	C-22-220p
C314	10pF, 500V, Polystrene	D3	B3	C-138-10p
C315	10μF, 25V, Aluminum Electrolytic	C5	D4	C-314-10
C316	10μF, 25V, Aluminum Electrolytic	C4	D4	C-314-10
C317	4.7μF, 350V, Aluminum Electrolytic	F3	F3	C-240-4.7
C318	.01μF, 500V, Ceramic Disc	F2	E4	C-22-.01
C319	.1μF, 16VDC, Ceramic Disc	E2	E4	C-238-.1
C320	.02μF, 500V, Ceramic Disc	E2	E4	C-22-.02
C321	.1μF, 16VDC, Ceramic Disc	E2	E5	C-238-.1
C322	.01μF, 500V, Ceramic Disc	F1	F5	C-22-.01
C323	4.7μF, 350V, Aluminum Electrolytic	F1	F5	C-240-4.7
C324	10μF, 25V, Aluminum Electrolytic	B6	D5	C-314-10
C325	10μF, 25V, Aluminum Electrolytic	B6	D5	C-314-10
C326	0.1μF, 250V,Metalized Polyester	B4	D4	C-178-0.1
C327	10μF, 25V, Aluminum Electrolytic	B6	D4	C-314-10
C328	.01μF, 500V, Ceramic Disc	C5	D4	C-22-.01
C329	.01μF, 500V, Ceramic Disc	C5	D5	C-22-.01
C330	1.5μF, 25V, Aluminum Electrolytic	G4	D5	C-314-15
CR301	Diode, Germanium, 1N3592	E2	C2	RF-39
CR302	Silicon Diode, 1N914	C3	D3	RF-28
CR303	Silicon Diode, 1N914	C3	D3	RF-28
CR304	Diode Dual, Low Leakage, 1D101	D2	B3	DN-3
CR305	Rectifier, 1N3595	D3	B4	RF-43
CR306	Rectifier, 1N3595	E3	B5	RF-43
CR307	Silicon Diode, 1N914	A4	D3	RF-28
CR308	Silicon Diode, 1N914	B4	D4	RF-28
CR316	Silicon Diode, 1N914	F2	F4	RF-28
CR317	Silicon Diode, 1N914	F1	F5	RF-28
J1003	Connector, Male	B2	D5	CS-389-3
K301	Relay	SEV	B4	RL-70
K302	Relay	SEV	B4	RL-70
K303	Relay	SEV	B4	RL-70
K304	Relay	SEV	B5	RL-70
K305	Relay	SEV	B5	RL-70
K306	Relay	SEV	B5	RL-70
K307	Relay	SEV	B5	RL-50
Q301	N-Channel FET, 2N4393	E1	B3	TG-130
Q302	N-Channel FET, PF5301	D1	B3	TG-139
Q303	N-Channel FET, 2N4392	E4	C3	TG-128
Q304	N-Channel FET, 2N4392	F4	C3	TG-128
Q305	N-Channel FET, 2N4392	F4	C3	TG-128
Q306	N-Channel FET, 2N4392	G4	D3	TG-128
Q307	N-Channel FET, 2N4392	F4	C3	TG-128
Q308	N-Channel FET, 2N4392	F4	C3	TG-128
Q309	N-Channel FET, 2N4392	F4	C3	TG-128
Q310	N-Channel FET, 2N4392	G4	D3	TG-174

Table 6-4. Analog Board D220-123, Parts List (Cont.)

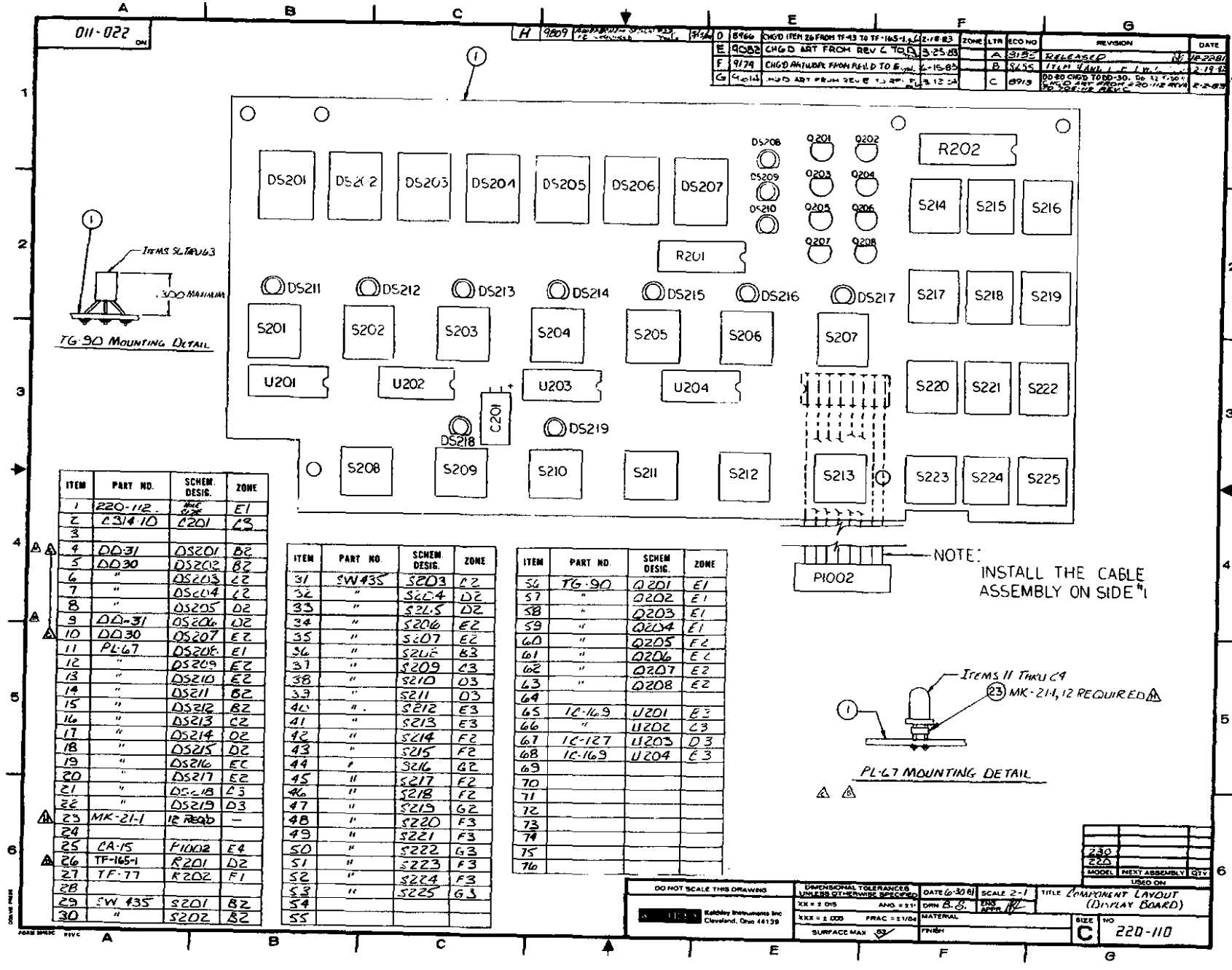
Circuit Desig.	Description	Location Sch.	Location Pcb.	Keithley Part No.
Q311	NPN-Power Transistor, 2N5190	D5	D3	TG-108
Q312	PNP-Power Transistor, 2N5193	D5	D4	TG-107
Q313	PNP, Transistor, Silicon, 2N3906	E3	E4	TG-84
Q314	PNP, Transistor, Silicon, 2N3906	F2	F4	TG-84
Q315	NPN, Silicon, 2N3904	Es	E5	TG-47
Q316	Diode Current Unit, J505	E1	F5	TG-140
Q317	NPN, Silicon, 2N3904	F2	E5	TG-47
Q319	NPN, Transistor, MJ15011	F3	E4	TG-154
Q318	PNP, Transistor, MJ15012	F1	E5	TG-155
R301	301k, 1%, 1/8W, Metal Film	F5	B2	R-88-301k
R302	1M, 1%, 0.12W, Metal Film	G5	B2	R-88-1M
R303	100k Pot	G5	B1	RP-97-100k
R304	100k Pot	G5	B2	RP-97-100k
R305	49.9k, 1%, 1/8W, Metal Film	G5	B2	R-88-49.9k
R306	10k, 1%, 1/8W, Metal Film	G5	B2	R-88-10k
R307	6.04k, 1%, 1/8W, Metal Film	F5	B2	R-88-6.04k
R308	47k, 5%, .11W, Thick Film Resistor	E5	B2	TF-103-4
R309	47k, 5%, .11W, Thick Film Resistor	D5	C2	TF-103-3
R310	47k, 5%, .11W, Thick Film Resistor	D4	C2	TF-103-3
R311	47k, 5%, .11W, Thick Film Resistor	D1	C2	TF-103-4
R312	10k, 5%, 1/4W, Composition	B3	D1	R-76-10k
R313	1k, 5%, 1/4W, Composition	C4	D2	R-76-1k
R314	20k, 5%, 1/4W, Composition	C4	D2	R-76-20k
R315	20k, 5%, 1/4W, Composition	G3	D2	R-76-2.2k
R316	301k, 1%, 1/8W, Metal Film	F5	B2	R-88-301k
R317	22.2k, .1%, 1/10W, Metal Film	F4	B2	R-263-22.2k
R318	200Ω Pot	F4	B3	RP-97-200
R319	2k Pot	E2	B3	RP-97-2k
R320	22.2K, 1%, 1/10W, Metal Film	F4	C2	R-263-22.2k
R321	20k, 1%, 1/8W, Metal Film	F2	C2	R-88-20k
R322	20k, 1%, 1/8W, Metal Film	E1	C3	R-88-20k
R323	11k, 1%, 1/8W, Metal Film	G4	C2	R-88-11k
R324	10k, 5%, 1/4W, Composition	B2	C3	R-76-10k
R325	20k, 5%, 1/4W, Composition	C3	C3	R-76-20k
R326	1k, 5%, 1/4W, Composition	C3	C3	R-76-1k
R327	10k, 5%, 1/4W, Composition	B2	C2	R-76-10k
R328	1k, 1%, 1/8W, Metal Film	E2	C2	R-88-1k
R329	4.99k, 1%, 1/8W, Metal Film	B2	D2	R-88-4.99k
R330	1.2M, 5%, 1/4W, Composition	C2	D2	R-76-1.2M
R331	4.99k, 1%, 0.12W, Metal Film	B3	D2	R-88-4.99k
R332	1.2M, 5%, 1/4W, Composition	B3	D2	R-76-1.2M
R333	10k, 5%, 1/4W, Composition	C3	D3	R-76-10k
R334	100Ω, 5%, 1/4W, Composition	C5	D3	R-76-100
R335	470Ω, 5%, 1/4W, Composition	D5	D3	R-76-470
R336	4.7k, 5%, 1/4W, Composition	F5	C3	R-76-4.7k
R337	4.7k, 5%, 1/4W, Composition	E5	C3	R-76-4.7k
R338	5.6k, 5%, 1/4W, Composition	C1	B3	R-76-5.6k
R339	39Ω, 5%, 1/4W, Composition	C1	B3	R-76-39
R340	39Ω, 5%, 1/4W, Composition	C2	B3	R-76-39
R341	5.6k, 5%, 1/4W, Composition	C2	B3	R-76-5.6k
R342	1k, 5%, 1/4W, Composition	E2	B3	R-76-1k
R343	10k Pot	D2	B3	RP-97-10k
R344	10k, 5%, 1/4W, Composition	D2	B3	R-76-10k
R345	470k, 5%, 1/4W, Composition	E2	B3	R-76-470k
R346	47k, 5%, 1/4W, Composition	B1	B3	R-76-47k
R347	15k, 5%, 1/4W, Composition	B1	B3	R-76-15k
R348	2.4k, 5%, 1/4W, Composition	D1	B3	R-76-2.4k
R349	10k, 1%, 0.12W, Metal Film	D2	B3	R-88-10k
R350	100k, 5%, .11W, Thick Film Resistor	SEV	C3	TF-103-2
R351	10k, 5%, 1/4W, Composition	A4	D3	R-76-10k

Table 6-4. Analog Board D220-123, Parts List (Cont.)

Circuit Desig.	Description	Location Sch.	Location Pcb.	Keithley Part No.
R352	10k, 5%, 1/4W, Composition	A4	D3	R-76-10k
R353	2.2M, 10%, 0.25W, Composition	B4	D4	R-76-2.2M
R354	100k Pot	E4	C4	RP-97-100k
R355	10k Pot	E4	C4	RP-97-10k
R356	10k Pot	E4	C4	RP-97-10k
R357	10k Pot	D4	C4	RP-97-10k
R358	4.75G, 2%, 1.5W, Glass Epoxy coated, Metal Oxide	D3	C4	R-289-4.75G
R359	100k, 1%, 1/4W, Composition	D3	C4	R-88-100k
R360	1k, 1%, 1/4W, Composition	D3	C4	R-76-1k
R361	530M, 2%, 1.5W, Glass Epoxy coated, Metal Oxide	E3	C4	R-289-530M
R362	48M, 2%, 1.5W, Glass Epoxy coated, Metal Oxide	E3	C4	R-289-48M
R363	2.2k, 5%, 1/4W, Composition	E3	E4	R-76-2.2k
R364	24k, 5%, 1/4W, Composition	E3	E4	R-76-24k
R365	100k, 1%, 1/2W, Metal Film	C3	F4	R-94-100k
R366	100k, 1%, 1/2W, Metal Film	B3	F4	R-94-100k
R367	10Ω, 1%, 0.12W, Metal Film	G2	F4	R-88-10
R368	13Ω, 1%, 0.12W, Metal Film	G2	F4	R-88-13
R369	22Ω, 10%, 1/2W, Composition	F1	F4	R-1-22
R370	22Ω, 10%, 1/2W, Composition	F2	F5	R-1-22
R371	2.2k, 5%, 1/4W, Composition	E1	E5	R-76-2.2k
R372	13Ω, 1%, 1/8W, Metal Film	G1	F5	R-88-13
R373	10Ω, 1%, 0.12W, Metal Film	G1	F5	R-88-10
R374	4.7k, 5%, 1/4W, Composition	E2	E5	R-76-4.7k
R375	54.1k, .1%, 1.10W, Metal Film	F3	D5	R-263-54.1k
R376	4.93k, .1%, 1/10W, Metal Film	F4	D5	R-263-4.93k
R377	20k, 1%, 0.12W, Metal Film	G3	C5	R-88-20k
R378	4.85M, .5%, 1/2W, Metal Film	E3	C4	R-265-4.85M
R379	485k, .1%, 1/4W, Metal Film	F3	C4	R-264-485k
R380	499Ω, .1%, 1/25W, Metal Film	G4	C5	R-286-499
R381	100Ω, 0.1%, 3W Fixed	G4	C5	R-308-100
R382	49.9k, 1%, 0.12W, Metal Film	G5	C5	R-88-49.9k
R383	3.57k, 1%, 0.12W, Metal Film	G3	D5	R-88-3.57k
R384	5k, Pot			RP-95-5k
R385	500 Pot	F4	C5	RP-97-500
R386	10k Pot	G4	C5	RP-97-10k
R387	1k Pot	G4	C5	RP-97-1k
R388	100k, 5%, 1/4W, Composition	D4	D5	R-76-100k
R389	10k, 5%, 1/4W, Composition	B3	D5	R-76-10k
R390	10k, 5%, 1/4W, Composition	B4	D5	R-76-10k
R391	10k, 5%, 1/4W, Composition	B3	D5	R-76-10k
R392	10k Pot	F4	B3	RP-97-10k
R393	3.9k, 5%, 1/4W, Film or Composition			R-76-3.9k
U301	8-bit Shift Registor, 14094	C4	B1	IC-251
U302	8-bit Shift Registor, 14094	C3	C1	IC-251
U303	8-bit Shift Registor, 14093	C2	C1	IC-251
U304	Quad 2-Input AND, 4081	SEV	D2	IC-138
U305	Quad 2-Input NAND, 4011	SEV	D2	IC-102
U306	Quad Monolithic SPST CMOS Analog Switch	SEV	C2	IC-320
U307	Wide Bandwidth Dual JFET, LF353N	E5	C2	IC-246
U308	CMOS 8-bit Multiplying D/A Converter,AD7523	E2	C2	IC-321
U309	Wide Bandwidth Dual JFET, LF353N	E2	C2	IC-246
U310	Operational Amplifier, AD3247	E1	C2	IC-77
U311	Integrated Circuit D/A Converter,DAC80-CBI-V	E4	B2	IC-323
U312	Operational Amplifier, AD3247	F4	B3	IC-77
U313	Quad Comparator, LM339	SEV	B3	IC-219
U314	Quad 2 input NAND, 4011	SEV	C3	IC-102
U315	Operational Amplifier, AD3247	B4	C3	IC-248
U316	Hex Inverter, 16-Pin, 4049	SEV	D3	IC-106
U317	Quad Comparator, LM339	SEV	C3	IC-219
U318	Decoder/Demultiplexer, 14555	SEV	C3	IC-312
U319	Op Amp, AD515K	D2	B3	IC-241
U320	High/Voltage, High/Current Transistor Array, VLN2003A	C5	C3	IC-206
VR301	+5V Regulator, 7805	B6	D5	IC-93

Table 6-5. IEEE Interface Board, Parts List

Circuit Desig.	Description	Location Sch.	Location Pcb.	Keithley Part No.
C401	.01μF, 500V, Ceramic Disc	H3	E2	C-22-.01
C402	.01μF, 500V, Ceramic Disc	F1	C3	C-22-.01
C403	10μF, 25V, Aluminum Electrolytic	F1	C3	C-314-10
CR401	Rectifier Bridge (1.5A), W04M	B4	E1	RF-46
CR402	Rectifier Bridge (1.5A), W04M	A4	E1	RF-46
J1017	IEEE Bus Connector	H2	F2	CS-443
P1004	Cable Assembly	C1	C2	CA-10-2
Q401	NPN, Silicon Transistor, 2N3904	C5	C2	TG-47
R401	4.7k, 5%, 1/4W, Composition	D2	C1	R-76-4.7k
R402	4.7k, 5%, 1/4W, Composition	C5	C1	R-76-4.7k
R403	Thick Film Resistor	C4	D1	TF-102-2
R404	Thick Film Resistor	B4	D1	TF-103-2
R405	100Ω, 10%, 1/2W, Composition	A5	E1	R-1-100
R406	100Ω, 10%. 1/2W, Composition	B5	E1	R-1-100
R407	100Ω, 10%, 1/2W, Composition	A5	E1	R-1-100
R408	100Ω, 10%, 1/2W, Composition	B5	E1	R-1-100
R409	Thick Film, Resistor Network	F5	E2	TF-100
R410	Thick Film Resistor	G2	E2	TF-103-1
R411	33Ω, 10%, 1W, Composition	G1	E2	R-2-33
S401	Primary Address Switch, Bank of 5 switches	G5	E2	SW-450-5
U401	8-bit Shift Register, 4094	C2	D2	IC-251
U402	Shift Register, 4021	C3	D2	IC-130
U403	Hex Inverter, 74LS04	SEV	D2	IC-186
U404	GPIB Adapter, 59914	F3	D2	LSI-49
U405	Interface Bus Tranceiver, SN75160	G2	E2	IC-298
U406	Decoder/Demultiplexers,74LS138	E4	D3	IC-182
U407	Hex 3-state Buffer, 74LS367	F4	D3	IC-161
U408	Interface Bus Tranceiver, 75161	G3	E3	IC-299
U409	Quad 2 input NAND gate, 74LS00	G3	E3	IC-163



ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	220-112		E1
2	CA14-10	C201	C3
3			
4	DD-31	DS201	B2
5	DD30	DS202	B2
6	"	DS203	C2
7	"	DS204	C2
8	"	DS205	D2
9	DD-31	DS206	D2
10	DD30	DS207	E2
11	PL-67	DS208	E1
12	"	DS209	E2
13	"	DS210	E2
14	"	DS211	B2
15	"	DS212	B2
16	"	DS213	C2
17	"	DS214	D2
18	"	DS215	D2
19	"	DS216	E2
20	"	DS217	E2
21	"	DS218	C3
22	"	DS219	D3
23	MK-21-1	12 Reqd	—
24			
25	CA-15	P1002	E4
26	TF-165-1	R201	D2
27	TF-77	R202	F1
28			
29	SW-435	S201	B2
30	"	S202	B2

ITEM	PART NO.	SCHEM. DESIG.	ZONE
31	SW-435	S203	C2
32	"	S204	D2
33	"	S205	D2
34	"	S206	E2
35	"	S207	E2
36	"	S208	B3
37	"	S209	C3
38	"	S210	D3
39	"	S211	D3
40	"	S212	E3
41	"	S213	E3
42	"	S214	F2
43	"	S215	F2
44	"	S216	G2
45	"	S217	F2
46	"	S218	F2
47	"	S219	G2
48	"	S220	F3
49	"	S221	F3
50	"	S222	G3
51	"	S223	F3
52	"	S224	F3
53	"	S225	G3
54			
55			

ITEM	PART NO.	SCHEM DESIG.	ZONE
56	TG-90	Q201	E1
57	"	Q202	E1
58	"	Q203	E1
59	"	Q204	E1
60	"	Q205	F2
61	"	Q206	E2
62	"	Q207	E2
63	"	Q208	E2
64			
65	IC-169	U201	E3
66	"	U202	C3
67	IC-127	U203	D3
68	IC-169	U204	E3
69			
70			
71			
72			
73			
74			
75			
76			

Figure 6-3. Display Board, Component Location Drawing, Dwg. No. 220-110

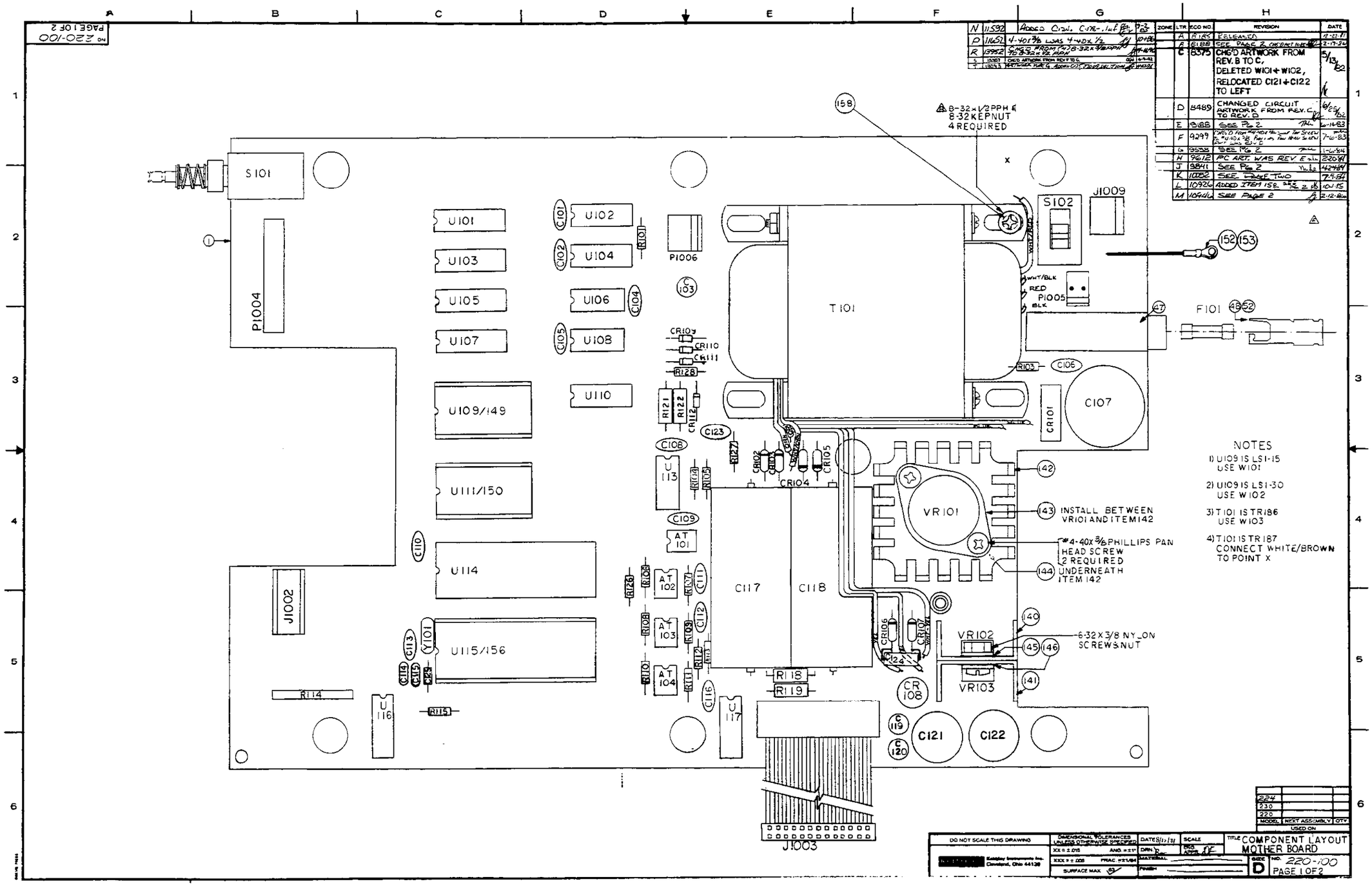


Figure 6-4. Mother Board, Component Location Drawing, Dwg. No. 220-100 (sheet 1 of 2)

NO. 220-100 PAGE 2 OF 2

ZONE	LTR	ECO NO	REVISION	DATE
	A	8185	RELEASED	[illegible]
	B	8188	[illegible]	2-17-82
	C	8375	ITEM 10 WAS C-314-11600, DELETED ITEM 125 J3, DELETED ITEM 126 J3	5/13/82
	D	8489	CHG'D CIRCUIT ART REV C TO D SEE PAGE 1	6-25-82
	E	9188	ITEM # 105 WAS LSI-25 ITEM # 107 WAS LSI-30	6-14-83
	F	9299	ADDED SOFTWARE TABLE	7-6-83
	G	9598	DELETED ITEMS 151-155	1-6-84
	H	9612	SEE PAGE 1	2-20-84
	J	9841	DELETED U112 R125 & R102 ADDED 224 SOFTWARE.	4-24-84
	K	10052	ITEM 121 WAS IC-98	7-1-84
	L	10926	ADDED ITEM 158	10-1-85
	M	10946	ITEM 90 - DELETED SW-426 ADDED SW-466.	2-12-86
	N	11592	ITEM 35 WAS RF-64. ADDED ITEM 27. SEE PG. 1	9-2-86
	P	11652	SEE PG. 1	10-1-86
	R	13952	SEE PG. 1	4-16-90
	S	15307	SEE PG. 1	1-6-92
	T	18093	ITEM 56 WAS CS-358 J1001 ADDED ITEMS 28, 152 & 153	4-22-96

ITEM	PART NO.	SCHEM DESIG.	ZONE
1	220-101	STAKING	A 2
2			
3			
4	C-238-.1	C101	D 2
5	C-238-.1	C102	D 2
6	C-314-10	C103	D 2
7	C-22.0068	C104	D 2
8	C-238-.1	C105	D 3
9	C-22-.01	C106	G 3
10	C-342-10,000	C107	G 3
11	C-238-.1	C108	D 3
12	C-238-.1	C109	D 4
13	C-238-.1	C110	C 4
14	C-238-.1	C111	E 4
15	C-238-.1	C112	E 5
16	C-238-.1	C113	C 5
17	C-64-22PF	C114	C 5
18	C-64-22PF	C115	C 5
19	C-238-.1	C116	E 5
20	C-337-330	C117	E 5
21	C-337-330	C118	E 5
22	C-314-10	C119	F 5
23	C-314-10	C120	F 6
24	C-309-1000	C121	F 6
25	C-309-1000	C122	F 6
26	C-22-330 PF	C123	E 3
27	C-178-.1µf	C124	F5
28	C-365-.1	C125	C5
29			
30			
31			
32			
33			
34			
35	RF-64	CR101	G 3
36	RF-38	CR102	E 4
37	RF-38	CR103	E 4
38	RF-38	CR104	E 4
39	RF-38	CR105	E 4
40			

ITEM	PART NO.	SCHEM DESIG.	ZONE
41	RF-38	CR106	F 5
42	RF-38	CR107	F 5
43	RF-46	CR108	F 5
44	RF-38	CR109	E 3
45	RF-38	CR110	E 3
46	RF-38	CR111	E 3
47	FH-21		G 3
48	FH-25		H 3
49	FU-19	F101	H 3
50	FU-18	F101	H 3
51			
*52	FH-26		H 3
*53	FU-52	F101	H 3
*54	FU-53	F101	H 3
55			
56	CS-772-3	J1009	G 2
57	CS-288-2	P1005	G 2
58			
59	CS-389-3	P1004	B3
60	CA-10-3	J1003	E 5
61	CS-288-3	P1006	D2
62			
63			
64			
65	R-76-18K	R101	D 2
66			
67	R-76-220K	R103	F 3
68	R-76-4.7K	R104	E4
69	R-76-390	R105	E4
70	R-76-220	R106	D 4
71	R-76-2.4K	R107	E 4
72	R-76-220	R108	D 5
73	R-76-2.4K	R109	E 5
74	R-76-220	R110	D 5
75	R-76-2.4K	R111	E 5
76	R-76-4.7K	R112	E 5
77	R-76-220	R113	E 5
78	TF-140	R114	B5
79	R-76-4.7K	R115	C5
80			

ITEM	PART NO.	SCHEM DESIG.	ZONE
81			
82			
83	R-1-100K	R118	E 5
84	R-1-100K	R119	E 5
85			
86	R-1-100	R121	E3
87	R-1-100	R122	E3
88			
89			
90	SW-466	S101	B 2
91	SW-397	S102	G 2
92			
93			
94	TR186	T101	F 2
*95	TR187	T101	F 2
96			
97	LSI-15	U101	C 2
98	IC-197	U102	D 2
99	LSI-15	U103	C 2
100	IC-214	U104	D 2
101	LSI-15	U105	C 2
102	IC-163	U106	D 2
103	LSI-15	U107	C 3
104	IC-179	U108	D 3
105	SEE TABLE	U109	C 3
106	IC-182	U110	D 3
107	SEE TABLE	U111	C 4
108			
109	IC-116	U113	D 4
110	LSI-28	U114	C 4
111	LSI-27	U115	C 5
112	IC-250	U116	C 5
113	IC-106	U117	E 5
114			
115			
116	IC-292	AT101	D 4
117	IC-292	AT102	D 4
118	IC-292	AT103	D 5
119	IC-292	AT104	D 5
120			

ITEM	PART NO.	SCHEM DESIG.	ZONE
121	IC-34	VR101	F 4
122	IC-174	VR102	F 5
123	IC-96	VR103	F 5
124			
125			
126			
127			
128			
129	CR-10	Y101	C 5
130			
131	RF-38	CR112	E3
132			
133			
134			
135	R-76-10K	R126	D5
136	R-76-4.7K	R127	E3
137	R-76-47K	R128	E3
138			
139			
140	HS-15		F 5
141	HS-15		F 5
142	HS-22		F 4
143	MK-16		F4
144	MK-20		F4
145	MK-18		F5
146	MK-18		F5
147			
148	SO-65	J1002	B5
149	SO-68		C 3
150	SO-68		C 4
151			
152	SC-73-5	–	H2
153	LU-88	–	H2
154			
155			
156	SO-84-40		C 5
157			
158	WA-41-2	4 REQ'D	E2
159			
160			

*NOTES:

1) FOR 100V JAPANESE VERSION SUBSTITUTE ITEM 95 (TR-187) FOR ITEM 94 (TR-186).
2) FOR EUROPEAN VERSION SUBSTITUTE FU-50 AND FU-51 FOR FU-4 AND FU-17. ALSO SUBSTITUTE FH-26 FOR FH-25.

SOFTWARE SELECTION TABLE

ITEM	SCHEMATIC DESIGNATION	MODEL 220 USAGE	MODEL 230 USAGE	MODEL 224 USAGE
105	U109	220-800	230-800	224-800
107	U111	220-801	230-801	224-801

SELECT APPROPRIATE SOFTWARE PER MODEL

MODEL	NEXT ASSEMBLY	QTY
224		
230		
220		

USED ON

DO NOT SCALE THIS DRAWING

KEITHLEY Keithley Instruments Inc. Cleveland, Ohio 44139

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: XX = ±.015, ANG = ±1°, XXX = ±.005, FRAC = ±1/64, SURFACE MAX 63

DATE 8/13/81 SCALE 1:1 DRN ENG APPR MATERIAL FINISH

TITLE COMPONENT LAYOUT MOTHER BOARD

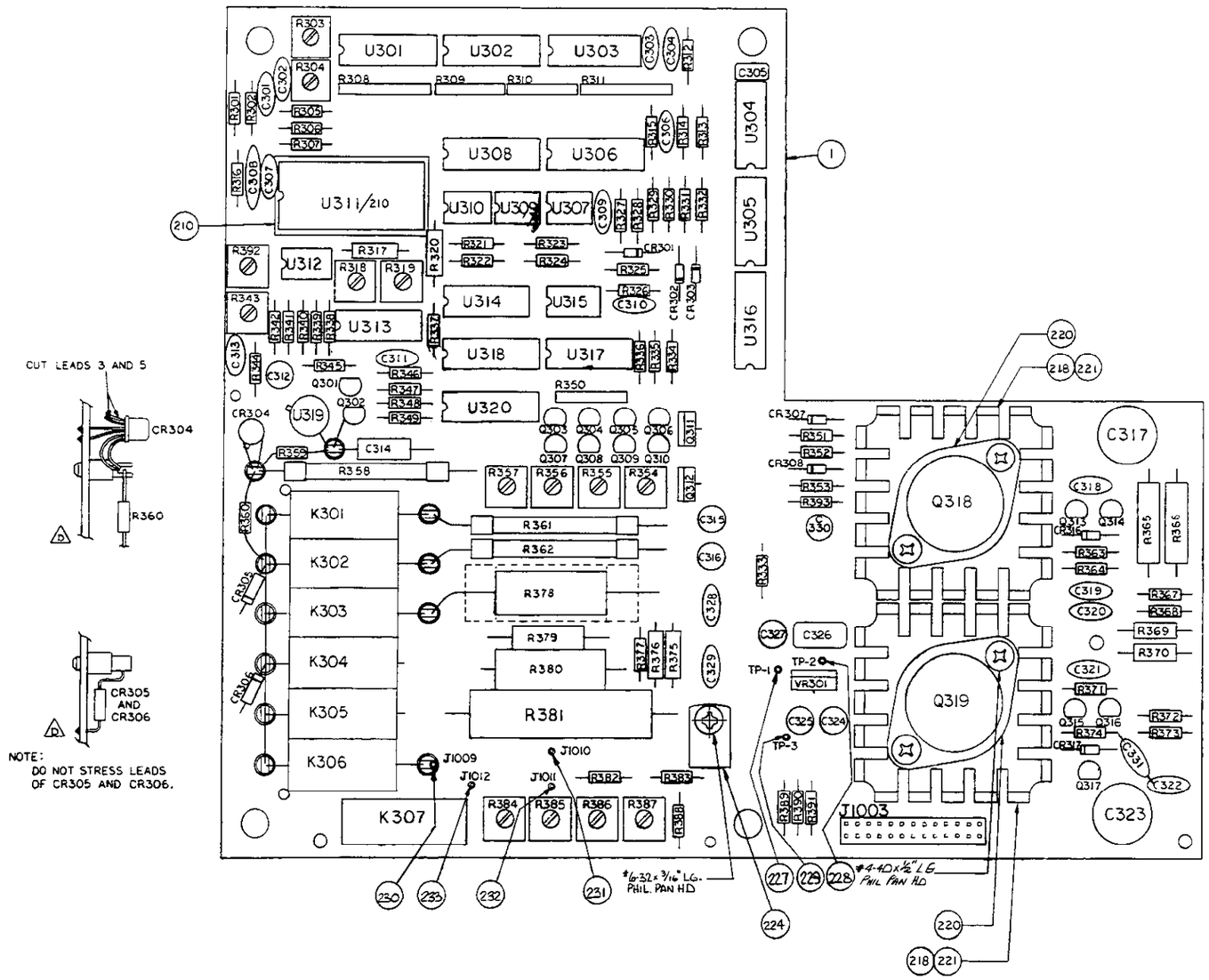
SIZE D NO. 220-100 PAGE 2 OF 2

FORM 285119 REV C

Figure 6-4. Mother Board, Component Location Drawing, Dwg. No. 220-100 (sheet 2 of 2)

220-120

ZONE	LTR	ECO NO	REVISION	DATE
	A	8887	RELEASED	1-4-82
	B	9188	[illegible]	2-3-82
	C	9231	SEE PG 2	2-10-82
	D	9270	SEE PAGE 2	2-5-82
	E	9657	CHG'D ASYLUM FROM DTOE	9-13-82
	F	9840	SEE PAGE 2	12-8-82
	G	9020	CHG'D ARTWORK FROM REV E TO REV F. CHG'D LOCATION OF R333 FROM D9.	2-27-83
	H	9068	SEE PAGE 2	3-21-83
	J	9371	SEE PG 2	9-6-83
	K	9598	SEE PAGE 2	1/6/84
	L	9825	SEE PAGE 2	3/27/84
	M	10511	SEE PAGE 2	3-5-85
	N	10765	SEE PAGE 2	12-3-86
	P	12115	SEE PAGE 2	4-28-87
	R	12287	SEE PG. 2	9-9-87
	S	11098	SEE PAGE 2	12-8-88
	T	14353	ADD C331	11-20-89



DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 8-31-81	SCALE 2:1	TITLE COMPONENT LAYOUT, ANALOG BOARD	
Keithley Instruments Inc. Cleveland, Ohio 44139	XX = ± .010 ANG. = ±1°	DRN.	ENG APPR.		
	XXX = ± .005 FRAC. = ±1/64	MATERIAL		SIZE D	NO 220-120
	SURFACE MAX. 63	FINISH			

MODEL	NEXT ASSEMBLY	QTY
220/224		

USED ON

Figure 6-5. Analog Board, Component Location Drawing, Dwg. No. 220-120 (sheet 1 of 2)

DWG NO 220-120

ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	220-121	STAKING	
2			
3			
4	C-238-.1	C301	B2
5	"	C302	B2
6	"	C303	D1
7	C-22-.01	C304	D1
8	C-237-.47	C305	D2
9	C-64-470pF	C306	D2
10	C-22-.01	C307	B2
11	C-22-.02	C308	B2
12	C-22-.02	C309	C2
13	C-64-470pF	C310	C3
14	C-22-.001	C311	B3
15	C-314-10	C312	B3
16	C-22-.001	C313	B3
17	C-405-10P	C314	B3
18	C-314-10	C315	D4
19	"	C316	D4
20	C-240-4.7	C317	F3
21	C-22-.01	C318	E4
22	C-238-.1	C319	E4
23	C-22-.001	C320	E4
24	C-238-.1	C321	E5
25	C-22-.01	C322	F5
26	C-240-4.7	C323	F5
27	C-314-10	C324	D5
28	"	C325	D5
29	C-178-0.1µF	C326	D4
30	C-314-10	C327	D4
31	C-22-.01	C328	D4
32	"	C329	D5
33	C-314-15	C330	D4
34	C-64-150p	C331	F5
35			
36			
37			
38	RF-39	CR301	C2
39	RF-28	CR302	D3
40	"	CR303	D3

ITEM	PART NO.	SCHEM. DESIG.	ZONE
41	DN-3	CR304	B3
42	RF-43	CR305	B4
43	"	CR306	B5
44	RF-28	CR307	D3
45	"	CR308	D4
46			
47			
48			
49			
50			
51			
52			
53	RF-28	CR316	E4
54	"	CR317	F5
55			
56			
57			
58	RL-70	K301	B4
59	"	K302	B4
60	"	K303	B4
61	"	K304	B5
62	"	K305	B5
63	"	K306	B5
64	RL-50	K307	B5
65			
66			
67	CS-389-3	J1003	D5
68			
69			
70	TG-130	Q301	B3
71	TG-139	Q302	B3
72	TG-128	Q303	C3
73	"	Q304	C3
74	"	Q305	C3
75	"	Q306	D3
76	"	Q307	C3
77	"	Q308	C3
78	"	Q309	C3
79	TG-174	Q310	D3
80	TG-108	Q311	D3

ITEM	PART NO.	SCHEM. DESIG.	ZONE
81	TG-107	Q312	D4
82	TG-84	Q313	E4
83	"	Q314	F4
84	TG-47	Q315	E5
85	TG-140	Q316	F5
86	TG-47	Q317	E5
87	TG-155	Q318	E4
88	TG-154	Q319	E5
89			
90			
91			
92	R-88-30.1K	R301	B2
93	R-88-1M	R302	B2
94	RP-97-100K	R303	B1
95	"	R304	B2
96	R-88-49.9K	R305	B2
97	R-88-10K	R306	B2
98	R-88-6.04K	R307	B2
99	TF-103-4	R308	B2
100	TF-103-3	R309	C2
101	"	R310	C2
102	TF-103-4	R311	C2
103	R-76-10K	R312	D1
104	R-76-1K	R313	D2
105	R-76-20K	R314	D2
106	A-76-2.2K	R315	D2
107	R-88-301K	R316	B2
108	R-263-22.2K	R317	B2
109	RP-97-200	R318	B3
110	RP-97-2K	R319	B3
111	R-263-22.2K	R320	C2
112	R-88-20K	R321	C2
113	"	R322	C3
114	R-88-11K	R323	C2
115	R-76-10K	R324	C3
116	R-76-20K	R325	C3
117	R-76-1K	R326	C3
118	R-76-10K	R327	C2
119	R-88-1K	R328	C2
120	R-88-4.99K	R329	D2

ITEM	PART NO.	SCHEM. DESIG.	ZONE
121	R-76-1.2M	R330	D2
122	R-88-4.99K	R331	D2
123	R-76-1.2M	R332	D2
124	R-76-1K	R333	D4
125	R-76-100	R334	D3
126	R-76-470	R335	D3
127	R-76-4.7K	R336	C3
128	"	R337	C3
129	R-76-5.6K	R338	B3
130	R-76-39	R339	B3
131	"	R340	B3
132	R-76-5.6K	R341	B3
133	R-76-1K	R342	B3
134	RP-97-10K	R343	B3
135	R-76-10K	R344	B3
136	R-76-470K	R345	B3
137	R-76-47K	R346	B3
138	R-76-15K	R347	B3
139	R-76-2.4K	R348	B3
140	R-88-10K	R349	B3
141	TF-103-2	R350	C3
142	R-76-10K	R351	D3
143	"	R352	D3
144	A-76-2.2M	R353	D4
145	RP-97-100K	R354	C4
146	RP-97-10K	R355	C4
147	"	R356	C4
148	"	R357	C4
149	R-289-4.75G	R358	C4
150	R-88-100K	R359	C4
151	R-76-1K	R360	C4
152	R-289-590M	R361	C4
153	R-289-48M	R362	C4
154	R-76-2.2K	R363	E4
155	R-76-24K	R364	E4
156	R-94-100K	R365	F4
157	"	R366	F4
158	R-88-10	R367	F4
159	R-88-13	R368	F4
160	R-1-22	R369	F4

ITEM	PART NO.	SCHEM. DESIG.	ZONE
161	R-1-22	R370	F5
162	R-76-2.2K	R371	E5
163	R-88-13	R372	F5
164	R-88-10	R373	F5
165	R-76-4.7K	R374	E5
166	R-263-54.1K	R375	D5
167	R-263-4.93K	R376	D5
168	R-88-20K	R377	C5
169	R-265-4.85M	R378	C4
170	R-264-485K	R379	C4
171	R-286-499	R380	C5
172	R-308-100	R381	C5
173	R-88-49.9K	R382	C5
174	R-88-3.57K	R383	D5
175	RP-97-1K	R387	C5
176	RP-97-10K	R386	C5
177	RP-97-500	R385	C5
178	RP-97-5K	R384	C5
179	R-76-100K	R388	D5
180	R-76-10K	R389	D5
181	"	R390	D5
182	"	R391	D5
183	RP-97-10K	R392	B3
184	R-76-3.9K	R393	D4
185			
186			
187			
188			
189	IC-251	U301	B1
190	"	U302	C1
191	"	U303	C1
192	IC-138	U304	D2
193	IC-102	U305	D2
194	IC-320	U306	C2
195	IC-246	U307	C2
196	IC-321	U308	C2
197	IC-246	U309	C2
198	IC-77	U310	C2
199	IC-323	U311	B2
200	IC-248	U312	B3

ITEM	PART NO.	SCHEM. DESIG.	ZONE
201	IC-219	U313	B3
202	IC-102	U314	C3
203	IC-77	U315	C3
204	IC-106	U316	D3
205	IC-219	U317	C3
206	IC-312	U318	C3
207	IC-241	U319	B3
208	IC-206	U320	C3
209			
210	SO-68	——	B2
211			
212			
213	IC-93	VR301	D5
214			
215			
216			
217			
218	MS-22	2/UNIT	E3EG
219			
220	MK-16	2/UNIT	E3EG
221	MK-20	2/UNIT	E3EG
222			
223			
224	CC-46-1	——	D6
225			
226			
227	24249A	TP-1	D5
228	"	TP-2	D5
229	"	TP-3	D5
230	"	J1009	C5
231	"	J1010	C5
232	"	J1011	C5
233	"	J1012	C5
234			
235			
236			
237			
238			
239			
240			

ZONE	LTR	ECO NO	REVISION	DATE
	A	8187	RELEASED	2-4-82
	B	8188	C330 WAS C-314-15P, C331 WAS C-64-150P, C-64-470P, ITEM 12 FROM C-22-.02 TO C-22-.01, C-309, ITEM 13 FROM C-64-470P TO C-314-10, ITEM 14 FROM C-22-.001 TO C-22-.01, ITEM 16 FROM C-22-.001 TO C-314-10, ITEM 17 FROM C-405-10P TO C-314-10, ITEM 29 FROM C-178-0.1µF TO C-314-10, ITEM 33 FROM C-314-15 TO C-64-150P, ITEM 34 FROM C-64-150P TO C-314-10, ADDED ITEM 35 R-88-100K AND ITEM 183 RP-97-10K (R392).	2-17-82
	C	8331	C306 WAS C22-470pF, C310 WAS C-22-470pF, C313 WAS C-22-22.0uF, C320 WAS C-22-.02, C-22-.0330, C-25-.01, K330 WAS R-76-82.0K, K332 WAS R-76-82.0K, K395 WAS R-88-365K, K340 WAS R-76-10.0K, K388 WAS R-88-47.5K ADD. W.O. REV B.	4-20-82
	D	8470	REMOVED CR35/B; ADDED ITEM 33 C-314-15 (C330) AND ITEM 184 R-76-3.92K (R393); ADDED TWO DETAIL VIEWS; CHG'D ITEMS 58 THRU 63 FROM RL-64 TO RL-70; CHG'D R384 TO R387; R385 TO R386; R386 TO R385 AND R387 TO R384 (DESIGNATIONS CHG'D ONLY).	8-5-82
	E	8651	SEE PAGE 1	9-15-82
	F	8840	ITEM "199 WAS IC-323	10-6-82
	G	9020	SEE PAGE 1.	12-27-82
	H	9068	ITEM "106 WAS R-76-20K	3-2-83
	J	9371	ITEM "124 WAS 10K. PART W/BS REV F.	9-15-83
	K	9598	CHG'D ITEM 199 FROM 220-600 TO IC-323.	1-6-84
	L	9845	ITEMS 121, 123 WERE 1M ITEMS 127 & 132 WERE 2.4K	5-10-84
	M	10571	A310 WAS TG-128	3-5-85
	N	10765	CHG'D PATTERN TO REV. H	2-3-86
	P	12115	ITEM 200 = 202 WAS IC-77	10-28-87
	R	12287	CHG'D ITEM 203 TO IC-77	9-9-87
	S	12490	ITEM 17 WAS C-314-10PF	10-8-88
	T	24523	ADDED C331	6-15-00

DO NOT SCALE THIS DRAWING

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: XX = ± .015 ANG = ± 1°; XXX = ± .005 FRAC = ± 1/64; SURFACE MAX

Kaye Instruments Inc. Bedford, Mass. 01730

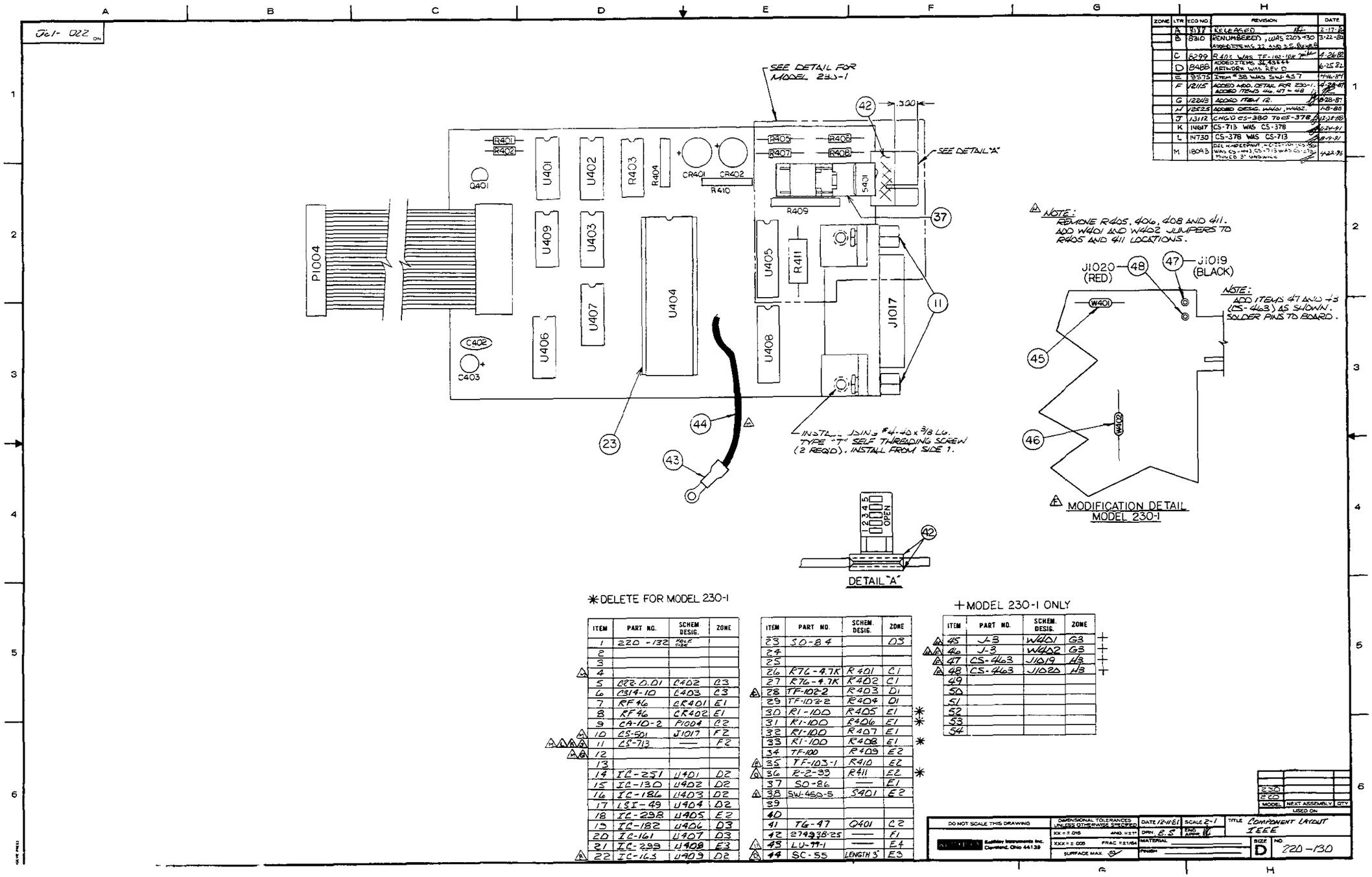
DATE 8-31-81 SCALE FULL DRN APPD MATERIAL FINISH

TITLE COMPONENT LAYOUT, ANALOG BOARD

SIZE D NO. 220-120

220-600 | MOD. | NEXT ASSEMBLY | QTY | USED ON

Figure 6-5. Analog Board, Component Location Drawing, Dwg. No. 220-120 (sheet 2 of 2)



ZONE	LTR	ECO NO.	REVISION	DATE
	A	8417	RELEASED	2-17-82
	B	8810	RENUMBERED, WAS 2205-130	3-22-82
			ADDED ITEMS 44 AND 45	
	C	8299	R401 WAS TF-102-10K	4-26-82
	D	8488	ADDED ITEMS 32, 43 & 44	6-25-82
			ARTWORK WAS REV D	
	E	9575	ITEM #38 WAS SW-457	4-16-84
	F	12115	ADDED ADD. DETAIL FOR 230-1, ADDED ITEMS 46, 47 & 48	4-28-87
	G	12248	ADDED ITEM 12	6-23-87
	H	12525	ADDED DESIG. W401, W402	1-8-88
	J	13112	CHG'D CS-380 TO CS-378	6-23-88
	K	14087	CS-713 WAS CS-378	6-24-91
	L	14730	CS-378 WAS CS-713	8-19-91
	M	18093	DEL HARDPART # CS-501 (CS-502 WAS CS-494), CS-713 WAS CS-378, MOVED 3" WIRE WIRE	9-23-96

✱DELETE FOR MODEL 230-1

ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	220-132	MAKE FROM	
2			
3			
4			
5	CC2-0.01	C402	C3
6	CS19-10	C403	C3
7	RF46	CR401	E1
8	RF46	CR402	E1
9	CA-10-2	P1004	C2
10	CS-501	J1017	F2
11	CS-713	—	F2
12			
13			
14	IC-251	U401	D2
15	IC-130	U402	D2
16	IC-186	U403	D2
17	LSI-49	U404	D2
18	IC-238	U405	E2
19	IC-182	U406	D3
20	IC-161	U407	D3
21	IC-299	U408	E3
22	IC-163	U409	D2
23	SO-84		D3
24			
25			
26	RT6-4.7K	R401	C1
27	RT6-4.7K	R402	C1
28	TF-102-2	R403	D1
29	TF-102-2	R404	D1
30	RI-100	R405	E1
31	RI-100	R406	E1
32	RI-100	R407	E1
33	RI-100	R408	E1
34	TF-100	R409	E2
35	TF-103-1	R410	E2
36	R-2-33	R411	E2
37	SO-86	—	E1
38	SW-450-5	S401	E2
39			
40			
41	TG-47	Q401	C2
42	2749338-25	—	F1
43	LU-77-1	—	E4
44	SC-55	LENGTH 3"	E3

+MODEL 230-1 ONLY

ITEM	PART NO.	SCHEM. DESIG.	ZONE
45	J-3	W401	G3
46	J-3	W402	G3
47	CS-463	J1019	H3
48	CS-463	J1020	H3
49			
50			
51			
52			
53			
54			

230			
220			
MODEL	NEXT ASSEMBLY	QTY.	
	USED ON		

DO NOT SCALE THIS DRAWING
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: XX = ± .015 ANG. = ±1°; XXX = ± .005 FRAC. = ±1/64; SURFACE MAX.
Keithley Instruments Inc. Cleveland, Ohio 44139
DATE 12-11-81 SCALE 2-1
DRN. E.S. ENG. APPR.
MATERIAL
FINISH
TITLE COMPONENT LAYOUT IEEE
SIZE D NO. 220-130

Figure 6-6. IEEE Interface Board, Component Location Drawing, Dwg. No. 220-130

911-022 D

ZONE	LTR	ECO NO	REVISION	DATE
	A	8137	RELEASED	1-14-82
	B	8913	ADDED P1002	2-2-83
	C	8966	CHG'D R208-R210 FROM 68 Ω TO 150 Ω	2-16-83
	D	9179	ADDED PROVISIONAL FOR JUMPER	6-15-83

NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS.
3. ○ DENOTES FRONT PANEL CONTROL.
4. ▽ DENOTES DIGITAL COMMON.

DS201 DS202 DS203 DS204 DS205 DS206 DS207

U204A U204B U204C U201A U201F U201E U201D U201C U201B U202C U202B U202A U202F U202E U202D

S225 (+/−) S221 (2) S222 (3) S223 (●) S224 (0)
SINGLE S201 (for 230 I-LIMIT / for 220 V-LIMIT) S218 (5) S219 (6) S220 (1)
SOURCE S205 S204 STEP S203 CONTINUOUS S202
START/STOP S209 RESET S208 MEMORY S207 DWELL TIME S206
EXPONENT S213 ENTER S212 COPY S211 OPERATE S210
4 S217 9 S216 8 S215 7 S214

DS210 "REMOTE"

"OPERATE" DS219 "LISTEN" DS209 "START/STOP" DS218
"SOURCE" DS214 (for 230 "I-LIMIT" / for 220 "V-LIMIT") DS215 "DWELL TIME" DS216 "MEMORY" DS217 "TALK" DS208 "SINGLE" DS211 "CONTINUOUS" DS212 "STEP" DS213

R201A 150 R201D 150 R201C 150 R201H 150 R201G 150 R201B 150 R201E 150 R201F 150

Q201 Q205 Q207 Q208 Q206 Q203 Q202 Q204

R202D 3.3K R202B 3.3K R202A 3.3K R202H 3.3K R202G 3.3K R202C 3.3K R202E 3.3K R202F 3.3K

U203 SHIFT REGISTER
DATA A, CLOCK, GND, V_{CC}, DATA B, CLEAR
C201 10

P1002
S1 S2 S3 S4 PB5 CA2 DIGITAL COMMON +5V
FA4 (dp) PA7 (g) PA0 (f) PA6 (e) PA2 (d) PA1 (c) PA3 (b) PA5 (a)

HIGHEST SCHEMATIC DESIGNATIONS USED		
C201	DS219	Q208
R202	S225	U204
P1002		

SCHEMATIC DESIGNATIONS NOT USED			
J1002	P1001		

230	
220	
MODEL	NEXT ASSEMBLY QTY USED ON

DO NOT SCALE THIS DRAWING — DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: XX ± .015, XXX ± .005, FRAC ± 1/64, ANG ± 1°, SURFACE MAX 63 — DATE 1-14-82 — SCALE N/A — DRN — ENG — MATERIAL — FINISH

KEITHLEY Keithley Instruments Inc. Cleveland, Ohio 44139

TITLE SCHEMATIC PC-DISPLAY BOARD

SIZE D NO 220-116

FORM 28511D REV A

Figure 6-7. Display Board, Schematic Diagram, Dwg. No. 220-116

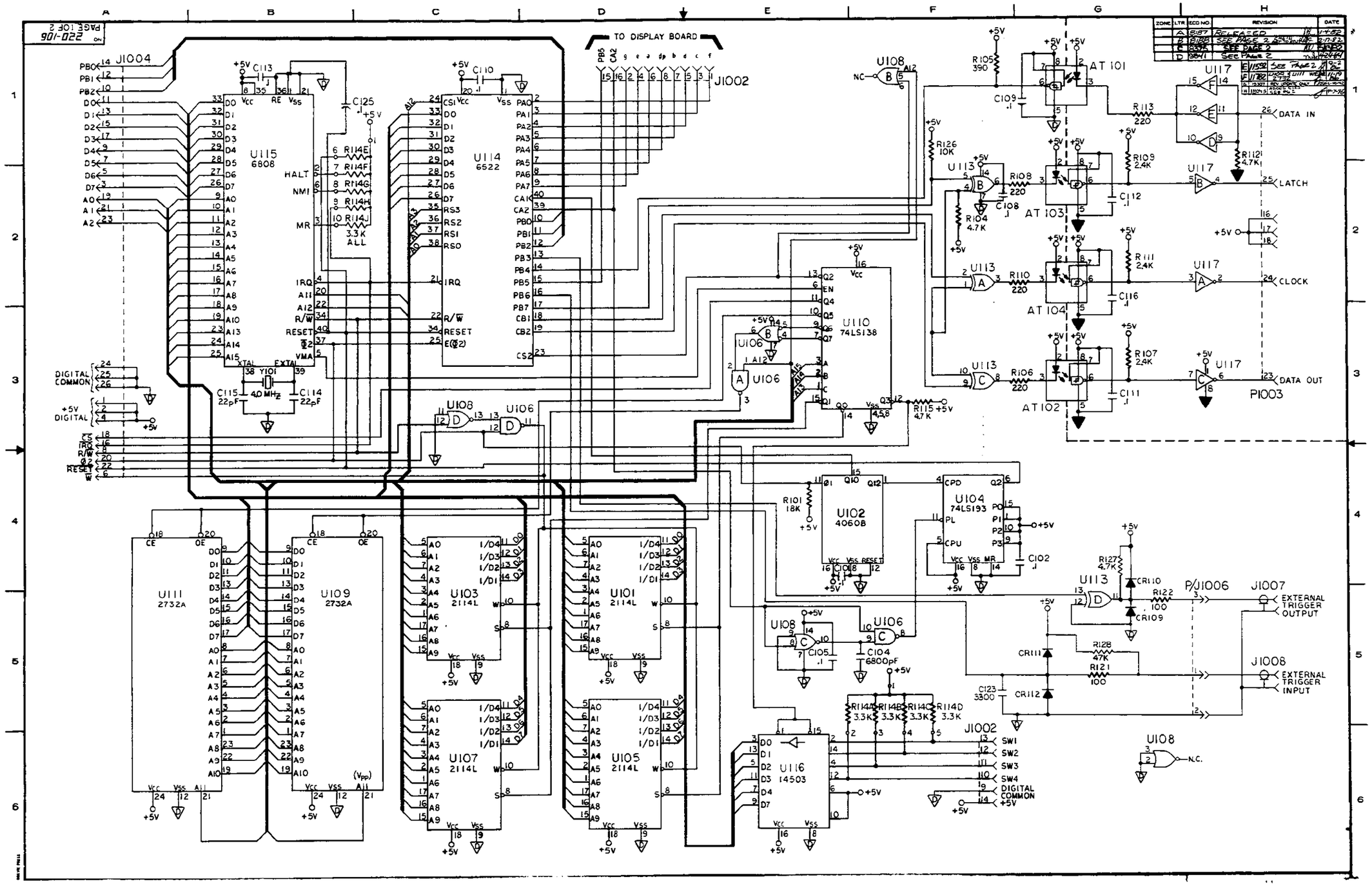
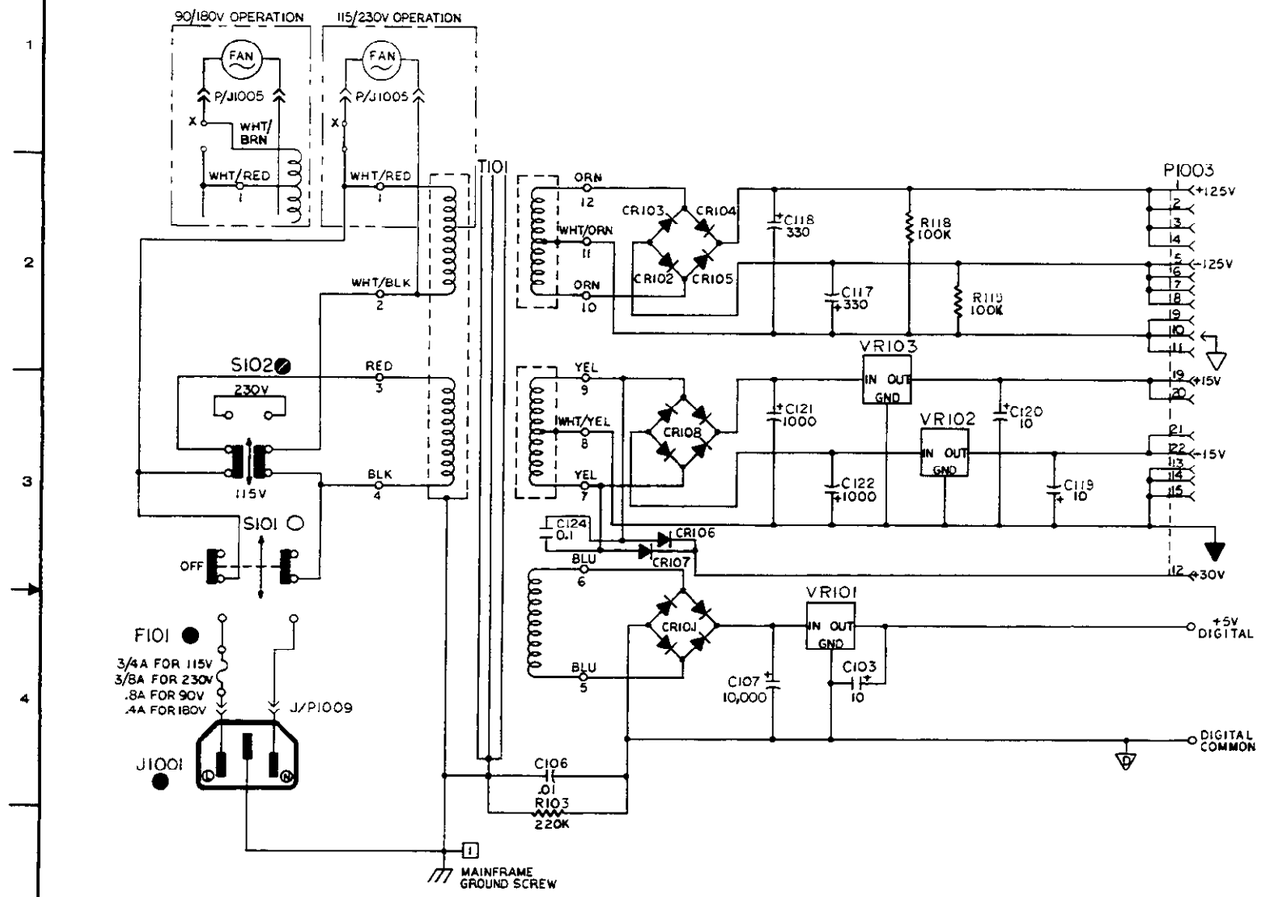


Figure 6-8. Digital Circuitry, Schematic Diagram, Dwg. No. 220-106 (sheet 1 of 2)



ZONE	LTR	ECO NO	REVISION	DATE
	A	8187	RELEASED	1-19-82
	B	8355	T101 WAS: 76 A PRI 75V, 16A SECOND ADDED F101 - 8A FAST BLO, 3AG GLASS & SIZE; F102 FAST BLO, 8AG GLASS, DELETED R110 470K, DELETED R115 820K, DELETED R116 10K; DELETED Q101; DELETED W103; ADDED C133 - 350; ADDED R127 - 4.7K; R128 - 470.	2-17-82
	C	8375	ON PAGE 1 - CHANGED CONNECTION FROM PIN 3 TO PIN 1 ON U102, CHANGED CONNECTION FROM PIN 7 TO PIN 6 ON U104, DELETED JUMPERS W101 + W102, CORRECTED PIN 8 CONNECTION ON U111 + U109 TO A0 BUSS FROM D0 BUSS. ON THIS PAGE - REPLACED (C107) C-314-11600 WITH C-342-10,000	5/13/82
	D	9841	DELETED U112 R125 R126	4-24-84
	E	11592	ADDED C124 (.1)	9-2-86
	F	11782	SEE REV 1	11-9-86
	G	13001	REV UPDATE ONLY	2-10-87
	H	18093	ADDED J/P1009	9-7-88

NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE MARKED (K-KILOHMS, M-MEGOHMS).
2. ALL CAPACITOR VALUES ARE (IN MICROFARADS UNLESS OTHERWISE MARKED (pF-PICOFARADS).
3. ▽ DENOTES DIGITAL COMMON.
4. ▽ DENOTES OUTPUT COMMON.
5. ▼ DENOTES GUARD.
6. ○ DENOTES FRONT PANEL CONTROL.
7. ● DENOTES REAR PANEL MOUNTING.
8. ⊘ DENOTES INTERNAL ADJUST.
9. ⏚ DENOTES CHASSIS CONNECTION.
10. T101 IS TR-187 CONNECT WHT/BRN WIRE TO X.

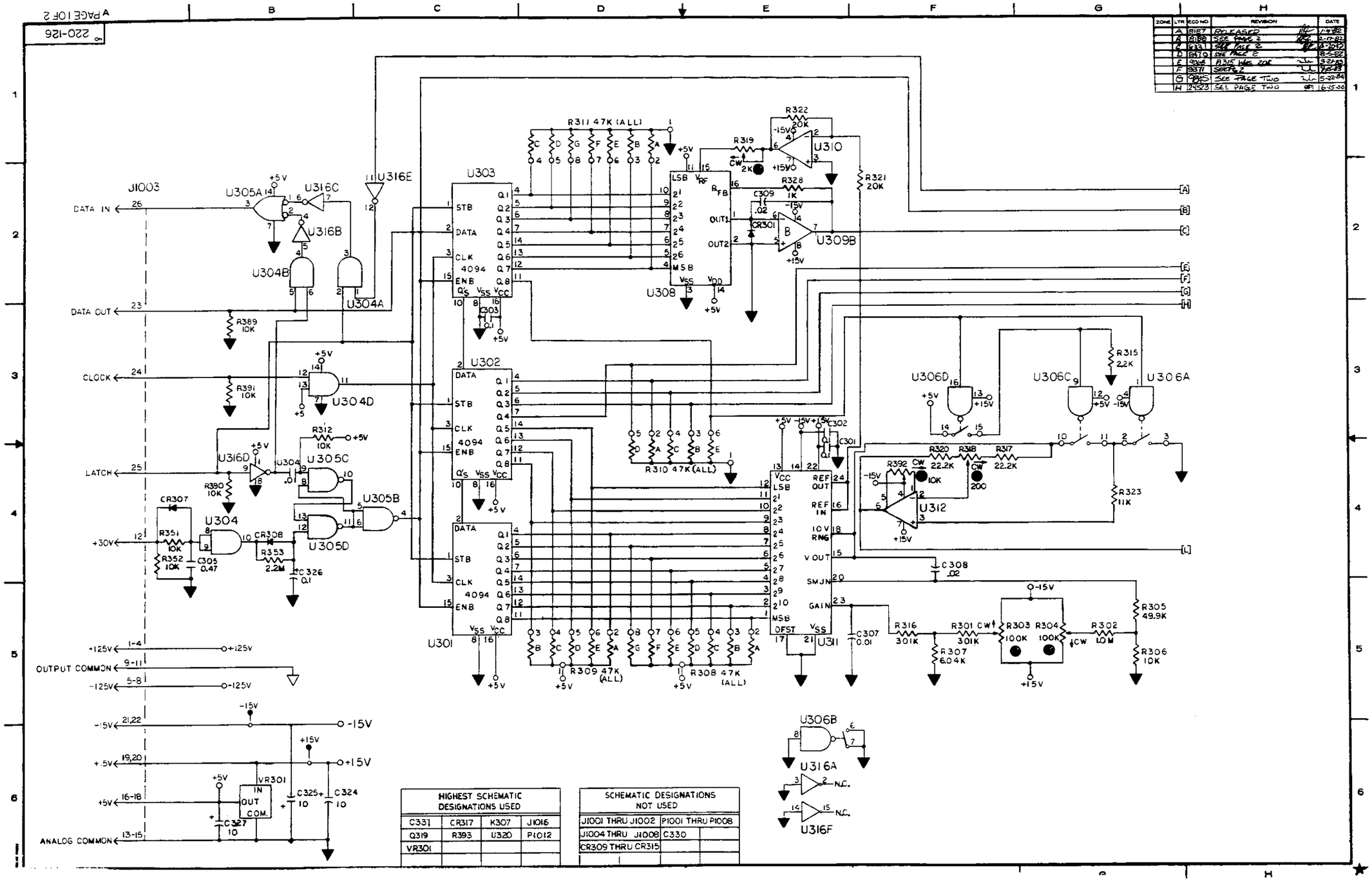
HIGHEST SCHEMATIC DESIGNATIONS USED			
C125	CR112	S102	R128
U117	J1009	T101	F101
P1006	AT104	Y101	W102
VR103			

SCHEMATIC DESIGNATIONS NOT USED			
J1003	P1001	P1002	R116
R117	P1004	P1007	P1008
R120	R123	R124	R125
R102	U112		

Figure 6-8. Power Supply Circuitry, Schematic Diagram, Dwg. No. 220-106 (sheet 2 of 2)

220-126

ZONE	LTR	ECO NO	REVISION	DATE
	A	9187	RELEASED	1-9-82
	B	9188	SEE PAGE 2	1-9-82
	C	9331	SEE PAGE 2	4-7-82
	D	9470	SEE PAGE 2	8-5-82
	E	9908	R315 WAS 20K	3-22-83
	F	9911	SEE PAGE 2	2-28-84
	G	9965	SEE PAGE TWO	5-22-84
	H	2423	SEE PAGE TWO	6-15-00



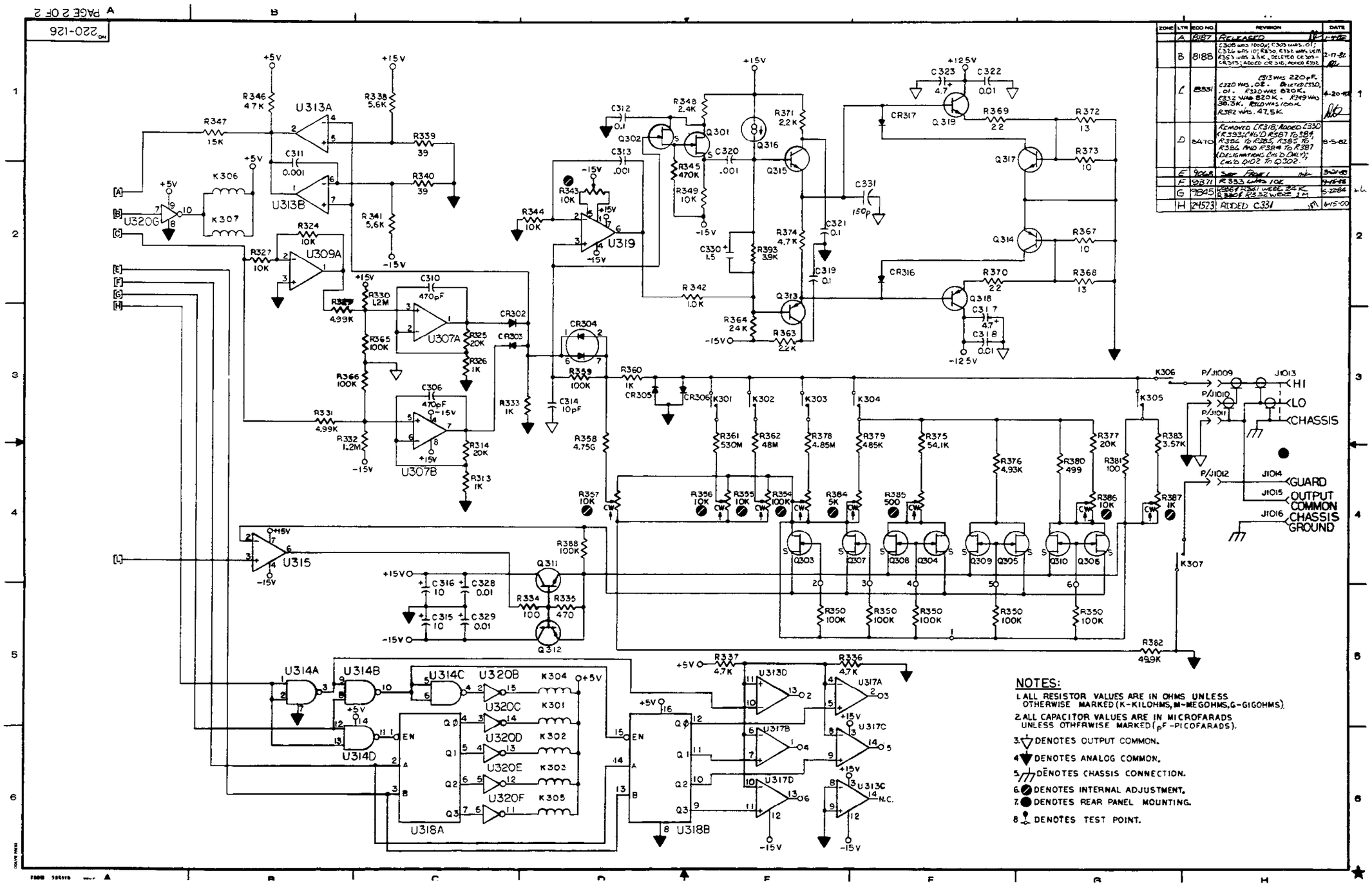
HIGHEST SCHEMATIC DESIGNATIONS USED			
C331	CR317	K307	J1016
Q319	R393	U320	P1012
VR301			

SCHEMATIC DESIGNATIONS NOT USED			
J1001 THRU J1002	P1001 THRU P1008		
J1004 THRU J1008	C330		
CR309 THRU CR315			

Figure 6-9. Analog Board, Schematic Diagram, Dwg. No. 220-126 (sheet 1 of 2)

220-126 ON

ZONE	LTR	ECO NO.	REVISION	DATE
	A	8187	RELEASED	1-8-82
	B	8188	C305 WAS 1000pF, C305 WAS .01; C326 WAS 10; R330, R331 WAS 1.5M; R365 WAS 2.5K, DELETED CR303-CR313; ADDED CR315, ADDED R392	2-17-82
	C	8331	C313 WAS 220pF, C320 WAS .02. DELETED C330, .01. R320 WAS 820K, R332 WAS 820K. R349 WAS 38.5K. RESISTORS 100K R382 WAS 47.5K	4-20-82
	D	8470	REMOVED CR318; ADDED C330 CR393; CHG'D R387 TO 38.1, R382 TO R385; R385 TO R382 AND R384 TO R387 (DESIGNATIONS CHG'D ONLY); CHG'D Q102 TO Q302.	6-5-82
	E	9065	See Sheet 1 note	3-29-83
	F	9371	R333 WAS 10K	7-15-83
	G	9845	R387 WAS 38.1K, R382 WAS 82.5K, R384 WAS 1.5M	5-22-84
	H	24523	ADDED C331	6-15-00



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE MARKED (K-KILOHMS, M-MEGOHMS, G-GIGOHMS).
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE MARKED ($_{pF}$-PICOFARADS).
3. ▽ DENOTES OUTPUT COMMON.
4. ▼ DENOTES ANALOG COMMON.
5. ⏚ DENOTES CHASSIS CONNECTION.
6. ⊘ DENOTES INTERNAL ADJUSTMENT.
7. ● DENOTES REAR PANEL MOUNTING.
8. DENOTES TEST POINT.

Figure 6-9. Analog Board, Schematic Diagram, Dwg. No. 220-126 (sheet 2 of 2)

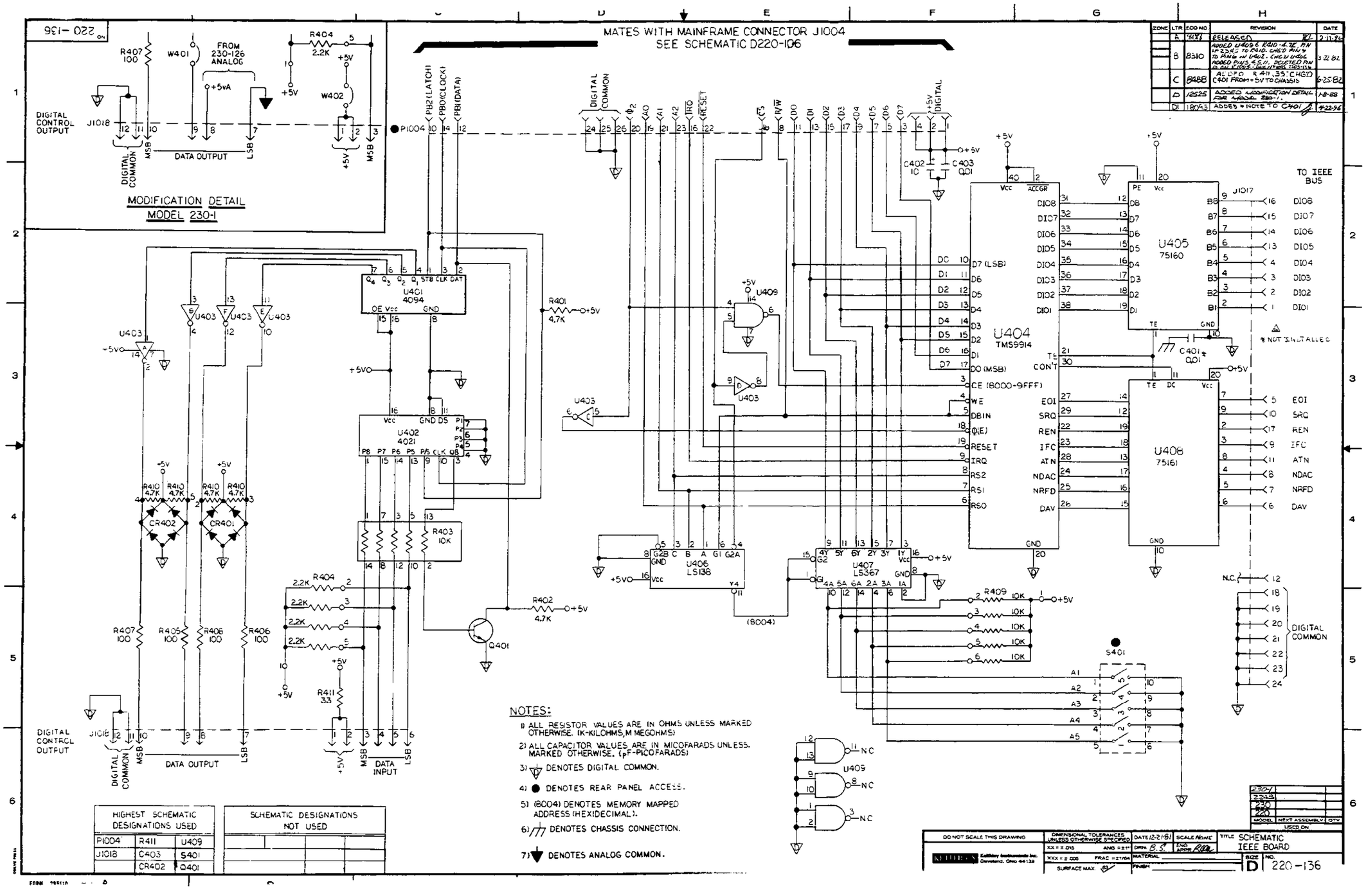


Figure 6-10. IEEE Interface Board, Schematic Diagram, Dwg. No. 220-136

KEITHLEY

Service Form

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

- ❑ Intermittent
- ❑ IEEE failure
- ❑ Front panel operational
- ❑ Analog output follows display
- ❑ Obvious problem on power-up
- ❑ All ranges or functions are bad
- ❑ Particular range or function bad; specify _____
- ❑ Batteries and fuses are OK
- ❑ Checked all cables

Display or output (check one)

- ❑ Drifts
- ❑ Unstable
- ❑ Overload
- ❑ Unable to zero
- ❑ Will not read applied input

- ❑ Calibration only
- ❑ Data required
- ❑ Certificate of calibration required

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

_____

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

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