Technische Dokumentation

Technical Documentation

SERIE 8201

PROGRAMMIERBARE 20 MHz PULSGENERATOREN

PG 8201/8241

deutsch/englische Version

KONTRON ELEKTRONIK

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SECTION 1

GENERAL INFORMATION

1.1 INTRODUCTION

This manual provides operation and maintenance information for the Model 8201 Series Function Generators. Section 1 is a general description of the Model 8201. Sections 2 and 3 contain installation and operation instructions. IEEE programming is explained in Section 4. Maintenance and performance checks are give in section 5. The theory of operation is described in section 6. Section 7 outlines troubleshooting aids and adjustment procedure. Section 8 has tables of replaceable parts. Section 9 contain schematic and component location diagrams.

1.2 DESCRIPTION

Model 8201 is a modern, multipurpose fully programmable pulse/function generator suitable for all electronic laboratories as well as design centers and automatic test systems. It provides sine, triangle, squarewaves and pulses with variable amplitude, symmetry and offset over a frequency range of 2 millihertz to 20MHz. It also provides a complete control over pulse parameters such as pulse width, pulse delay, duty cycle high level low level rise and fall times.

Model 8201 displays all parameters with an 8 digit - bright 7 segment LED display. The selected function is indicated by an LED. Model 8201 is fully programmable via the IEEE - 488 interface bus.

When used as a bench unit, an internal battery provides an indefinite backup to internal RAM which allow to store and recall up to 10 front panel setups thus, saving the time which is required to set up the instrument for different tests.

Output can be continuous, gated or triggered, by an external signal or by means of front panel manual switch. An internal timer is provided to repeatedly generate an internal trigger stimulus. An internal burst counter provide an integer number of bursts from a minimum of 2 pulses to 500,000.

Output amplitude ranges from 2.0 mV to 30 p-p into open circuit or 1.0mV to 15V p-p into 50 ohms. DC offset is available in a wide dynamic range. Operator may further adjust all output waeshapes using the symmetry control throughout the range of 10% to 90%.

Pulse width is continuously adjustable throughout the range of 25 nSec to 25 mSec. Double pulse delay as well as pulse delay, in reference to the Sync Out signal, is adjustable from 50 nSec to 25 mSec.

Enhanced flexibility in pulse generation is provided with the lead/trail edge control option. This option, when installed, allows an independent adjustment of the leading or the trailing edges. While changing rise and fall times, pulsewidth remain unchanged . Such a performance is not commonly available in similar instruments.

Another unique feature in the Model 8201 is the built in counter. Although given free, this counter utilizes the state-off-the-art reciprocal technique. This technique enables a complete measurement cycle. even when measuring low frequency, within a gate time of 250mSec. The result is then displayed with a fixed resolution of 6 digits plus exponent, regardless of the input frequency. (e.g an input signal of 10 Hz will be measured with a resolution of 0.1 mHz).
Also. with the built in counter, the output frequency is periodically monitored and internally corrected to an enhenced accuracy of 0.1% of the programmed value.

1.3 INSTRUMENT AND MANUAL IDENTIFICATION

The serial number of the instrument is located on the rear panel of the instrument. The two most significant digits identify instrument modifications. If this prefix differs from that listed on the title page of this manual, there are differences between this manual and your instrument.

Technical corrections to this manual (if any) are listed in the back of this manual on an enclosed MANUAL CHANGES sheet.

1.4 OPTIONS

There is only one option available with the Model 8201:

Option 40 - Lead/Trail edge control option

Option is field installable or may be ordered with the option installed. Installation procedures are given in Section 6 of this manual. There are no software modifications necessary when installing the option. Model 8201 will automatically sense the presence of the new option and will then allow to access parameters which are associated with the newly installed option. .

1.5 SPECIFICATIONS

Instrument specifications are listed in Tables 1-1. These specifications are the performance standards or limits against which the instrument is tested.

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** NOTE **
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All specifications in the following table apply with output terminated with 50 ohms feedthrough termination and with an amplitude of 15Vp-p.
Warm-up period is 30 min at an ambient temperature of 25 Deg C +/- 5 Deg C.

Table 1-1. Model 8201 Specifications

WAVEFORMS	: Sine, Triangle, Square, Pulse, Pulse complement, Fixed base line positive and negative square waves, fixed base line positive and negative pulses and their complements, Ramp, TTL Pulse
TIMING CHARACTERISTICS	
Frequency	
Range	: 2mHz to 20MHz
Resolution	: 3 1/2 digits (1999 counts) with exponent
Accuracy	: +/- 3% of reading from 2mHz to .999Hz +/- .1% from 1Hz to 20MHz
Jitter	: Less than 0.1%
WAVEFORM CHARACTERISTICS	
Sine	
Total harmonic distortion	: Less than 1% from 2mHz to 19.9Hz Less than 0.5% from 20Hz to 100KHz Less than 1% from 100KHz to 1MHz
Harmonic signals	: more than 25db below the carier level from 1MHz to 20MHz
Flatness	: less than 0.5db up to 1.9MHz less than 1.5db up to 20MHz
Triangle, Ramp	
Linearity	: Better than 99% up to 100KHz (measured between 10% to 90% of amplitude)
Square, Pulse	
Rise/Fall time	: Less than 12 ns (10% to 90% of amplitude)
Abberation	: Less than 5%
Symmetry	
Range	: Up to 4MHz 10% to 90% Above 4MHz not to exceed a positive or negative transition of less than 25nSec
Resolution	: 2 digits
Accuracy	: Up to 4MHz +/- 2% above 4MHz +/-5%

Table 1-1. Model 8201 Specification (continued)

OUTPUT CHARACTERISTICS

Mode	: Normal / Disabled (disable function thru IEEE bus)
Impedance	: 50 ohm +/- 2%
Output Level (*)	: From 2.0mV to 30V p-p into open circuit from 1.0mV to 15V p-p into 50 ohm
Resolution	: 2 1/2 digits (150 counts) with exponent
Accuracy (1KHz)	: +/- 2% of reading from 1.6V to 15.0V +/- 3% of reading from .16V to 1.5V +/- 4% of reading from 16mV to 150mV +/- 5% of reading from 1mV to 15.0mV
Vernier Control	: Continuous throughout the output level
Output Protection	: protected against continuous short to case ground, fuse protected to 230V rms.
Offset Range	: Offset and amplitude are independently selectable within the following window levels:
Offset Resolution	: 3 digits with exponent

Window	Amplitude Range	Offset Range	Offset accuracy
7.50 V	1.6 E 0 - 15.0 E 0	0 E 0 - +/- 6.70 E 0	1% +/-(1% of Ampl + 40mV)
2.37 V	.48 E 0 - 1.50 E 0	0 E 0 - +/- 2.13 E 0	2% +/-(1% of Ampl + 10mV)
750 mV	.16 E 0 - .47 E 0	0 E-3 - +/- 670 E-3	2% +/-(1% of Ampl + 4mV)
237 mV	48 E-3 - 150 E-3	0 E-3 - +/- 213 E-3	3% +/-(1% of Ampl + 1mV)
75.0 mV	16 E-3 - 47 E-3	0 E-3 - +/- 67 E-3	3% +/-(1% of Ampl + 1mV)
23.7 mV	1.0 E-3 - 15.0 E-3	0 E-3 - +/- 23.2 E-3	4% +/-(1% of Ampl + 1mV)

TRIGGERING CHARACTERISTICS

Modes	
Normal	: Continuous waveform is generated
Ext Trigger	: Each input cycle generates a single output cycle
Int Trigger	: An internal timer repeatedly generates a single output cycle. Trigger period is adjustable
Gated	: External signal enables generator. First output cycle synchronous with active slope of triggering signal. Last cycle always completed
Ext Burst	: As ext triggered mode for programmed number of cycles.
Int Burst	: As int triggered mode for programmed number of cycles.
Manual	: Triggered and gated via a push switch on the front panel
Triggerable Frequency	: Up to 20MHz
Trigger Sensitivity	: +/- 300mV around the selected level
Trigger Level	: Adjustable from -10 V to + 10 V
Slope	: Selectable positive or negative going edge
Int Triger Period	: Continuously adjustable from 10 uSec to 1000 Sec
Burst Count Range	: 2 to 500,000
Burst Rate	: 20 MHz maximum

(*) Output level span is divided by 2 for functions with a fixed base line

Table 1-1. Model 8201 Specification (continued)

PULSE CHARACTERISTICS

Mode	: Normal pulse, Delayed pulse, Double pulse, Complement to all
Pulse Period	
Range	: 50 nSec to 500 Sec
Resolution	: 3 digits (500 counts) with exponent
Accuracy	: 1% of reading
Pulse Width	
Range	: 25 nSec to 25 mSec
Resolution	: 3 digits (250 counts) with exponent
Accuracy	: +/- (5% + 5 nSec)
Max Duty Cycle	: More than 75% to 1Mhz. Decreasing to 50% at 20MHz
Pulse Delay	
Range	: 50 nSec to 25 mSec
Resolution	: 3 digits (250 counts) with exponent
Accuracy	: +/- (5% + 5 nSec)
Double Pulse	: Two pulses with a time interval between them which is determined by the pulse delay
Lead/Trail Time	(Available with option 40 only)
Range	: 10 nSec to 10 mSec (10% to 90% of amplitude). Rise and fall times are independently programmed within a common range with 5 overlapping ranges.
In-range span	: 100:1
Resolution	: 3 1/2 digits (1000 counts) with exponent
Accuracy	: +/- (5% + 5 nSec)

PULSE WIDTH MODULATION CHARACTERISTICS

Input	: Via rear panel BNC connector
Impedance	: 100 K ohm +/- 5%
Sensitivity	: 0 to .25V +/- 20% produces 10% pulse width change from pulse width setting.
Bandwidth	: DC to 70 KHz

Table 1-1. Model 8201 Specification (continued)

VCO CHARACTERISTICS	
Impedance	: 10 K ohm +/- 5%
Sensitivity	: 0V to +10 V +/-20% produces 1/1000 frequency change from main frequency setting, when main frequency is set to 199(9) counts and symmetry is set to 50%
Bandwidth	: DC to 70KHz
FM Sensitivity	: 0V to +/-100mV modulates to 1% deviation from center frequency
COUNTER CHARACTERISTICS	
Input	: Via EXT FREQ / TRIG IN BNC
Range	: 10 Hz to more than 20 MHz
Resolution	: 6 digits independent of frequency
Measurement Technique	: Reciprocal counting
Gate Time	: 250mSec
Sensitivity	: 600mV p-p
Dimension	: one digit exponent
Accuracy	: 0.001% at 25 Deg C
Temperature Stability	: 10 ppm from 10 Deg C to 40 Deg C
IEEE - 488 INTERFACE	
Programmable controls	: All front panel controls except trigger level and POWER switch. Output may be disabled through a bus command
Subsets Implemented	: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP2, DC1, DT1, C0
Data Output Format	: Fixed output format consisting of 15 or 17 ASCII characters plus terminators
Data Input Format	: ASCII characters lower or upper case. ASCII characters smaller than 20 HEX (32) are ignored except CR (0D HEX)
Service Request	: Selectable for illegal commands, illegal parameters, limit errors and pulse setup errors
String Termination	Selectable CR, LF, EOI or combination of all.
GENERAL	
Display	: 8 digits 7 segmet LED 14.2mm high with automatic decimal point, exponent and polarity indication
Power	: 115/230VAC +/- 10%, 48-62Hz, 60 W max
Stored Settings	: A battery back-up memory stores up to 10 front panel settings
Operating temperature	: 0 Deg C to 40 Deg C ambient
Specified Accuracy	: 25 Deg C +/- 5 Deg C
Storage temperature	: -40 Deg C to +70 Deg C
Humidity range	: 80% R.H
Dimensions	: 140 x 300 x 345 mm (H X W X L)
Weight	: approx 5 Kg

1.6 SAFETY CONSIDERATIONS

Model 8201 is a Safety Class 1 instrument with an exposed metal chassis that is directly connected to earth via the power supply cable and has been manufactured according to international safety standards.
Before the instrument is switched on, make sure that protective earth terminal is connected to a protective earth via the power cord.
Do not remove instrument covers when operating or when power cord is connected to mains.

Any adjustment, maintenance and repair of the opened instrument under voltage should be avoided as much as possible, but when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

1.7 ACCESSORIES SUPPLIED

The 8201 is supplied with ac power cord and with an instruction manual.

SECTION 2

INSTALLATION

2.1 INTRODUCTION

This section provide installation instruction for the instrument and its accessories. It also includes information about initial inspection and warranty claims, preparation for use, and packing instruction for storage or shipment.

2.2 UNPACKING AND RECEIVING INSPECTION

Inspect the shipping container for damage before unpacking the instrument. If the container is damaged it should be kept until the content of the shipment have been checked mechanically and electrically. Check immediately for loose or broken control knobs, bent or broken connectors or for any physical damage. Procedure for checking the electrical operation is given in Section 5. If there is a mechanical damage, or if the instrument does not pass the performance test, notify immediately the nearest office.

2.3 POWER LINE SELECTION

Model 8201 is designed to operate either from 115 vac or 230 vac power source. Procedure for selecting the correct line voltage is given in Section 5. Unless otherwise specified, Model 8201 was shipped from factory for operation on 230 vac line supply and with a .315A fuse. To prevent damage to the instrument, check for proper match of line and instrument voltage and proper fuse type and rating.

W A R N I N G

Damage caused by using incorrect primary input voltage --V O I D S-- the instrument warranty.

W A R N I N G

The instrument is provided with a three conductor power cord which will ground the case when connected to a three prong grounding power line outlet. If a grounding outlet is not available, an adapter must be used to provide a good connection to ground.

2.4 PERFORMANCE CHECK

This instrument was carefully inspected for mechanical and electrical performance before shipment from factory. This unit should be free of physical defects and should comply with all electrical specifications upon receipt. Check the instrument for possible damage incurred in transit and refer to the performance check outlined in Section 5.
If there is any indication of damage or improper operation refer to the warranty included in this manual.

2.5 ENVIRONMENTAL REQUIREMENTS

In order for the instrument to meet the specifications listed in Table 1-2, the operating temperature should range of 20 Deg C to 30 Deg C.

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** W A R N I N G **
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To prevent potential hazard, do not expose instrument to rain or moisture.

2.6 REPACKING FOR SHIPPING OR STORAGE

Model 8201 is rugged instrument built to perform in sever environments. If the unit is to be shipped or stored for a long periods of time the following procedure is recommended:

a) Place the instrument into an oversized plastic bag and seal the bag.
b) Place the bagged instrument into the original carton and packing material or into a heavy duty corrugated cardboard box. The box must contain at least two inches of rubberized hair or equivalent cushion on all six sides of the instrument. the instrument must fit snugly into the cushion and the cushion must fit into the box to prevent any movement of the instrument in transit.
c) Place the instruction manual into the box. if accessories are also to be packed put them in separate plastic bag and pack into the cushion leaving at least 2 inches of cushion between accessories and the box.
d) Seal the box fully with 2 or 3 inch wide packing tape.
e) Properly label and address outside of the box with tapped label or indelible pen. Mark the box FRAGILE, DELICATE INSTRUMENT, HANDLE WITH CARE.

If shipment is to the factory, please notify in advance and include detailed reasons for return inside the box along with your name, firm and full address. Also include your phone number and purchase order number.

SECTION 3

OPERATING INSTRUCTIONS

3.1 INTRODUCTION

Model 8201 operation is divided into two general categories: basic bench operation, and IEEE-488 operation. Basic bench operation, which is covered in his section, consists of using the Model 8201 to perform basic waveforms generation. IEEE programming can also be used to greatly enhance the capability of the instrument in applications such as automatic test equipment. These aspects are covered in detail in Sections 3 and 4.

3.2 FRONT PANEL FAMILIARIZATION

The front panel layout of the Model 8201 is shown in Figure 3-1. The front panel is generally divided into three sections: controls, terminals, display and indicators. The following paragraphs describe the purpose of each of these in detail.

3.2.1 Controls

All the front panel controls except POWER are momentary contact switches. Many controls include an annunciator light to indicate the selected mode. Controls which do not have an annunciator light, when pressed, will cause an immediate reaction on the display. The controls are grouped into functional groups for easier operation.
Front panel controls are divided into functional groups: Display modify, Operating Mode, Trigger, Output, Setups and, Numeric control.
Some of the controls have a second function and are marked with numerals from 0 to 9 and with a decimal point.

In general, front panel markings which are printed in yellow, are associated with the pulse output. Changing these parameters in the Display Modify group will have no effect on the traditional output waveforms e.g sinewave. On the other hand, lettering which are printed in white, will effect all output waveforms, including pulse output.

1. POWER

The POWER switch controls the AC power to the instrument. Depressing and releasing the switch once turns the power on. Depressing and releasing the switch the second time turns the power off.

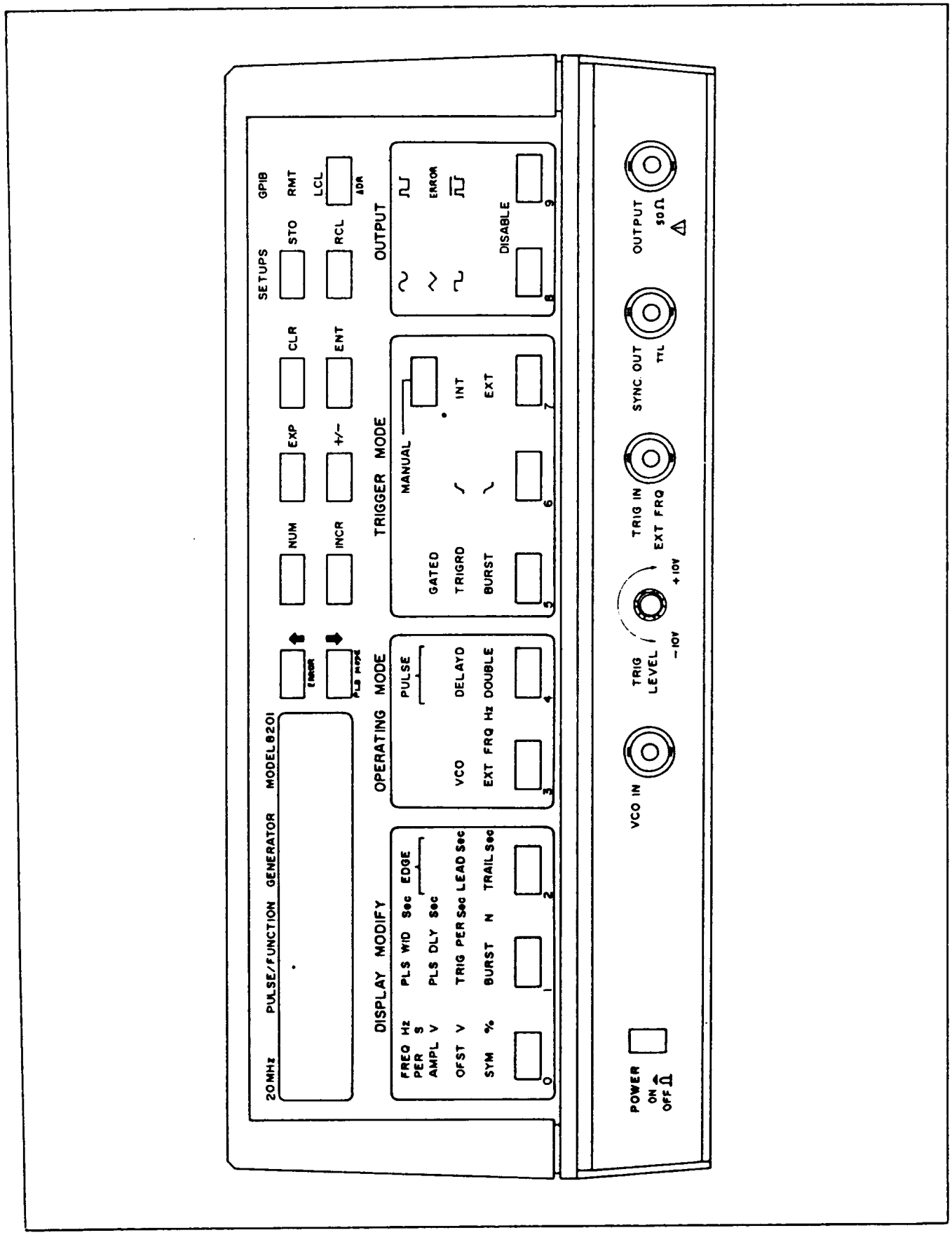

Figure 3-1. Model 8201 Front Panel Layout

2. DISPLAY MODIFY

The three DISPLAY MODIFY pushbuttons control the parameter to be displayed on the display. Each of the pushbutton marked with 0 and 1 are used to select one of four parameters. The pushbutton marked with 2 is used to select one of two parameters.

0 - The button which is marked with the number 0 selects one of four parameters to be displayed; FREQ/PER, AMPL, OFST and SYM. There is a light associated with each parameter. Depressing the pushbutton once will increment the light to the next parameter. Depressing and holding the pushbutton for more than one second will cause the light to scan between the above functions. When the light next to FREQ/PER turns on, depending on the output function, the instrument is set to display the output frequency or the output period. Dimension is in Hz or Sec. The instrument displays the frequency with 4 digits plus exponent and the period with 3 digits plus exponent.
Depressing the the push button once more will cause the light next to FREQ/PER to turn off and the light next to AMPL to turn on indicating that the instrument is set to display the OUTPUT amplitude. Dimension is in volts peak to peak and the instrument displays the amplitude with 3 digits plus exponent.
Depressing the pushbutton once more will cause the light next to AMPL to turn off add the light next to OFST to turn on indicating that the instrument is set to display the offset at the output terminal. Dimension is in volts and the instrument displays the offset with 3 digit plus exponent.
Depressing the pushbutton once more will cause the light next to the OFST to turn off and to the light next to SYM to turn on indicating that the instrument is set to display the duty cycle ratio of the selected wave shape. Dimension is in % and the instrument will display the duty cycle ratio with two digits.
Depressing the pushbutton once more will turn off the SYM light and will turn on the FREQ/PER light.

1 - The button which is marked with the number 1 selects between four parameters to be displayed; PLS WID, PLS DLY, TRIG PER and, BURST. There is a light associated with each parameter. Depressing the pushbutton once will increment the light to the next parameter. Depressing and holding the pushbutton for more than one second will cause the light to scan between the above functions. When the light next to PLS DLY turns on, the instrument is set to display the pulse width. Dimension is in Sec and the instrument displays the pulse width with 3 digits plus exponent.
Depressing the pushbutton once more will cause the light next to PLS WID to turn off and the light next to PLS DLY to turn on indicating that the instrument is set to display the delay time. Dimension is in seconds and the instrument displays the delay time with 3 digits plus exponent.

Depressing the pushbutton once more will cause the light next to PLS DLY to turn off and the light next to TRIG PER to turn on indicating that the instrument is set to display the period of the internal trigger generator. Dimension is in Sec and the instrument displays the trigger period with 3 digits plus exponent. Depressing the pushbutton once more will cause the light next to the TRIG PER to turn off and to the light next to BURST to turn on indicating that the instrument is set to display the number of burst cycles that the instrument will generate when triggered. The number is dimensionless and the instrument displays the burst count with as many as 6 digits.

2 - The button which is marked with the number 2 selects between two parameters to be displayed; LEAD and TRAIL. There is a light associated with each parameter. Depressing the pushbutton once will increment the light to the next parameter. When light next to LEAD turns on the instrument is set to display the leading edge rise time. Dimension is in Sec and the instrument displays the leading edge rise time with 3 digits plus exponent. Depressing the the pushbutton once more will cause the light next to LEAD to turn off and the light next to TRAIL to turn on indicating that the instrument is set to display the trailing edge fall time. Dimension is in Sec and the instrument will display the trailing edge fall time with 3 digits plus exponent.

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** NOTE **
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When Lead/Trail control option (option 40) is not installed in your instrument, and push button 2 is depressed, the instrument will display NO OPTION message and will sound an audible alarm.

3. OPERATING MODE

The two OPERATING MODE pushbuttons control the special operating modes of the instrument. Each pushbutton marked with 3 and 4 are used to select one of two operating modes. When none of the lights associated with the OPERATING MODE group are on, the instrument is set to normal operating mode.

3 - The button which is marked with the number 3 places the instrument in one of two operating modes; VCO or EXT FRQ. When the button is first depressed the light next to VCO turns on indicating that the instrument is set to operate as a voltage controlled oscillator.
Depressing the button the second time the light next to VCO turns off and the light next to EXT FRQ turns on indicating that the instrument is set to measure the external frequency which is applied to the EXT FRQ input terminal. Depressing the button once more will cause the light next to EXT FRQ to turn off indicating that the instrument is set to normal operating mode.

4 - The button which is marked with the number 4 places the instrument in one of two pulse operating modes; DELAYED or DOUBLE. When the button is first depressed the light next to DELAYD turns on indicating that the instrument is set to operate in delayed pulse mode.
Depressing the button the second time the light next to DELAYD turns off and the light next to DOUBLE turns on indicating that the instrument is set to double pulse operation. Depressing the button once more will cause the light next to DOUBLE to turn off indicating that the instrument is set to normal operating mode. Note that if output was not yet selected to be one of the pulses mode, and button number 4 was depressed, the instrument will sound an audible alarm and the depression will be ignored.

4. TRIGGER

The four TRIGGER pushbuttons control condition of which the instrument will trigger on. Pushbutton marked with the number 5 is used to select one of three trigger modes where each pushbutton marked with 6 and 7 are used to select one of two parameters.

5 - The button which is marked with number 5 places the instrument in one of three trigger modes; GATED, TRIGRD or BURST. When the button is first depressed the light next to GATED turns on, indicating that the instrument is set to receive a gating signal through the TRIG IN BNC terminal. Then OUTPUT waveform will continue for the entire period of the gating signal. When button is depressed the second time, the light next to GATED turns off and the light next to TRIGRD turns on indicating the instrument is set to receive a triggering signal through the TRIG IN BNC terminal. When button is depressed once more, the light next to TRIGRD turns off and the light next to BURST turns on indicating that the instrument is set to output a burst of pulses when a triggering signal is received. Depressing the button once more will cause the light next to BURST to turn off indicating that the instrument is in normal operating mode (continuously free-running).

6 - The button which is marked with the number 6 places the instrument in one of two slopes; Positive going or Negative going. When the instrument is in one of triggered gated or burst mode and the light next to the positive going slope is turned on the instrument will trigger on the positive going edge of the trigger input signal. Depressing the button once will cause the light next to the positive going slope to turn off and the light next to the negative going slope will turn on indicating that the instrument will trigger on the negative going edge of the trigger input signal. Depressing the button more then once will toggle between negative and positive going slopes.

7 - The button which is marked with the number 7 selects between two trigger stimulus options; internal - periodical trigger or external trigger. When the instrument is in trigger, gated or burst mode and the light next to INT is turned on the instrument will trigger continuously with a period determined by the internal trigger generator. Depressing the button once more will cause the light next to INT to turn off and the light next to EXT to turn on indicating the instrument will trigger when a triggering signal is applied to the EXT TRIG BNC connector. Trigger level is continuously adjustable with a front panel control throughout the range of -10V to +10V.

MANUAL - The button which is marked MANUAL triggers the instrument when a triggering signal is not available. When the instrument is in triggered mode and the button is depressed once, the instrument will output one complete cycle of the selected waveforms. When the instrument is in gated mode and the button is depressed, the instrument will output continuous wavesforms as long as the button is depressed. When the instrument is in burst mode and the button is depressed, the instrument will output a burst of waves. Other than the above reactions the MANUAL button, when depressed, does not cause any visual response on the front panel.

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** NOTE **
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The Model 8201 will respond to a front panel MANUAL trigger only when front panel trigger setting is as follows: Trigger Mode: TRIGRD, GATED or BURST. Trigger Slope: Negative going edge. Trigger Level: +1V to +10V, otherwise the MANUAL button, when depressed, will be ignored.

5. OUTPUT

The two OUTPUT pushbuttons control the waveshape that will be present at the OUTPUT BNC terminal. Pushbutton marked with number 8 selects between 3 waveshapes where pushbutton marked with 9 is used to select one of two waveshapes. It is also possible , using buttons which are marked with numbers 8 and 9, to select between 6 additional fixed-base-pulse functions. Instructions as to how to enter these functions are given in paragraph 3.6.11.

8 - The button which is marked with the number 8 select one of three waveforms which are then routed to the OUTPUT terminal; Sinewave, Triangle or Squarewave. When the light next to the sinewave in turned on the instrument will output a sinewave. Depressing the button once will turn the light next to the sinewave off and will turn the light next to the triangle on, indicating that the instrument will output a signal with the shape of triangle. Depressing the button once more will turn the light next to the triangle off and will turn the light next to the squarewave on, indicating that the instrument will output a squarewave, positive squarewave or negative squarewave (see paragraph 3.6.11). Depressing the button once more will again select the sinewave function.

9 - The button which is marked with the number 9 selects one of six pulse modes which are then routed to the OUTPUT terminal; Normal - symmetrical pulse or it's complement, Positive pulse or it's complement and negative pulse or it's complement (see paragraph 3.6.11). When the light next to the normal pulse is turned on the instrument will output a pulse with parameters which are associated with the pulse mode. Depressing the button once more will turn the light next to the normal pulse off and will turn the light next to the pulse complement on, indicating that the instrument will output a complement to the normal pulse with the same parameters as assigned to the normal pulse. Depressing the button once more will again select the normal pulse function.

6. LCL

When the LCL pushbutton is depressed and the instrument is in REMOTE operation (but not in local lockout condition), the instrument will change state to local operation, that means that you can manually operate the instrument from the front panel controls. When the instrument is in local operation and the LCL button is depressed the display will change to display the address of the interface bus. Depressing the button once more will change the display to the previously selected parameter.

7. SETUPS

The two SETUPS buttons are used to store and recall 10 complete front panel setups.

STO - The STO pushbutton when pressed prepares the instrument to store a complete front panel setup in one of 10 storage locations marked from 0 to 9. When the STO button is depressed once more the store function is cancelled and the instrument resumes normal operation.

RCL - The RCL pushbutton when depressed prepares the instrument to recall a complete front panel setup which was previously stored in one of 10 storage locations marked 0 to 9. When the RCL button is depressed once more the recall function is cancelled and the instrument resumes normal operation. The RCL button in conjunction with the vernier buttons are also utilized to access special modes such as pulse error verification and output waveform modification. These aspects are later on covered in paragraphs 3.5.4.3 and paragraph 3.6.11.

8. VERNIER

There are two vernier pushbuttons which are marked with an arrow pointing up and an arrow pointing down. Each time the up button is depressed the instrument will increment once. Each time the down button is depressed the instrument will decrement once. When up or down buttons are held for more than one second, the instrument will increment or decrement continuously. The vernier control is not active in the EXT FREQ function.

9. INCR

The INCR pushbutton selects the increment step for the vernier control. when depressed the display will be modified to show the increment step, the far right LED will flash with the last selected increment step and also indicates that the instrument is ready to receive a new step size. Depressing the button again will cancel this function and the instrument will resume normal operation. The increment function is disabled in the EXT FREQ function.

10. NUM

The NUM pushbutton when depressed places the instrument in a numeric mode. The far right digit in the displayed reading will start flashing. This indicates that the instrument is ready to receive a new numeric input from the numeric keyboard buttons which are marked 0 to 9 plus decimal point Depressing the button again will cancel the numeric function and will restore the previousl selected value and also will resume normal operation. To enter the newly selected numeric depres the ENT push buton. The numeric key is disabled in the EXT FREQ function.

11. EXP

The EXP pushbutton is used to select an exponent. When the EXP button is depressed the exponent numeric will start flashing, indicating that the instrument is ready to receive a new numeric value for the exponent from the numeric keyboard buttons which are marked from 0 to 9. Depressing the +/- push button will change the sign of the exponent. Depressing the button again will cancel the exponent function and will restore the previously selected value and also will resume normal operation. To enter the newly selected exponent depress the ENT push button.

12. +/-

The +/- pushbutton when depressed and the instrument is in NUMeric, EXPonent or OFFSET modes will change the sign of the selected function. Depressing the button more then once will toggle between positive and negative values. The +/- button is disabled in the EXT FREQ function.

13. CLR

The CLR pushbutton when depressed with the instrument in OFST, DC, NUMeric or EXPonent functions will clear the display to 0. When the CLR pushbutton is depressed and the instrument is in a function other then the above, the instrument will preset to a factory preset value. The preset value may differ from function to function. The CLEAR function is disabled in the EXT FREQ function.

14. ENT

The ENT pushbutton when depressed will enter the selected numeral to the appropriate location. The ENT button may be depressed after NUM, INCR, EXP or adr functions are selected. The enter function is disabled in the EXT FREQ function.

3.2.2 Terminals and non-programmable controls

The terminals are used to connect the Model 8201 to the device under test or to connect the Model 8201 to a triggering or reference signal. Their is only one non-programmable control on the front panel which is being used to adjust the trigger level threshold point.

1. OUTPUT. The OUTPUT terminal is used to output the waveforms which are generated by the instrument. Output may be disabled with a GPIB command.

2. SYNC OUT. The SYNC OUT terminal is used to output a TTL signal which is synchronous with the wavwshape at the OUTPUT terminal.

3. TRIG IN / EXT FRQ . The TRIG IN / EXT FRQ terminal has two functions; when the instrument is in triggered or gated, the triggering signal or the external frequency reference signal are applied to this terminal. When the instrument is set to EXT FRQ Operating Mode this terminal accepts the unknown signal.

4. TRIGGER LEVEL. The trigger level control is adjustable with a front panel knob. This control sets the trigger level within a range of -10V to +10V. A signal which is applied to the EXT TRIG BNC connector will trigger the function generator providing the input level has reached the trigger level setting.

5. VCO IN. The VCO terminal accepts either a DC level to control the frequency of the main generator or a variable signal to generate frequency mdulation at the OUTPUT terminal.

3.2.3 Display and Indicators

The function of the display and indicators is described below.

1. Display. The display consists of a 6 digit mantissa and a single digit exponent. The exponent uses a leading minus to indicate negative values. There is no sign for zero or positive values. The dimension in use may be determined by the exponent and the dimension which is associated with each of the display modify parameters.

2. IEEE Status Indicator. The RMT indicator is used when programming the instrument over the IEEE-488 bus. Refer to Section 4 for complete IEEE programming information. The remote indicator is not operational during front panel instrument operation.

3.3 REAR PANEL FAMILIARIZATION

Figure 3-2 shows the rear panel layout of the instrument.

3.3.1 Connectors and Terminals

1. AC MAINS RECEPTACLE

AC Mains Power is applied through the supplied power cable to the 3 - terminal AC receptacle. Note that selected power supply voltage of 115 or 230V is marked on the line voltage selector switch.

2. IEEE-488 GPIB CONNECTOR

This connector is used to connect the instrument to the IEEE-488 bus. Note that there is no address select switch on the rear panel. Address is selected through front panel programming and is stored in the non-volatile memory until changed.

3. PULSEWIDTH MODULATION INPUT CONNECTOR

This BNC connector is used to connect an external signal to pulsewidth modulate the pulse output. Input accepts voltage levels up to about 1V.

3.3.2 LINE Switch

The LINE VOLTAGE SELECTOR switch selects one of the primary voltage which are marked on both sides of the switch. For information on selecting primary voltage, refer to Section 5.

3.3.3 LINE Fuse

The LINE fuse provide protection for the AC power line input. For information on replacing this fuse, refer to Section 5.

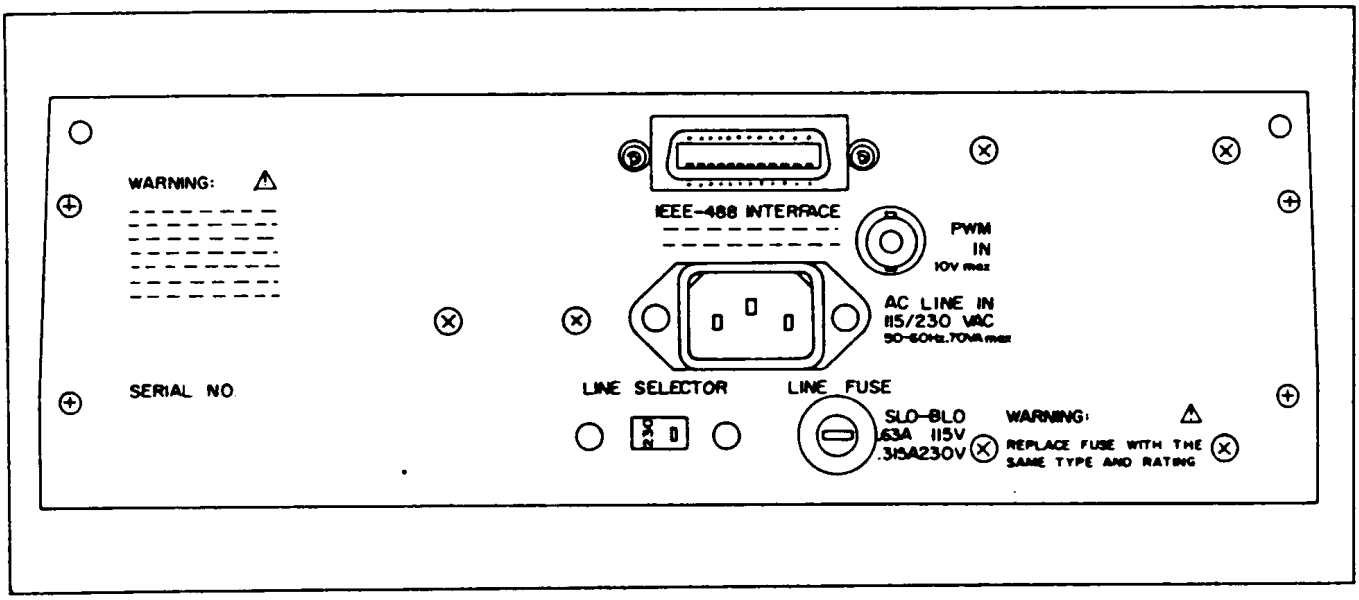

Figure 3-2. Model 8201 Rear Panel Layout

3.4 POWER-UP PROCEDURE

The basic procedure of powering up the function generator is described below.

1. Connect the female end of the power cord to the AC receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

****
** CAUTION **
****

Be sure the power line voltage agrees with the indicated value on the line voltage selector of the instrument. Failure to heed this warning will result in instrument damage and may void the warranty. If necessary, the power line voltage may be changed by sliding the recessed Line Voltage Selector switch to the required voltage position.

****
** WARNING **
****

The instrument is equipped with a 3-wire power cable designed to be used with grounded outlets. When the proper connections are made, the instrument chassis is connected to the power line ground. Failure to use a properly grounded outlet may esult in personal shock hazard.

2. Turn on the instrument by depressing and releasing the POWER switch on the front panel.

3. The instrument will then begin operation by performing a display and indicator test which takes approximately one second. All mode and IEEE indicators will turn on and the display will appear as follows:

```
----------------------
  8.8.8.8.8.8.8.8.
----------------------
```

To verify that all display segments are operating, compare the instrument's display with the above figure during the test.

4. Following the display test, the instrument proceeds by displaying the options installed. When no option is installed, the instrument will display the following message:

```
--------------------
      8201
--------------------
```

When leading/trailing edge control option is installed (option 40) the instrument will display the following:

```
--------------------
       8241
--------------------
```

5. Once the model number and the installed options are displayed, the instrument will perform ROM and RAM tests. If all these tests are passed, the display will show the software revision level for about 1 second similar to the example below:

```
--------------------
     SoFt 1.0
--------------------
```

6. following the software revision level, the instrument will display the previously selected IEEE primary address which is set through front panel programming. For example, with address set to 17, the display will show:

```
--------------------
     GPIb 17
--------------------
```

7. Following these display messages, the instrument will go into the normal operating mode and begin displaying paramters and outputing waveforms. The instrument will be set to the previously programmed front panel setup.

8. The battery voltage which is provided internaly to the non-volatile back-up RAM storage is constantly monitored by the software routines. Losing the battery back-up power will cause a loss of the preselected setups. When back-up power is lost for any reason, the instrument will display the following message:

```
--------------------
      no bAt
--------------------
```

This message will be displayed for about 2 seconds and an audible alarm signal will sound, simultaneously, indicating that the back-up power test has failed and that the previously stored setups are lost.

3.5 DISPLAY MESSAGES

The Model 8201 has several display messages associated with basic front panel operation. These messages indicate that options are no installed or that an error which is associated with front panel programming has occured.

3.5.1 IEEE-488 Messages

The instrument incorporates a number of display messages which are associated with errors through IEEE-488 bus programming. These messages are discussed in details in Section 4 of this manual. However, there is one message that should be explained at this point because it may interfere with front panel operation. A remote enable or a device dependent command sent to the function generator through the bus will turn on the RMT light. In this case, all front panel pushbutton except LCL are disabled. an attempt to depress one of these buttons will cause the following message to be displayed:

```
------------------
   PrES LcL
------------------
```

This indicates that the instrument will not obey any front panel programming before the LCL button is depressed once and the RMT light turns off.

3.5.2 No Option Message

Option 40 - The option 40 must be installed in the instrument before the operator will have the capability to vary the rise and fall times. If the pushbutton which is marked with the number 3 is depressed, without the option 40 installed, the following message will be displayed and an audible alarm will sound as long as button is depressed:

```
----------------------
       no oPt
----------------------
```

```
**********
** NOTE **
**********
```

There is no additional modifications in software after options 40 is installed. In the Model 8201 when option is first installed, the internal circuitry will automatically sense its presence and will eliminate the no option message.

3.5.3 No Storage Message

It is possible that the Model 8201 will loose the entire setups storage due to one of the following events:

1. Back-up battery power was completely drained
2. RAM was replaced
3. A component in the back-up circuitry was replaced
4. A component associated with the data bus was replaced

When one of the previously described failure occurs, and the user attempts to recall a setup, the function generator will display the following for about 1 second and then resume normal operation:

```
-----------------
   no StorE
-----------------
```

3.5.4 Error Messages

In general, whenever a front panel or GPIB programming attempts to put the 8201 into an error condition, the 8201 responds both by front panel message and by making a Service request. Keyboard programming errors are indicated on the front panel by an error message and by an audible alarm. For errors made via the GPIB, a service request is made, providing the appropriate service request mask was selected. Under these circumstances, the controller will address the 8201 using the serial poll command.

Errors are categorized in three main groups:

1. General errors
2. Limit errors
3. Pulse setup errors

3.5.4.1 General Errors

Errors in this group are caused by improper usage of the instrument. For example, when the function generator is incorrectly calibrated the instrument may display an error message.

FREQUENCY ERROR - The frequency error message will display when option 40 is first installed and/or is not calibrated. The function generator will then attempt to correct the internal frequency but will not have the required dynamic range. In that case the following message will be displayed, indicating that the instrument is unable to correct the frequency:

```
------------------
   FrEq Err
------------------
```

It is advised that when the above message is displayed that the instrument be properly calibrated or returned to a qualified repair center.

3.5.4.2 Limit Errors

Errors in this group are caused by programming values outside the legal limits of the parameter being programmed. For example, programming a frequency value of 20E9 will cause a parameter error. At this time the instrument will disregard the new value and retain the previously programmed value. Table 3-1 summarizes all front panel parameter entry limits.

ILLEGAL PARAMETER - The illegal parameter message will display when attempting to program a parameter which exceeds the instrument limits. When such an error occurs, the instrument will sound an audible alarm and will momentary display the following message:

```
----------------
    ILL PAr
----------------
```

It is also possible to exceed the instrument's limit when parameters are being modified through the vernier control. in this case the instrument will cease modification of the display and will sound an audible alarm.

Tabel 3-1. Front Panel Parmeter Entry Limits

PARAMETER	LOW LIMIT	HIGH LIMIT	REMARKS
FREQ	2E-3	20E6	
PER	50E-9	500E0	refer to par 3.6.11
AMPL	1.0E-3	15.0E0	
OFST	0	7.5E0	
SYM	10	90	
PLS WID	25E-9	25.0E-3	
PLS DLY	50E-9	25.0E-3	
TRIG PER	0.01E-3	1000E0	
BURST	2	500,000	
LEAD	10E-9	10.00E-3	refer to par 3.6.12
TRAIL	10E-9	10.00E-3	refer to par 3.6.12
INCR	1	10 (100)	refer to par 3.6.8
STO	0	9	
RCL	0	9	
ADR	0	30	

SYMMETRY ERRORS - A symmetry error message will occur when attempting to program a symmetry value which exceeds the instrument limits. This limit is reached when the symmetry modifies the output waveform to have a negative or positive pulsewidth of 25nSec.
In this case the instrument will display the following message:

```
---------------
    SYm Err
---------------
```

OFFSET ERROR - An offset error message will occur when attempting to program an offset which exceeds the instrument limits. Offset and amplitude are independently selectable within the level windows which are given in Table 3-2.

Table 3-2. Amplitude - Offset dynamic range summary.

Level Window	Amplitude Range	Offset Range
+/- 7.50 V	1.6 E0 - 15.0 E0	0 E0 - +/- 6.70 E0
+/- 2.37 V	.48 E0 - 1.50 E0	0 E0 - +/- 2.13 E0
+/- 750 mV	.16 E0 - .47 E0	0 E-3 - +/- 670 E-3
+/- 237 mV	48 E-3 - 150 E-3	0 E-3 - +/- 213 E-3
+/- 75.0 mV	16 E-3 - 47 E-3	0 E-3 - +/- 67 E-3
+/- 23.7 mV	1.0 E-3 - 15.0 E-3	0 E-3 - +/- 23.2 E-3

When attempting to program an amplitude or an offset parameters outside the limits in Table 3-2 an error meassage will appear on the display as follows:

```
----------------
    oFSS Err
----------------
```

3.5.4.3 Pulse Setup Errors

The pulse setup errors are interparameter inconsistencies errors, such as leading edge rise time greater than the pulse width. The function generator tests the programmed parameter every time the ENT or vernier keys are depressed. The instrument will also respond with a service request if wrong pulse parameters are programmed through the GPIB. Programming the Model 8201 with a pulse error is possible and executable however, when pulse error is detected, the error light in the OUTPUT block illuminate and an audible alarm sounds. This indicates that the signal at the output connector may appear distorted. For evaluation purpose, it is then possible to recall the error status to the front panel display. Table 3-3 lists the errors and indicates the parameters affected by each error.

To evaluate the pulse setup errors proceed as follows:

1. Depress the RCL push button and observe that the display is modified to show the following message:

```
----------------
    rEcALL ?      (? appears flashing)
----------------
```

2. Depress the ERROR push button and observe that the display is now modified as follows (note that the vernier UP has a second function - error):

To resume normal operation of the instrument simply depress any front panel push button.

```
----------------
   DDDDDDDD
----------------
```

"D" could be either 0 or 1. "0" designates no error. "1" designates an error. Since more than 1 error may occur at a time, the location of "D" within the display was arranged in a sequence which makes it easy to identify the programmed error. The following summarizes all possible pulse setup errors and their associated display message.

```
**********
** NOTE **
**********
```

The following abbreviations were used throughout the following error descriptions:

PW - Programmed pulse width in Sec
DL - Programmed pulse delay in Sec
LE - Programmed leading edge rise time in Sec
TE - Programmed trailing edge fall time in Sec
T - Period of the output signal in Sec
t - Period of the internal trigger generator in Sec
N - Number of programmed burst count
Kpw - Range dependent PW recovery time. (appl. notes available)
Kdl - Range dependent DL recovery time. (")

Error 0.

PW + 0.625(LE - TE) < 25nSec or when
PW + 0.625(LE - TE) > 25mSec

The displayed message will appear as follows:

```
----------------
   11111111
----------------
```

```
**********
** NOTE **
**********
```

When error 0 occurs, the internal conditions that are generated within the instrument are contradictory to the normal operation of the internal circuitry. Upon such conditions, the instrument will not look further for other error conditions.

Error 1.

$1.05[PW + 0.625(LE - TE)] + Kpw > T$

The displayed message will appear as follows: 00000001

Error 2.

Error 3 may occur as a result of one of the following conditions:

1. $1.05(DL + PW) + 0.625(LE - TE) + Kpw > T$
2. $1.05DL + Kdl > T$

The displayed message will appear as follows: 00000010

Error 3.

$1.05PW + 0.625(LE - TE) + Kpw > 0.95DL$

The displayed message will appear as follows: 00000100

Note that error 4 may occur only in Double Pulse operating mode.

Error 4.

$DL - PW < 0.7(LE + TE)$

The displayed message will appear as follows: 00001000

Figure 3-3 illustrates the resultant waveshape, at the output connector, which occur with error 4.

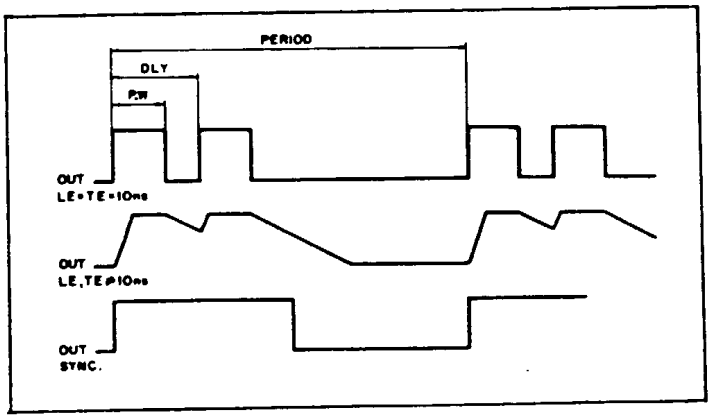

Figure 3-3. Model 8201 Output With Error 4.

Error 5.

$1.05(DL + PW) + 0.65(LE + TE) > T$

The displayed message will appear as follows:

```
00010000
```

Figure 3-4 illustrates the resultant waveshape, at the output connector, which occur with error 5.

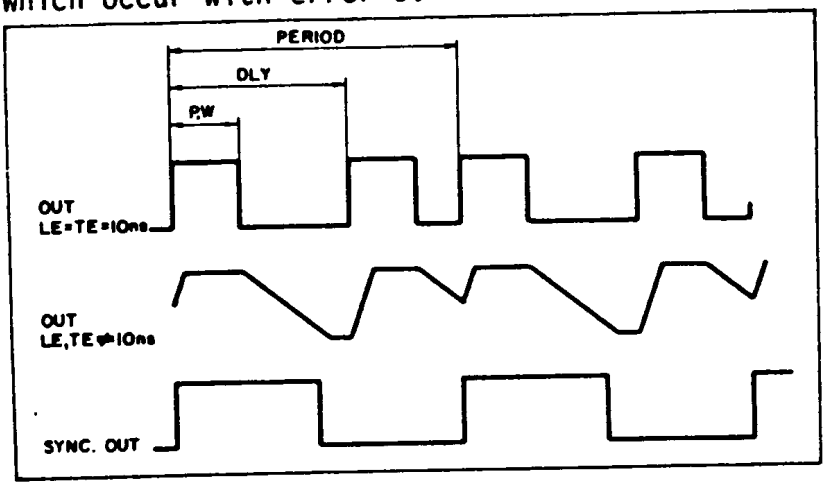

Figure 3-4. Model 8201 output with error 5.

Error 6.

$0.7(LE + TE) > PW$

The displayed message will appear as follows:

```
00100000
```

Figure 3-5 illustrates the resultant waveshape, at the output connector, which occur with error 6.

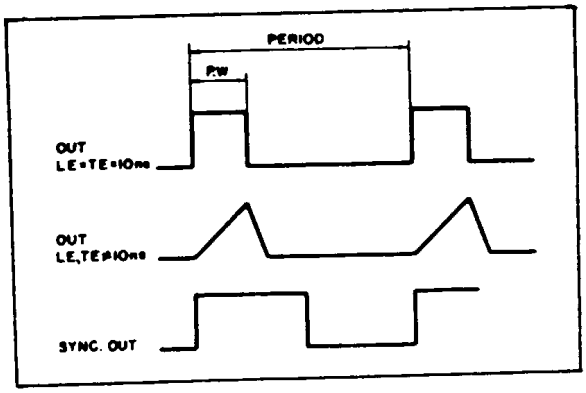

Figure 3-5. Model 8201 output with error 6.

Error 7.

t <T

The displayed message will appear as follows: 01000000

Error 8.

t <T x N

The displayed message will appear as follows: 10000000

Table 3-3. Interparameter Error Summary.

	DISPLAY MODIFY							OPERATING MODE			
ERROR	PER	PLS WID	PLS DLY	LEAD	TRAIL	N BURST	TRIG PER	DELAYD	DOUBLE	NORMAL	TRIGGRD
0		-		-	+						
1	-	+		+	-						*
2	-	+	+	+	-					*	*
3		+	-					*		*	
4		+	-	+	+			*		*	
5	-	+	+	+	+						*
6		-		+	+						
7	+						-				
8	+					+	-				

Notes: (+) - Programmed parameter may be too large
(-) - Programmed parameter may be too small
(*) - Error will not occur in this operating mode

****
** NOTE **
****

When the Model 8201 is set to operate in Triggered mode of operation, errors 1, 2 and 5 are computed with "t" rather than "T".

3.6 CONTROL SELECTION

Selecting the various front panel operating modes is simply a matter of once or twice depressing the appropriate button as described in the following paragraphs.

3.6.1 Display Modify

The function generator may be set to display the proper parameter with one of the three Display Modify buttons.

1. To display the frequency or the period of the output waveform, depress the button which is marked with the number 0 until the light next to FREQ/PER turns on.
2. To display the amplitude of the output waveform, depress the button as above until the light next to AMPL turns on.
3. To display the offset of the output waveform , depress the button as above until the light next to OFST turns on.
4. To display the symmetry of the output waveform, depress the button as above until the light next to SYM turns on.
5. To display the pulsewidth, depress the button which is marked with the number 1 until the light next to PLS WID turns on.
6. To display the pulse delay, depress the button as above until the light next to SWP TIME turns on.
7. To display the period of the internal trigger generator, depress the button as above until the light next to TRIG PER turns on.
8. To display the burst count, depress the button as above until the light next to BURST turns on.
9. To display the leading edge rise time, depress the button which is marked with the number 2 until the light next to LEAD turns on.
10. To display the trailing edge fall time, depress the button which is marked with the number 2 until the light next to LEAD turns on.

3.6.2 Selecting an Operating Mode

The function generator may operate in one of the special pulse operating modes:

1. Delayed pulse
2. Double pulse

The function generator may also operate in one of the special operating modes:

1. VCO
2. External frequency measurement

The function generator may be set to operate in one of the operating modes with one of the two Operating Mode buttons.

To place the instrument in VCO operating mode, depress the button which is marked with the number 3 and observe that the light next to VCO turns on. This indicates that the instrument is placed in VCO operating mode. Depressing the button once more will place the instrument in a counter mode of operation.

****
** NOTE **
****

When the instrument is placed in the EXT FRQ mode, all other functions of the instrument are disabled and the instrument is turned into a high resolution counter. Resolution is 6 digits regardless of the frequency to be measured. External frequency input is through the BNC connector marked EXT FREQ.

3.6.3 Selecting a trigger mode

The function generator may be operated in normal continuous mode or in one of the following triggered modes:

1. Gated mode
2. Triggered mode - external stimulus
3. Triggered mode - internal stimulus
4. Burst mode - external stimulus
5. Burst mode - internal stimulus

1. To place the instrument in triggered mode, depress the button which is marked with the number 5 until the light next to the desired trigger mode turns on. When the number 5 button is first depressed and no light is turned on, the instrument will be set to gated mode. That is, the signal at the OUTPUT terminal will be present as long as a gating signal is applied to the TRIG IN terminal. Depressing the button once more will place the instrument in triggered mode. When an external stimulus was selected, the instrument will output one complete OUTPUT waveform cycle every time that a trigger signal is present at the TRIG IN terminal. When an internal stimulus was selected, the instrument will periodically output one complete cycle. The period of the trigger stimulus is determined by the internal trigger period counter. Depressing the button once more will place the instrument in burst mode. Every time that the instrument is triggered the main generator will output a burst of waveforms at the OUTPUT terminal. To operate the instrument with the internally stimulated burst select the INT TRIG mode. The instrument will then output a periodical burst. The period of the trigger stimulus is determined by the internal trigger counter. The number of pulses is preselected using the burst count in the Display Modify group. Depressing the button once more will turn all light off This indicates that the instrument is placed in the normal continuous operating mode.

3.6.4 Selecting Trigger Level

Trigger level is manually adjustable with a front panel control within a range of -10V to +10V. To select the correct trigger level, first place the instrument in triggered mode. Apply the external triggering signal to the EXT TRIG BNC connector on the front panel. Connect the OUTPUT BNC connector from the function generator to an oscilloscope. Rotate the trigger level control until a signal appears on the oscilloscope. The instrument is now ready to operate in triggered mode. Changing the triggering signal may require readjustment of the trigger level control. To set trigger level to operate at approximately OV, adjust the trigger level control so that the line on the botton will appear centered.

****
** NOTE **
****

Observe that due to internal DC levels which are close to the threshold level, the instrument may be self-gated in some trigger level settings even with no gating signal present at the TRIG IN terminal. This may also occur when the instrument is set to operate with an internal trigger generator.

3.6.5 Selecting Trigger Slope

There are two trigger slopes on which the instrument will trigger ; positive going edge and, negative going edge. When the instrument is placed in one of the trigger operating modes, the light which is associated with the trigger level turns on automatically. Depressing the button which is marked with the number 6 toggles between the two available trigger slope options.

3.6.6 Selecting an Output Waveform

The pulse/function generator outputs standard five different waveshapes through the OUTPUT terminal. Selecting one of the output waveshapes is done with the push buttons in the OUTPUT block of the front panel.

1. To select sine wave output, depress the button marked 8 until the light next to the sine wave is turned on.
2. To select triangle wave, depress the button as above until the light next to the triangle turns on.
3. To select square wave output, depress the button as above until the light next to the square wave turns on.
4. To select pulse output, depress the button marked 9 until the light next to the pulse is turned on.
5. To select pulse complement output, depress the button as above until the light next to the pulse complement turns on.

The instrument may also be programmed to output positive or negative pulses with a fixed base line. This gives the operator an option to fix the base line level and only vary, using the Amplitude control, the high level. This feature is especially important in such applications where a change in both the high and low level may damage components that, for instance, would not tolerate negative voltages.

The output may be programmed to six additional functions which are factory preset to a base line of OV dc. The operator may then modify the base line using the Offset modifier. GPIB DCL or SDC bus commands defaults the base line to OV.
The functions as well as their associated controls are summarizes in the following:

1. Positive Square wave - Base line set by Offset setting, Amplitude setting controls high level (positive in reference to the base line).

2. Positive Pulse - Same as for Positive Square Wave.

3. Positive Pulse Complement - Same as for Positive Square Wave.

4. Negative Square wave - Base line set by Offset setting, Amplitude setting controls high level (negative in reference to the base line).

2. Negative Pulse - Same as for Negative Square Wave.

3. Negative Pulse Complement - Same as for Negative Square Wave.

To modify the output to have a fixed base line proceed as follows:

1. Depress the RCL button and observe that the display is modified to indicate the following:

```
--------------
  rEcALL ?      (? appears flashing)
--------------
```

2. Depress the vernier down pushbotton and observe that the display is modified to indicate the following:

```
--------------
   PuLSE |‾|    (|‾| appears flashing)
--------------
```

This indicates that the instrument is now ready to accept a modification in the output functions mode. Depressing the RCL button again cancels this indication and the instrument resumes operation with the previously programmed function.

Depressing the Vernier Up or Down changes the flashing indication to one of the following:

PuLSE |‾| Indicates a pulse output symmetrical around the base line.

PuLSE ¦‾¦ Indicates a positive pulse output with a fixed base line.

PuLSE ¦_¦ Indicates a negative pulse output with a fixed base line.

Depressing the ENT pushbotton permanently modifies the instrument to output one of the selected parameters. The pulse output functions are then modified to automatically output waveforms with half the normal amplitude.

****
** NOTES **
****

1. Modifying the instrument to output pulses with a fixed base line divides the maximum amplitude by two. That means that the maximum amplitude level is now 7.5V peak to peak.

2. Changing the output mode to have a fixed base line does not effect the sine and the triangle outputs.

3.6.7 Using the Vernier Control

The vernier control consists of two buttons; one of which is marked with an arrow pointing up and the other is marked with an arrow pointing down. The arrow up indicates that when this button is depressed, the instrument will increment one step. The down arrow indicates that when this button is depressed, the instrument will decrement one step. The vernier control is used similarly to a conventional potentiometer to modify the displayed setup. For example; if the display is modified to display frequency and the display reading is 100E0, depressing the up button will increment the reading to 101E0.(Note that the above example is given for an incremental step setting of 1) The output will then follow the new setting and the output waveform will have a frequency of 101Hz.
Decrementing one step is performed similarly using the down button. The instrument will increment or decrement continuously when depressing the vernier buttons for more then 1 second,

****
** NOTE **
****

To prevent operator's error, the instrument has an internal alarm which beeps whenever a limit is reached. e.g 1.0 mV low limit or 15 V high limit. When a limit is reached the alarm will sound and in some cases the instrument will display an error message. Table 3-1 describes the illegal conditions for which the alarm will sound.

3.6.8 Changing the Incremental Step

The increment step defines the magnitude of the step which the instrument will increment or decrement when the vernier control is depressed. The increment step size is adjustable from 1 to 10. The incremental step is adjustable from 1 to 100 for frequency and burst parameters. It is individually selectable for each parameter. Therefore, it is possible to set a step size of 100 for setting frequency and a step of 5 for the setting amplitude.
Depressing the INCR pushbutton will modify the display reading as follows:

```
----------------------
    Incr.    NX
----------------------
```

Where NX may be any number from 1 to 100.

Note that the right most digit (X) is flashing and indicating the previously selected step increment. This indicates that the instrument is in increment modify mode. To select a new step size depress one of the buttons marked with numbers 1 through 9. The selected number will replace the flashing number on the display and will also start flashing. To store the newly selected step size depress ENT. The instrument will then resume normal operation.
When the INCR pushbutton is depressed, to enter into the increment modify mode, it is also possible to proceed in two other ways;
1) Depressing the CLR pushbutton will clear the increment step to 1, or
2) If the previous increment step size was found to be satisfactory, depressing the the INCR button again will restore the previously entered step size.

3.6.9 Using the Numeric Keyboard

The instrument was designed to provide maximum flexibility when selecting parameters of frequency, amplitude, burst etc. The vernier control may at times be inconvenient in setting up a parameter or a set of parameters to be entered. The NUM, EXP, +/-, ENT in combination with the numeric keyboard minimizes setup time.

```
**********
** NOTE **
**********
```

The use of the numeric input is common to all parameters in the Display Modify group. In order to simplify the manual, the following illustrates a detailed procedure to enter numerals for frequency. The same procedure but with different limits may be applied to other Display Modify parameters. Display the FREQ as described in paragraph 3.6.1.

Depressing the NUM pushbutton will initiate a flashing in the right most digit, indicating that the instrument is ready to receive new data from the numeric keyboard. To clear the old data depress the CLR pushbutton. To restore previously selected data depress the NUM button. To insert new data observe that the right digit is flashing, and enter the number by sequencially depressing the desired numeric keys. Note that a newly entered number will start flashing. To enter the newly selected number depress ENT. The new data will be displayed without flashing to indicate that the instrument has resumed normal operation. Entered data must be within the limits defined for the parameter selected. any attempt to enter an illegal set of numbers will sound the audible alarm. See Table 3-1 for legal frequency parameter limits.

Depressing the EXP pushbutton will initiate a flashing in the exponent digit. This indicates that the instrument is ready to receive a new exponent from the numeric keyboard. To clear the old exponent simply depress the CLR button. To change the exponent sign depress the +/- pushbutton once. Depressing the +/- button more then once will toggle between positive and negative exponent. To restore the previously selected exponent depress the EXP button. To insert a new exponent observe that the exponent digit is flashing, as described before, and then enter the number by depressing the numeric keyboard. Note that the number, when entered, will start flashing. To enter the new exponent depress ENT. The new data will appear steady on the display indicating that the instrument resumed normal operation. Entered limits should be observed. Any attempt to enter an illegal exponent will sound the audible alarm. See Table 3-1 for legal frequency exponent limits.

3.6.10 Using the offset

When setting the offset parameter, the user must keep in mind that the offset is attenuated with the signal. The function generator utilizes 3 post amplitude attenuators of which 2 attenuate the signal by 20dB and one attenuates by 10dB. There is also a 10dB pre-amplifier attenuator. Ranges are internal to the instrument and are automatically selected with the required amplitude level. This may cause some confusion since the operator has no access to selecting an attenuator. Also, not knowing this fact may cause an offset error at amplitude values that seem to be reasonable.
As stated before, offset is amplitude dependent. It is therefore suggested to first set up the output amplitude and only after that to set the required offset. Offset and amplitude are independently selectable within the following window levels:

Level Window	Amplitude Range	Offset Range
+/- 7.50 V	1.6 E 0 - 15.0 E 0	0 E 0 - +/- 6.70 E 0
+/- 2.37 V	.48 E 0 - 1.50 E 0	0 E 0 - +/- 2.13 E 0
+/- 750 mV	.16 E 0 - .47 E 0	0 E-3 - +/- 670 E-3
+/- 237 mV	48 E-3 - 150 E-3	0 E-3 - +/- 213 E-3
+/- 75.0 mV	16 E-3 - 47 E-3	0 E-3 - +/- 67 E-3
+/- 23.7 mV	1.0 E-3 - 15.0 E-3	0 E-3 - +/- 23.2 E-3

To select an offset value proceed as follows:

1. Change Display Modify setting to AMPL and set the required amplitude level.
2. Change Display Modify setting to OFST. Using the vernier up or down, adjust the offset reading to the required value. Note that when exceeding the maximum offset setting the instrument sounds an audible alarm and displays an offset error message as described in paragraph 3.5.4.
   There is an alternate method to set the required offset value using the numeric keys as described in paragraph 3.6.9.

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** NOTE **
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If you refer to change the amplitude value using the vernier control, it is again suggested to clear the offset to 0 and then proceed with amplitude setting. Even the smallest offset level may cause an offset error when the vernier is being used. This is related to the above table where the maximum allowable offset, at the range changing point, is reduced significantly.

3.6.11 Using The Pulse Output

The Model 8201 is actually two high performance instruments built in one convenient package: conventional waveforms generator and pulse generator. Operating the pulse output as well as selecting pulse parameters are performed similarly to selecting parameters for the normal waveforms.
Figure 3-6 describes the different waveforms that are available with the pulse output. To select one of the pulse outputs simply depress button number 9: once to select the pulse output or twice to select the pulse complement output.
When setting up pulse parameters, inconsistencies of interparameters may occur. In this case, a light will illuminate in the OUTPUT block and an audible alarm will sound to indicate such an error. Table 3-3 may be used as an aid to correct the programmed parameters.

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** NOTE **
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When the function generator is set to output either sine, triangle or square waves, the output repetition rate is given as frequency and dimensions are in Hz. When operating the instrument in one of the pulse modes, the repetition rate is modified to period and the dimensions are given in Sec.

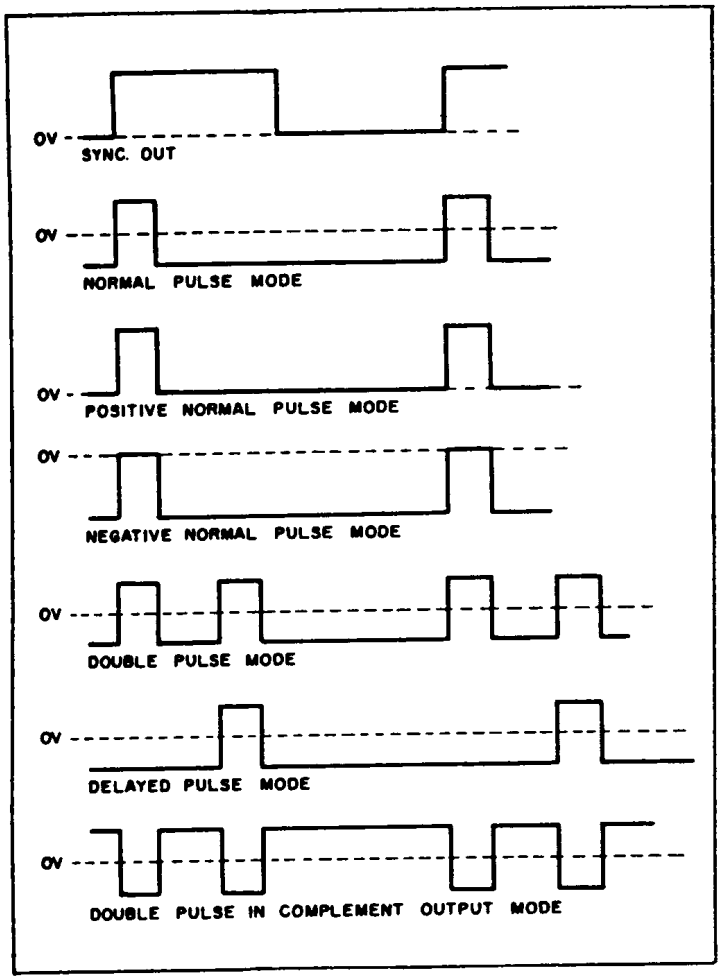

Figure 3-6. Pulse Output Waveforms.

3.6.12 Programming Rise and Fall Times

When option 40 is installed, one is capable to program a pulse output with different rise and fall times. Rise and fall times are independently selectable within 5 overlapping ranges. A summary of these ranges is given in Table 3-4.
While programming rise and fall times, pulse interparameter inconsistencies may generate. When such an error occur an error light in the OUTPUT block will illuminate and an audible alarm will sound. This indicates that the output signal at the output connector will appear distorted. Use Table 3-3 to aid in correcting such errors.

To program the rise and fall times proceed as follows:

1. Change display modify setting to LEAD. Using numeric entry method, as described in paragraph 3.6.9, program the required rise time. Use Table 3-4 to select the appropriate range. Note that ranges are overlapping. This means that a value within the overlapping range may end up being entered in the undesired range. To avoid such a mistake, program the required value exactly with the same decimal point and exponents as it appears in Table 3-4. For an example, if the required rise time is 15 uSec and the required rise/fall time range is the 3rd range (1.0 E-6 - 100.0 E-6), enter the value 15.0E-6. The same value if entered 15E-6, would select the 5th and the undesirable range.

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** NOTE **
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Changing rise time ranges is only possible using the numeric entry method as described in paragraph 3.6.9. After a rise time was selected, the vernier Up or vernier down may be used to modify the rise time within the selected range. When using vernier and the range limit is reached, the instrument will sound an audible alarm.

2. Change display modify setting to TRAIL. Using the vernier, program the required fall time. Note that when exceeding the maximum inter-range limit setting, the instrument will sound an audible alarm.
It is also possible to program the fall time value using the numeric entry. While using the numeric entry one should know that decimal point and exponent can not be modified. An attempt to modify them will cause the instrument to sound an audible alarm.

Table 3-4. Rise/Fall Time Ranges

RANGE	RISE/FALL TIME RANGE
1.	10 E-9 - 1000 E-9
2.	.10 E-6 - 10.00 E-6
3.	1.0 E-6 - 100.0 E-6
4.	10 E-6 - 1000 E-6
5.	.10 E-3 - 10.00 E-3

3.6.13 Using Front Panel Setups

Setting up all parameters in a versatile instrument such as function generator takes some time. The setup time is longer when more than one setup is required. The Model 8201 incorporates a battery backed up non-volatile memory that preserves stored information indefinitely. It is possible to store complete front panel setups in 10 different memory locations which are built into the instrument especially for this purpose.

STORE SETUPS - First modify the front panel parameters, as necessary to perform your tasks. When all parameters are set and checked proceed to store this setup as follows:

1. Depress the STO pushbutton and observe that the display is modified to indicate the following ;

StorE ? (? appears flashing)

This reading indicates that the instrument is ready to receive one the memory location where front panel setup is to be stored. Setups may be stored in locations 0 to 9. Depressing the STO again cancels this function and the instrument resumes normal operation.

2. Select one memory location from 0 to 9 and depress the button which is marked with the selected number. The instrument will display the following for one second;

```
--------------
  StorE  N
--------------
```

Where N is the selected memory location.

This display indicates that the function generator acknowledges the entered memory location. The instrument will then resume normal operation.

RECALL SETUPS - Turning AC mains power OFF will not effect the stored data in the RAM which preserves the front panel setup previously recorded by the user. To recall a front panel setup proceed as follows:

1. Depress the RCL pushbutton and observe that the display is modified to indicate the following;

```
--------------
   rEcALL ?
--------------
```

(? appears flashing)

This reading indicates that the instrument is ready to recall the memory location where front panel setup was stored. Depressing the RCL button cancels this function and the instrument resumes normal operation.

2. Select one memory location from 0 to 9 as to recall the desired setpup, and depress the button which is marked with the selected number. The instrument will display the following for one second;

```
--------------
  rEcALL  N
--------------
```

Where N is the selected memory location.

The instrument will then recall the parameters that where previously stored in the selected memory location and will update front panel setting with the recalled parameters.

3.6.14 Using The External Frequency Measurement Function

The function generator may be operated as a stand alone counter. Measurement capability covers the frequency range of 10Hz to more than 20MHz. The instrument utilizes the reciprocal counting technique to measure and display the reference signal with a fixed number of digits, regardless of the input frequency. i.e a 10Hz input may be measured with resolution of 100uHz. To operate the instrument in the counter mode of operation proceed as follows:

1. Select the EXT FRQ mode of operation using the procedure provided in paragraph 3.6.2. Once the function has been selected, all lights except slope selection are turned off and display reading is modified to 0E0.

2. adjust the trigger level using the procedure in paragraph 3.6.4
3. Select the triggering edge either positive going or negative slope
4. Apply the signal to be measured to the EXT FREQ terminal

The display now indicates the frequency of the external signal in Hz. Decimal point and exponent are automatically selected and correctly displayed. The decimal point is also flashing to indicate gating. When no signal is present at the input terminal or when the signal is below the minimum required level, the counter will cease its measurement cycle and will zero the display reading.

3.6.15 Changing the GPIB Address

GPIB address is modified using front panel programming. The non-volatile memory stores the GPIB address and conventional address switches are not provided. Detailed instructions to change the address is given in Section 4.

SECTION 4

IEEE-488 OPERATION

4.1 INTRODUCTION

The IEEE-488 bus is an instrumentation data bus with standards adopted by the IEEE (Institute of Electrical and Electronic Engineerings) in 1975 and given the IEEE-488 designation. The most recent revision of bus standards was made in 1978; hence the complete description for current bus standards is the IEEE-488-1978 designation. The Model 8201 conforms to 1978 standards.

This section contains general bus information as well as detailed programming information and is divided as follows:

1. General introductory information pertaining to the IEEE-488 bus may be found primarily in paragraphs 4.2 through 4.6.
2. Information necessary to connect the Model 8201 to the bus is contained in paragraphs 4.7 and 4.8.
3. Programming of the instrument with general bus command is covered in paragraph 4.9.
4. Device-dependent command programming is described in detail in paragraph 4.10. The commands outlined in this section can be considered to be the most important since they control virtually all instrument functions.
5. Additional information pertaining to front panel error messages and controller programs can be found in paragraph 4.12.

4.2 BUS DESCRIPTION

the IEEE-488 bus was designed as a parallel data transfer medium to optimize data transfer without using as excessive number of bus lines. In keeping with this goal, the bus has only eight data lines which are used for both data and most commands. Five bus management lines and three handshake lines round out the complement of signal lines. Since the bus is of parallel design, all devices connected to the bus have the same information available simultaneously. Exactly what is done with the information by each device depends on many factors, including device capabilities.

A typical bus configuration for remote controlled operation is shown in Figure 4-1. The typical system will have one controller an one or more instruments to which commands are given and from which data is received. There are three categories that describe device operation. These include: controller; talker; listener.

The controller controls other devices on the bus. A talker sends data, while a listener receives data. an instrument, may be a talker only, a listener only, or both a talker and listener.

Any given system can have only one controller (control may be passed to an appropriate device through a special command). Any number of talkers or listeners may be present up to the hardware constraints of the bus. The bus is limited to 15 devices, but this number may be reduced if higher than normal data transfer rates are required or if long interconnect cables are used.

Several devices may be commanded to listen at once, but only one device may be a talker at any given time. Otherwise, communications would be scrambled much like an individual's trying to select a single conversation out of a large crowd.

Before a device can talk or listen, it must be appropriately addressed. Devices are selected on the basis of their primary address. The addressed device is sent a talk or listen command derived from its primary address. Normally, each device on the bus has a unique primary address so that each may be addressed individually. The bus also has another addressing mode called secondary addressing, but not all devices use this addressing mode.

Once the device is addressed to talk or listen, appropriate bus transactions may be initiated. For example, if an instrument is addressed to talk, it will usually place its data on the bus one byte at a time. The listening device will then read this information, and the appropriate software is then be used to channel the information to the desired location.

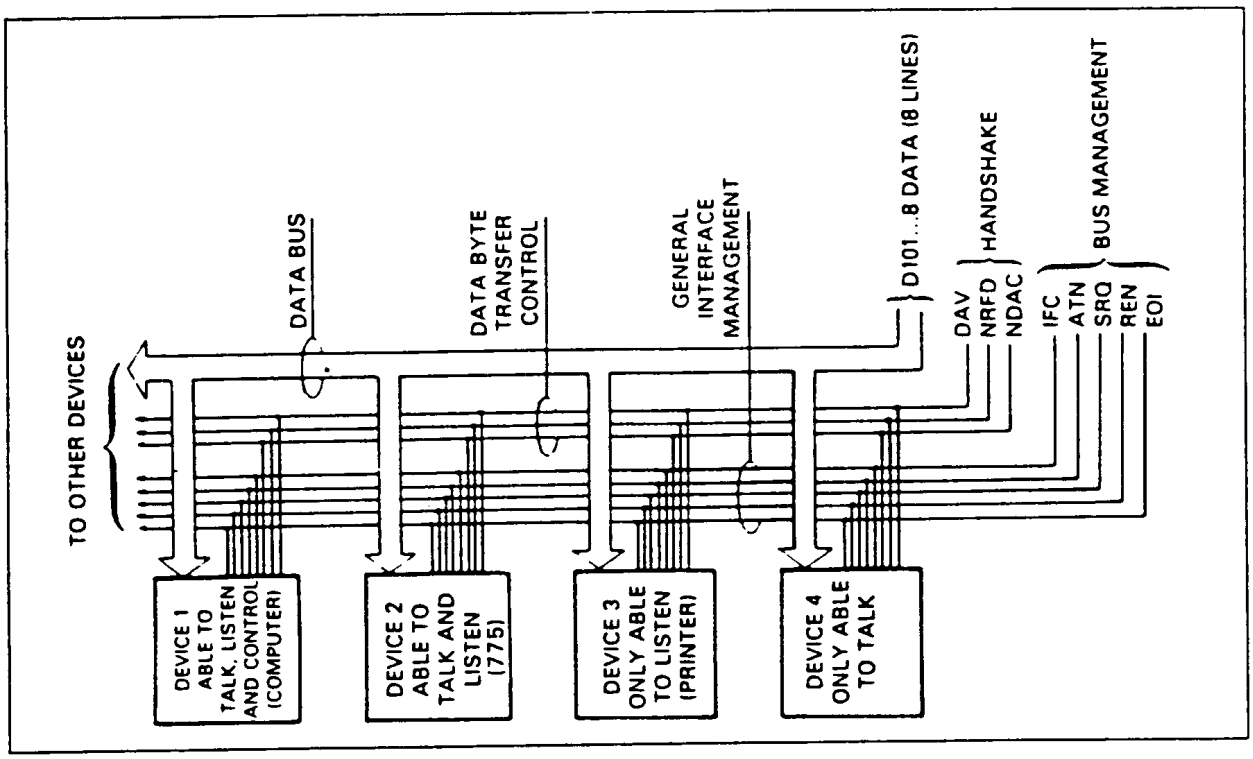

Figure 4-1. IEEE Bus Configuration

4.3 IEEE-488 BUS LINES

The signal lines on the IEEE-488 bus are grouped into three general categories. The data lines handle bus information, while the handshake and bus management lines assure that proper data transfer and bus operation takes place. Each of the bus lines is "active low" so that approximately zero volts is a logic "one". The following paragraphs describe the purpose of these lines, which are shown in Figure 4-1.

4.3.1 Bus Management Lines

The bus management group is made up of five signal lines that provide orderly transfer of data. These lines are used to send the uniline commands described in paragraph 4.4.1.

a. ATN (Attention) - the ATN line is one of the more important management lines. The state of the ATN line determines whether controller information on the data bus is to be considered data or a multiline command as described in paragraph 4.4.
b. IFC (Interface Clear) - Setting the IFC line true (low) causes the bus to go to a known state.
c. REN (Remote Enable) - Setting the REM line low sends the REM command. This sets up instruments on the bus for remote operation.
d. EOI (End Or Identify) - The EOI line is used to send the EOI command that usually terminates a multi-byte transfer sequence.
e. SRQ (eervice Request) - the SRQ line is set low by a device when it requires service from the controler.

4.3.2 Handshake Lines

The bus uses three handshke lines that operate in an interloced sequence. This method assures reliable data transfer regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.
One of the hanshake lines is controlled by the data source, while the remaining two lines are controlled by accepting devices. The three bus handshake lines are:

1. DAV (Data Valid) - The source controls the state of the DAV line.
2. NRFD (Not Ready For Data) - the acceptor controls the state of the NRFD line.
3. NDAC (Not Data Accepted) - the acceptor also controls the NDAC line.

The complete handshake sequence for one data byte is shown in Figure 4-2. Once data is on the bus, the source checks to see that NRFD is high, indicating that all devices on the bus are ready for data. At the same time NDAC should be low from the previous byte transfer. If these conditions are not met, the source must then wait until the NRFD and NDAC lines have the correct status. If the source is controller, NRFD and NDAC must remain stable for at least 100ns after ATN is set low. Because of the possibility of bus hang up, some controllers have time-out routines to display error messages if the handshake sequence stops for any reason.

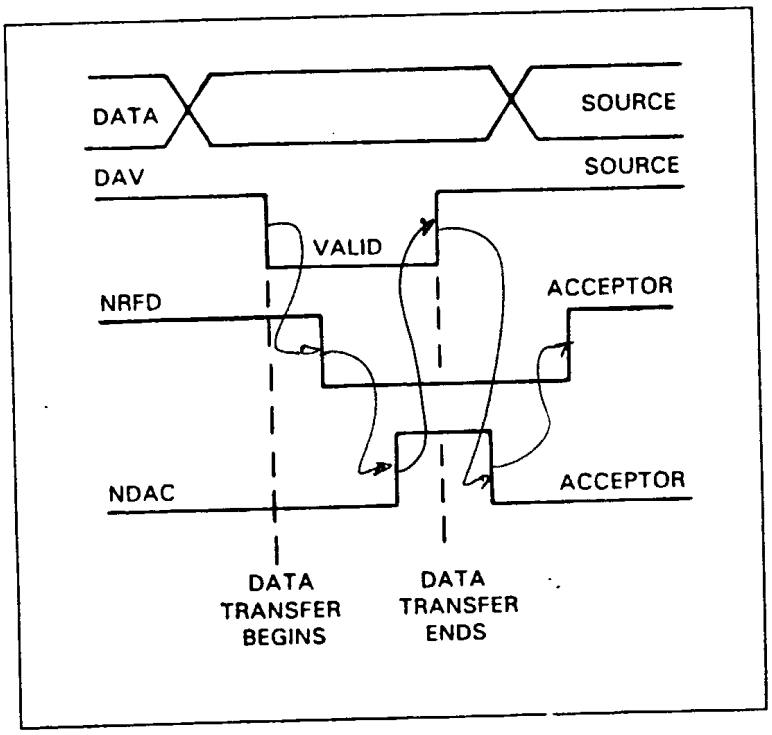

Figure 4-2. IEEE Handshake Sequence

Once the NRFD and NDAC lines are properly set, the source sets the DAV line low, indicating that data on the bus is now valid. the NRFD line then goes low; the NDAC line goes high once all devices on the bus have accepted the data. Each device will release the NDAC line at its own rate, but the NDAC line will not go high until the slowest device has accepted the data byte.

After the NDAC line goes high, the source then sets the DAV line high to indicate that the data on the bus is no longer valid. At this point, the NDAC line returns to its low state. Finally, the NRFD line is released by each of the devices at their own rates, until the NRFD line finally goes high when the slowest device is ready, and the bus is set to repeat the sequence with the next data byte.

The sequence just described is used to transfer both data and multiline command. The state of the ATN line determines whether the data bus contains data or commands as described in paragraph 4.4.

4.3.3 Data Lines

The IEEE-488 bus uses the eight data lines that allow data to be transmitted and received in a bit-parallel, byte-serial manner. These eight lines use the convention DIO1 through DIO8 instead of the more common D0 thru D7 binary terminology. The data lines are bidirectional and, as with the remaining bus signal lines, low is true.

4.4 BUS COMMANDS

While the hardware aspects of bus is essential, the interface would be essentially worthless without appropriate commands to control communications between the various instruments on the bus. This paragraph briefly describes the purpose of the bus commands, which are grouped into the following three categories:

a. Uniline commands: Sent by setting the associated busyline low.

b. Multiline commands: General bus commands which are sent over the dat lines with the ATN line low (true).

c. Device-dependent commands: Special commands that depend on device configuration; sent over the data lines with ATN high (false).

Table 4-1. IEEE-488 Bus Command Summary

Command Type	Command	State of ATN Line*	Comments
Uniline	Ren	X	Set up for remote operation
	EOI	X	Sent by setting EOI low
	IFC	X	Clears Interface
	ATN	Low	Defines data bus contents
	SRQ	X	Controlled by external device
Multiline Universal	LLO 11	Low	Locks out front panel controls
	DCL 14	Low	Returns device to default conditions
	SPE 18	Low	Enable serial polling
	SPD 19	Low	Disables serial polling
Addressed	SDC 04	Low	Returns unit to default condition
	GTL 01	Low	Returns to local control
	GET 08	Low	Triggers device for reading
Unaddress	UNL 3F	Low	Removes all listeners from bus
	UNT 5F	Low	Removes all talkers from bus
Device-dependent**		High	Programs Model 8201 for various modes.

*X=Don't Care
**See paragraph 4.10 for complete description

4.4.1 Uniline Commands

Uniline commands are sent by setting the associated bus line to low. The ATN, IFC, and REN commands are asserted only by the system controller. The SRQ command sent by an external device. The EOI command may be sent by either the controller or an external device depending on the direction of data transfer. The following is a brief description of each command.

a. REN (Remote Enable) - When the controller sends the REN commands, the instrument will be set up for remote operation. Generally, the REN command should be sent before attempting to program instruments over the bus.

b. EOI (End Or Identify) - The EOI command is used to positively identify the last byte in a multi-byte transfer sequence. This allows variable length data words to be transmitted easily.

c. IFC (Interface Clear) - The IFC command is sent to clear the bus and set devices to a known state. Although device configurations differ, the IFC comman usually places instruments in the talk and listen idle states.

d. ATN (Attention) - The controller sends ATN while transmitting addresses or multiline commands. Device-depndent commands are sent with the ATN line high (false).

e. SRQ (Service Request) - Te SRQ command is asserted by an external device when it requires service from the controller. If more than one device is present, a serial polling sequence, as described in paragraph 4.9.8, must be used to determine which has requested service.

4.4.2 Universal Commands

Universal commands are multiline commands that require no addressing. All instrumentation equipped to implement the command will do so simultaneously when the command is transmitted over the bus. As with all multiline commands, the universal commands are sent over the data lines with ATN set low:

a. LLO (Local Lockout) - The LLO command is used to lock out front panel controls on instruments so equipped.

b. DCL (Device Clear) - After a DCL is sent, instrumentation equipped to implement the command will revert to a known state. Usually, instruments return to their power-up conditions.

c. SPE (Serial Poll Enable) - The SPE command is the first step in the serial polling sequence, which is used to determine which instrument has requested service with the SRQ command.

d. SPD (Serial Poll Disable) - The SPD command is sent by the controller to remove all instrumentation on the bus from the serial poll mode.

4.4.3 Addressed Commands

Addressed commands are multiline commands that must be preceeded by a listen command derived from the device's primary address before the instrument will respond. Only the addressed device will respond to each of these commands:

a. SDC (Selective Device Clear) - The SDC command performs essentially the same function as the DCL command except that only the addressed device will respond. Instruments usually return to their default conditions when the SDC command is sent.

b. GTL (Go To Local) - The GTL command is used to remove instruments from the remote mode of operation. Also, front panel control operation will usually be restored if the LLO command was previously sent.

c. GET (Group Execute Trigger) - The GET command is used to trigger devices to perform a specific action that depends on device configuration. Although GET is considered to be an addressed command, many devices respond to GET without being addressed.

4.4.4 Unaddress Commands

The two unaddress commands are used by the controller to simultaneously remove all talkers and listeners from the bus. ATN is low when these multiline commands are asserted.

a. UNL (Unlisten) - All listeners are removed from the bus at once when the UNL commands is placed on the bus.
b. UNT (Untalk) - The controller sends the UNT command to clear the bus of any talkers.

4.4.5 Device-Dependent Command

The meaning of the device-dependent commands is determined by instrument configuration. Generally, these commands are sent as one or more ASCII characters that tell the device to perform a specific function. For example, DO is sent to the Model 8201 to place the instrument in the FRQ mode. The IEEE-488 bus treats device-dependent commands as data in that ATN is high (false when the commands are transmitted.

4.5 COMMAND CODES

Each muiltiline command is given a unique code that is transmitted over the data bus as 7-bit ASCII data. This section briefly explains the code groups which are summarized in Figure 4-3. Every command is sent with ATN low:

a. Addressed Command Group (ACG) - Addressed commands are listed in column 0(B) in Figure 4-3. Column 0(A) lists the corresponding ASCII codes.

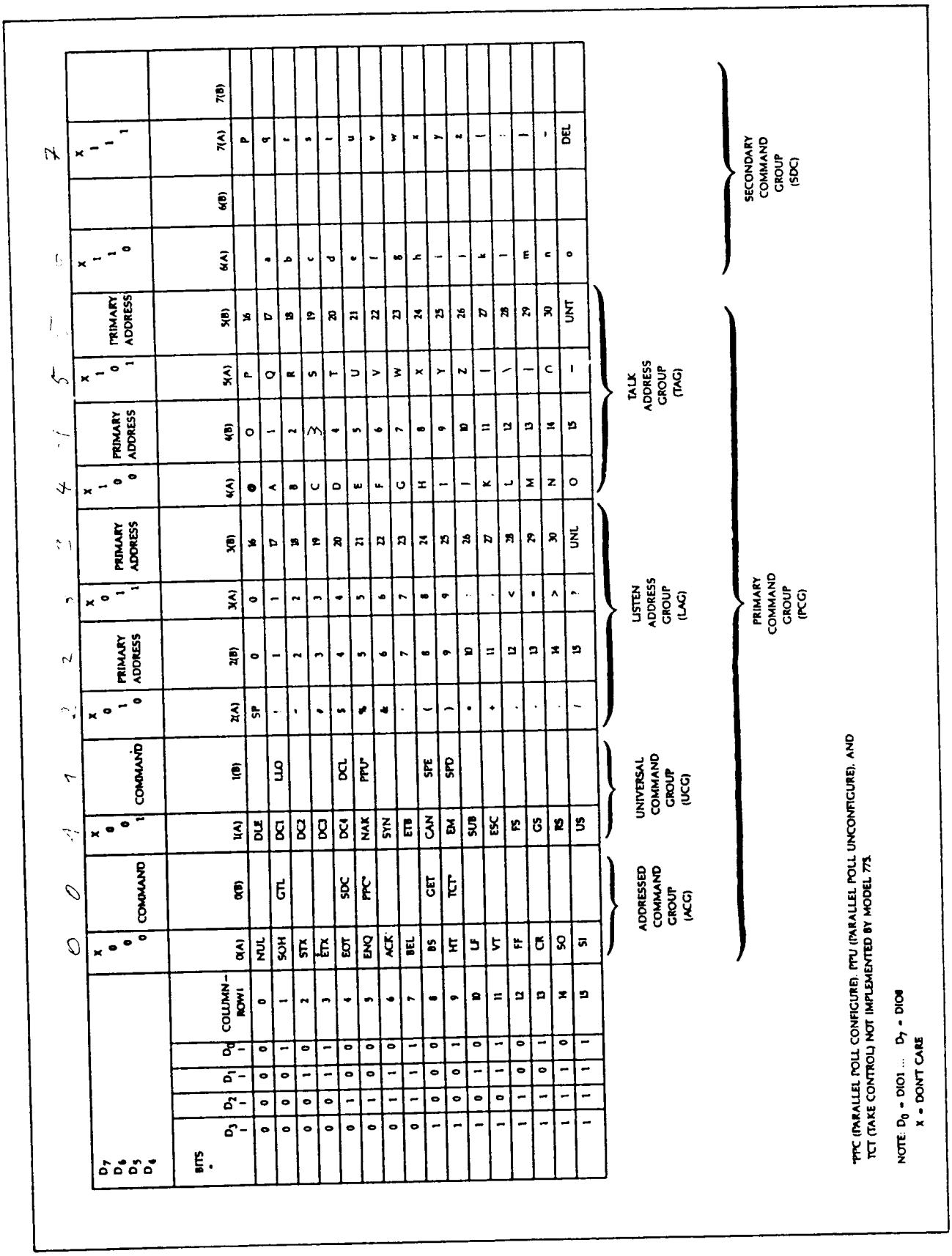

Figure 4-3. Command Codes

b. Universal Command Group (UCG) - Columns 1(A) and 1(B) list the Universal commands and the corresponding ASCII codes.

c. Listen Address Group (LAG) - Columns 2(A) and 3(A) list the ASCII codes corresponding to the primary address listed in columns 2(B) and 3(B). For example, if the primary address of the instrument is set to 16, the LAG byte will correspond to an ASCII zero.

d. Talk Address Group (TAG) - TAG primary address values and the corresponding ASCII characters are listed in columns 4(A) through 5(B).

The preceeding address group are combined together to form the Primary Command Group (PCG). The bus also has another group of commands, called the Secondary Command Group (SCG). These are listed in Figure 4-3 for informational purposes only; the Model 8201 does not respond to these commands, but other devices may have secondary addressing capability.

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** NOTE **
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Commands are normally transmitted with the 7-bit code listed in Figure 4-3. For most devices, the condition of D7 (DIO8) is unimportant, as shown by the "Don't Care" indication in the table. Some devices, however, may require that D7 assumes a specific logic state before the commands are recognized.

Hexadecimal and decimal values for each of the commands or command group are listed in Table 4-2. Each value in the table assumes that D7 is set to 0.

Table 4-2. Hexadecimal and Decimal Command Codes

Command	Hex value*	Decimal Value
GTL	01	1
SDC	04	4
GET	08	8
LLO	11	17
DCL	14	20
SPE	18	24
SPD	19	25
LAG	20-3F	32-63
TAG	40-5F	64-95
UNL	3F	63
UNT	5F	95

* Values shown with D7 = 0.

4.6 COMMAND SEQUENCES

The proper command sequence must be sent by the controller before an instrument will respond. The universal commands such as LLO and DCL, require only that ATN be set low before the command is sent. Other commands require that the device be addressed to listen first. This Section briefly describes the bus sequence for several types of commands.

4.6.1 Addressed Command Sequence

Before a device will respond to one of these commands, it must receive a LAG command derived from its primary address. Table 4-3 shows a typical sequence for the SDC command. The LAG command assumes that the instrument is set at primary address of 17.
Note that an UNL command is transmitted before the LAG, SDC sequence. This serves to remove all other listeners from the bus first so that only the addressed device responds.

4.6.2 Universal Command Sequence

The universal commands are sent by setting ATN low and then placing the command byte on the bus. For example, the following gives the LLO command:

ATN LLO

Note that both the ATN and LLO commands are on the bus simultaneously. Also, addressing is not required.

4.6.3 Device-Dependent Command Sequence

Device-dependent commands are transmitted with ATN high. However, the device must be addressed to listen first before the commands are transmitted. Table 4-4 shows the sequence for the following command:

DO

This command, which sets the Model 8201 to the FREQ mode, is described in detail in paragraph 4.10.1.

Table 4-3. Typical Addressed Command Sequence

Step	Command	ATN State	Data Bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	0	30	48
3	SDC	Stays low	EOT	04	4
4		Returns high			

* Assumes primary address = 17.

Table 4-4. Typical Device-Dependent Command Sequence

Step	Command	ATN State	Data Bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	0	30	48
3	Data	Set high	D	44	68
4	Data	Stays high	0	30	48

* Assumes primary address = 17

4.7 HARDWARE CONSIDERATIONS

Before the instrument can be used with the IEEE-488 bus, it must be connected to the bus with a suitable connector. Also, the primary address must be properly programmed as described in this section.

4.7.1 Typical Controlled Systems

The IEEE-488 bus is a parallel interface system. As a result, adding more device is simply a matter of using more cables to make the desired connections. Because of this flexibility, system complexity can range from simple to extremely complex.

The simplest possible controlled system comprises a controller and one Model 8201. The controller is used to send commands to the instrument, which sends data back to the controller.

The system becomes more complex when additional instrumentation is added. Depending on programming, all data may be routed through the controller, or it may be transmitted directly from one instrument to another.

For very complex applications, a much larger computer can be used. Tape drives or disks may then be used to store data.

4.7.2 Connections

The instrument is connected to the bus through an IEEE-488 connector. This connector is designed to be staked to allow a number of parallel connections on one instrument.

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** NOTE **
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To avoid possible mechanical damage, it is recommended that no more than three connectors be staked on any one instrument. Otherwise, the resulting strain may cause internal damage to the connectors.

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** NOTE **
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The IEEE-488 bus is limited to a maximum of 15 devices, including the controller. Also, the maximum cable length is 20 meters. Failure to observe these limits will probably result in erratic bus operation.

Table 4-5 lists the contact assignments for the various bus lines. Contacts 18 through 24 are return lines for the indicated signal lines, and the cable shield is connected to contact 12. Each ground line is connected to digital common in the Model 8201.

table 4-5. IEEE Contact Designations

Contact Number	IEEE-488 Designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN	Management
18	Gnd	Ground
19	Gnd	Ground
20	Gnd	Ground
21	Gnd	Ground
22	Gnd	Ground
23	Gnd	Ground
24	Gnd LOGIC	Ground

****
** CAUTION**
****

The voltage between IEEE common and ground must not exceed 0V or damage may result to your instrument.

4.7.3 Changing GPIB Address

The primary address of your instrument may be programmed to any value between 0 and 30 as long as the selected address is different from other devices addresses in the system. This may be accomplished using a front panel programming sequence. Note that the primary address of the instrument must agree with the address specified in the controller's program.

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** NOTE **
****

The programmed primary address is briefly displayed during the power-up cycle of the Model 8201. It is stored in the non-volatile memory of the instrument and is retained even when power is turned off.

To check the present address, or to enter a new one, proceed as follows:

Depress the LCL pushbutton once. If the instrument was in remote mode, (but not in local lockout mode) this step will change instrument's status to local operation. When Model 8201 is in local operation and this button was depressed the display will be modified to display the following:

```
----------------------
    GPIb  NX
----------------------
```

Where NX may be any number from 0 to 30.

Note that the most right digit (X) is flashing with the previously selected GPIB address, indicating that the instrument is in GPIB primary address modify mode. To select a new GPIB primary address depress one or more of the buttons marked with numbers 1 through 9. The selected number will replace the flashing number on the display and will start flashing. To store the newly selected primary address depress ENT. The instrument will then resume normal operation.

When LCL pushbutton is depressed, to enter into the address modify mode, it is also possible to proceed in two other ways;

a) Depressing the CLR pushbutton will clear the previously selected address to 0 ,or
b) If the GPIB primary address was found to be satisfactory, depressing the LCL button again will restore the last selected address.

4.8 Software Considerations

The most sophisticated computer in the world would be useless without the necessary software. This basic requirement is also true of the IEEE-488 bus, which requires the use of handler routines as described in this paragraph.

4.8.1 Controller Interface Routines

Before a controller can be used with the Ieee-488 interface, the user must make certain that appropriate handler software is present within the controller. With the IBM computer for example, the GPIB interface card must be used, which contains the necessary hardware and handler software.

Other small computers that can be used as controllers have limited IEEE command capability. The PET/CBM computers, for example, are incapable of sending multiline commands from BASIC, although these commands can be sent through machine language routines. The capabilities of other small computers depend on the particular interface being used. Often, little software "tricks" are required to achieve the desired results.

From the proceeding discussion, the message is clear: make sure the proper software is being used with the instrument. Often, the user may incorrectly suspect that a hardware problem is causing fault, when it was the software that was causing the problem all along.

4.8.2 Interface Function Codes

The interface function codes are part of the IEEE-488-1978 standards. These codes define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual.

Table 4-6 lists the codes for the Model 8201. The numeric value following each one or two letter code define Model 8201 capability as follows:

SH (Source Handshake Function) - The ability for the Model 8201 to initiate the transfer of message/data on the data bus provided by the SH function.

AH (Acceptor Handshake Function) - The ability for the Model 8201 to guarantee proper reception of message/data on the data bus provided by the AH function.

T (Talker Function) - The ability of the Model 8201 to send device-dependent data over the bus (to another device) is provided by the T function. Model 8201 talker capabilities exist only after the instrument has been addressed to talk.

L (Listen Function) - The ability of the Model 8201 to receive device-dependent data over the bus (from another device) is provided by the L function. Listener function capability of the MOdel 8201 exist only after it has been addressed to listen.

RS (Service Request Function) - The ability of the Model 8201 to request service from the controller is provided by the RS function.

RL (Remote-Local Function) - The ability of the Model 8201 to be placed in remote or local modes is provided by the RL function.

PP (parallel Poll Function) - The ability of the Model 8201 to respond to a parallel poll request from the controller is provided by the PP function.

DC (Device Clear Function) - The ability for the Model 8201 to be cleared (initialized) is provided by the DC function.

DT (Device Trigger Function) - The ability of the Model 8201 to have its output triggered is provided by the DT function.

C (controller Function) - The Model 8201 does not have a controller function.

TE (Extended Talker Capabilities) - The Model 8201 does not have extended talker capabilities.

LE (Extended Listener Function) - The Model 8201 does not have extended listener function.

Table 4-6. Model 8201 Interface Function Codes

Code	Interface Function
SH1	Source Handshake Function
AH1	Acceptor Handshake Capabilities
T6	Talker (basic talker, serial poll, unaddressed to talk on LAG)
L4	Listener (basic listener, unaddressed to listen on TAG)
SR1	Service request capability
RL1	Remote/Local capability
PP2	Parallel Poll capability
DC1	Device Clear capability
DT1	Device Trigger capability
C0	No controller capability
E1	Open collector bus drivers
TE0	No Extended Talker capabilities
LE0	No Extended Listener capabilities

4.8.3 Model 8201 Interface Commands

Interface commands controlling Model 8201 operation are listed in Table 4-7. Not included in the table are device depended commands, which are covered in detail in paragraph 4.10.

Table 4-7. IEEE Command Group

HANDSHAKE COMMAND GROUP	
DAC - Data Accepted	
RFD - Ready For Data	
DAV - Data Valid	
UNIVERSAL COMMAND GROUP	
ATN - Attention	
DCL - Device Clear	
IFC - Interface Clear	
LLO - Local Lockout	
REN - Remote Enable	
SPD - Serial Poll Disable	
SPE - Serial Poll Enable	
ADDRESS COMMAND GROUP	
Listen: LAG - Listen Address Group	
MLA - My Listen Address	
UNL - Unlisten 3F	
Talk: TAG - Talk Address Gropp	
MTA - My Talker Address	
OTA - Other Talk Address	
UNT - autalk 4F	
ADDRESSED COMMAND GROUP	
ACG - Addressed Command Group	
GET - Group Execute Trigger	08
GTL - Go t Local	01
SDC - Selective Device Clear	04
STATUS COMMAND GROUP	
RQS - Request Service	
SRQ - Serial Poll Request	
STB - Status Byte	
END - EOI	

4.9 General Bus Command Programming

General bus commands are those commands which have the same general meaning regardless of instrument configuration. These commands are grouped into two categories:

Addressed Commands - These commands require that the primary address of the instrument agree with the primary address in the controller's programming language.

Unaddressed Commands - No primary address is required for these commands. All devices equipped to implement these commands will do so simultaneously when the command is sent.
General bus commands are summarized in Table 4-8. Each addressed command statement assumes a primary address of 17.

****
** NOTE **
****

The Model 8201 address must be set for a primary address of 17 to work with addressed command examples.

Table 4-8. General Bus Commands

Command	Addressing Required ?
REN	Yes
IFC	No
LLO	No
GTL	Yes
DCL	No
SDC	Yes
GET*	No
GET	Yes

* GET may be sent with or without addressing.

4.9.1 REN (Remote Enable)

The remote enable command is sent to the Model 8201 by the controller to set the instrument up for remote operation. Generally, this should be done before attempting to program the instrument over the bus. The Model 8201 will indicate that it is in the remote mode by illuminating its front panel REM indicator.

To place the Model 8201 in the remote mode, the controller must perform the following steps:

1. Set the REN line true.
2. Address the Model 8201 to listen.

****
** NOTE **
****

Setting REN true without addressing will not cause the REM indicator to turn on; however, once REN is true, the REM light will turn on the next time an address command is received.

4.9.2 IFC (Interface Clear)

The IFC command is sent by the controller to set the Model 8201 to the talk and listen idle states. To send the IFC command, the controller need only set the IFC line true.

4.9.3. LLO (Local Lockout)

The LLO command is sent by the controller to remove the Model 8201 from the local operating mode.Once the unit receives the LLO command, all its front panel controls (except Power) will be inoperable.

****
** NOTE **
****

The REN bus line must be true before the instrument will respond to an LLO command.

To lock out the front panel controls of the Model 8201, the must perform the following steps:

1. Set ATN true.
2. Send the LLO command to the instrument.

4.9.4 GTL (Go To Local)

The GTL command is used to take the instrument out of the remote mode. To send the GTL command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8201 to listen.
3. Place the GTL command on the bus.

****
** NOTE **
****

The GTL command does not remove the local lockout state. With the local lockout condition previously set, the GTL command will enable front panel control operation until the next time a listener address command is received. This places the Model 8201 in the local lockout state again.

4.9.5 DCL (Device Clear)

The DCL command may be used to clear the Model 8201, setting it to a known state. Note that all devices on the bus equiped to respond to a DCL will do so simultanously. When the Model 8201 receives a DCL command, it will return to the default conditions listed in Table 4-9.

To send a DCL command the controller must perform the following steps:

1. Set ATN true.
2. Place the DCL command on the bus.

Table 4-9. Default Conditions. (Status after SDC or DCL)

Mode	Value	Status
Display Modify	D0	FREQ
Operating Mode	V0	VCO Off
	E0	EXT FRQ Off
	P0	DELAYED/DOUBLE Pulse Off
	G0	GATED Mode Off
	T0	TRIGRD Mode Off
	B0	BURST Mode Off
Trigger Slope	TS0	Positive Trigger Slope
Trigger Level	TM0	Internal Trigger Stimulus On
Waveform	U1	Sinewave
Parameters	FR50E+3	Frequency = 50 KHz
	PR20E-6	Period = 20 uSec
	AM5E+0	Amplitude = 5.0 V
	OF0	Offset = 00.0 V
	SY50	Symmetry = 50%
	PW2.0E-6	Pulse Width = 2 uSec
	PD5.0E-6	Pulse Delay = 5 uSec
	TP1E0	Trigger Period = 1 Sec
	TB2	Burst Count = 2
	LE10E-9	Rise Time = 10 nSec
	TE10E-9	Fall Time = 10 nSec
Readback	N0	Frequency Prefix: FREQ
Reading Format	X0	Prefix on, no leading zeroes
Terminator	Z0	CR,LF 13,10 with EOI
SRQ Mask	Q0	SRQ disabled

4.9.6 SDC (Selective Device Clear)

The SDC command performs the same function as the DCL command except that the only addressed device responds. This command is usefu l for clearing only a selected instrument instead of all devices simultaneously. The Model 8201 will return to the default conditions listed in Table 4-9 when responding to an SDC command.

To transmit the SDC command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 8201 to listen.
3. Place the SDC command on the data bus.

4.9.7 GET (Group Execute Trigger)

The GET command is sent to the Model 8201 to trigger the instrument. Using the GET command is only one of several methods that can be used to initiate a waveform. More detailed information on triggering can be found in Section 3 of this manual.

To send GET command over the bus, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8201 to listen.
3. Place the GET command on the data bus.

GET can also be sent without addressing by omitting step 2.

4.9.8 SPE, SPD (Serial Polling)

The serial polling sequence is used to obtain the Model 8201 status byte. Usually, the serial polling sequence is used to determine which of several devices has requested service over the SRQ line. However, the serial polling sequence may be used at any time to obtain the status byte from the Model 8201. For more information on status byte format, refer to paragraph 4.10.17.
The serial polling sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The SPE (Serial Poll Enable) command is placed on the bus by the controller.
3. The Model 8201 is addressed to talk.
4. The controller sets ATN false.
5. The Model 8201 then places its status byte on the bus to be read by the controller.
6. The contrlller then sets the ATN line low and places SPD (Serial Poll Enable) on the bus to end the serial polling sequence.

Steps 3 trough 5 may be repeated for other insruments on the bus by using the correct talk address for each instrument. ATN must be true when the talk address is transmitted and false when the status byte is read.

4.10 DEVICE-DEPENDENT COMMAND PROGRAMMING

IEEE-488 device-dependent commands are sent to the Model 8201 to control various operating conditions such as display modify, operating mode, output and parameter insertion. Each command is made up of an ASCII alpha character followed by one or more numbers designating specific parameters. For example the output waveform is programmed by sending an ASCII "U" followed by a number representing the output. The IEEE bus treats device-dependent commands as data in that ATN is high when the commands are transmitted.

A number of commands may be grouped together in one string. The Model 8201 will ignore all nonprintable ASCII characters (00 HEX through 20 HEX) except the "CR" (carriage return). A command string is terminated by an ASCII "CR" (carriage return) character (0D HEX) or by an "EOI" (end or identify) with the last character which tells the instrument to execute the command string.

If an illegal command or command parameter is present within a command string, the instrument will:

1. Ignore the entire string.
2. Display appropriate front panel error message.
3. Set certain bits in its status byte.
4. Generate an SRQ if programmed to do so.

These programming aspects are covered in paragraphs 4.12.1 and 4.12.2.

****
** NOTE **
****

Before performing a programming example, it is recommended that the instrument be set to its default values by sending an SDC over the bus. See paragraph 4.9.6 for information on using the SDC command.

In order to send a device-dependent command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8201 to listen.
3. Set ATN false.
4. Send the command string over the data bus one byte at a time.

****
** NOTE **
****

REN must be true when attempting to program the Model 8201.

Commands that affect the Model 8201 are listed in Table 4-10. All the commands listed in the Table 4-11 are covered in detail in the following paragraphs.

Table 4-10. Device-Dependent Command Summary

Mode	Command	Description
Display Modify	D0	Frequency
	D1	Amplitude
	D2	Offset
	D3	Symmetry
	D4	Pulse Width
	D5	Pulse Delay
	D6	Internal Trigger Period
	D7	Burst Count
	D8	Leading Edge Rise Time
	D9	Trailing edge Fall Time
Operating Mode	V0	VCO Off
	V1	VCO On
	E0	Ext Freq Off
	E1	Ext Freq On
	P0	Normal Pulse
	P1	Delayed Pulse
	P2	Double Pulse
	G0	Gated Mode Off
	G1	Gated Mode On
	T0	Triggered Mode Off
	T1	Triggered Mode On
	B0	Burst Mode Off
	B1	Burst Mode On
Trigger Slope	TS0	Positive Trigger Slope
	TS1	Negatve Trigger Slope
Trigger Level	TM0	Internal Trigger Stimulus
	TM1	External Trigger Stimulus

Table 4-10. Device Dependent Command Summary (continued)

Mode	Command	Description
Waveform	U0	Output Disabled
	U1	Sine wave
	U2	Triangular wave
	U3	Rectangular wave
	U4	Pulse
	U5	Pulse Complement
	U6	Positive Rectangular Wave - Fixed Base Line
	U7	Positive Pulse - Fixed Base Line
	U8	Positive Pulse Complement - Fixed Base Line
	U9	Negative Rectangular Wave - Fixed Base Line
	U10	Negative Pulse - Fixed Base Line
	U11	Negative Pulse Complement - Fixed Base Line
Setups	STOn	Store Front Panel Setup At n Location.
	RCLn	Recall Front Panel Setup From n Location. n = 0 to 9
Parameter Insertion	FRnE+/-n	Set Frequency. Limits: 2.0E-3 to 20.0E+6
	PRnE+/-n	Set Period. Limits: 50E-9 to 500E0
	AMnE+/-n	Set Amplitude. Limits: 1.0E-3 to 15.0E+0
	OFnE+/-n	Set Offset. Limits: +/-.01E-3 to +/-7.5E+0 (offset setting is amplitude dependent)
	SYn	Set Symmetry. Limits: 10 to 90 (symmetry setting is frequenct dependent)
	PWnE+/-n	Set Pulse Width. Limits: 25E-9 to 25E-3
	PDnE+/-n	Set Pulse Width. Limits: 50E-9 to 25E-3
	TPnE+/-n	Set Trigger Period. Limits: 0.05E-3 to 1000E0
	TBn	Set Burst Count. Limits: 2 to 500000
	LEnE+/-n	Set Leading Edge. Limits: 10E-9 to 10E-3
	TEn	Set Trailing Edge. Limits: 3 digits with the same decimal point and exponent as programmed for LE.
Triggering	TT	One Shot In Triggered Mode
Readback	N0	Frequency Prefix: FREQ *
	N1	Amplitude Prefix: AMPL
	N2	Offset Prefix: OFST
	N3	Symmetry Prefix: SYMM
	N4	Pulse Width Prefix: PLSW
	N5	Pulse Delay Prefix: PLSD
	N6	Trigger Period Prefix: TRGP
	N7	Burst Prefix: BRST
	N8	Leading Edge Prefix: LEDG
	N9	Trailing Edge Prefix: TEDG
	N10	Period Prefix: PERD **
	N11	Ext Freq Prefix: EXTF

Table 4-10. Device-Dependent Command Summary (Cont.)

Mode	Command	Description
	N12	Pulse Errors Prefix: PERR
	N13	Error Status Prefix: STAT
	N14	Machine Status Prefix: 82xx ***
Reading Format	X0	Prefix on, no leading zeroes
	X1	Prefix off, no leading zeroes
	X2	Prefix on, with leading zeroes
	X3	Prefix off, with leading zeroes
Terminator	Z0	CR,LF with EOI
	Z1	CR,LF without EOI
	Z2	LF,CR with EOI
	Z3	LF,CR without EOI
	Z4	CR with EOI
	Z5	CR without EOI
	Z6	LF with EOI
	Z7	LF without EOI
	Z8	No terminator with EOI
	Z9	No terminator without EOI
SRQ Mask	Q0	No mask
	Q1	SRQ on ready
	Q2	SRQ on reading done
	Q4	SRQ on pulse error
	Q8	SRQ on error

* String length for all proceedings is (Prefix) 11 characters (term)
** This prefix will occur in pulse output mode.
*** String length changes to (Prefix) 13 characters (term)

4.10.1 Display Modify (D)

The display modify command controls what the Model 8201 places on the display. The ten parameters associated with the display command set the instrument to display the frequency, amplitude, offset, symmetry, pulse width, pulse delay, internal trigger period, burst count, rise and fall times. The display mode may be programmed by sending one of the following commands:

D0 = Frequency
D1 = Amplitude
D2 = Offset
D3 = Symmetry
D4 = Pulse Width
D5 = Pulse Delay
D6 = Internal Trigger Period
D7 = Burst Count
D8 = Rise Time
D9 = Fall Time

4.10.2 Operating Mode (V, E, P, G, T, B)

This command gives the user control over the operating mode for the Model 8201. The operating mode may be programmed by sending one of the following commands:

V0 = VCO Mode Off
V1 = VCO Mode On

E0 = External Frequency Mode Off
E1 = External Frequency Mode On

P0 = Delayed Pulse or Double Pulse Mode Off (normal pulse)
P1 = Delayed Pulse Mode On
P2 = Double Pulse Mode On

G0 Gate Mode Off
G1 = Gate Mode On

T0 = Triggered Mode Off
T1 = Triggered ode On

B0 = Burst Mode Off
B1 = Burst Mode On

4.10.3 Trigger Slope (TS)

The slope selection command gives the user control over the triggering slope which is applied to the TRIG IN/EXT FREQ BNC terminal. The slope mode may be programmed by sending one of the following commands:

TS0 = Positive Trigger Slope
TS1 = Negative Trigger Slope

4.10.4 Trigger Mode (TM)

The trigger mode selection command gives the user a choice between an external stimulus or an internal periodical stimulus. The trigger mode may be programmed by sending one of the following commands:

TM0 = Internal Trigger Mode
TM1 = External Trigger Mode

4.10.5 Waveform (U)

The waveform commands give the user control over the output waveform. The six parameters which are associated with the waveform commands, set the instrument to output sinewave, triangle, squarewave, pulse and pulse complement. The command "U" also gives the user control over the output disable mode. The waveform may be programmed by sending one of the following commands:

U0 = Output Disable (*)	U6 = Positive Rectangular Wave - Fixed Base Line
U1 = Sine	U7 = Positive Pulse - Fixed Base Line
U2 = Triangle	U8 = Positive Pulse Complement - Fixed Base Line
U3 = Rectangular	U9 = Negative Rectangular Wave - Fixed Base Line
U4 = Pulse	U10= Negative Pulse - Fixed Base Line
U5 = Pulse Complement	U11= Negative Pulse Complement - Fixed Base Line

(*) Can not be selected through front panel programming. Output is enabled with the commands U1 through U11.

4.10.6 Setups (STO, RCL)

The setups commands select the memory location where the actual setup is to be stored (STO) or from where recalled (RCL). To store or recall a setup use one of the following commands:

STOn
RCLn

Where n may range from 0 to 9. n is the memory address the setup is to be stored or from where the setup is to be recalled.

4.10.7 Frequency (FR,PR)

This command gives the user control over the frequency generated by the Model 8201. Normally, when the function generator is set to operate in sine, triangle or squarewave, the repetition rate is programmed in frequency units - Hz. When the instrument is set to operate in pulse mode, the repetition rate is programmed in period units - Sec. The frequency may be programmed by sending one of the following commands:

FRn = set Frequency
PRn = set Period

Where n is the selected frequency in Hz or the selected period in Sec in engineering format e.g.(D.DDEsignD). The exponent and the sign are optional. The frequency may range from 2.00E-3 to 20.00E+6. The period may range from 50.0E-9 to 500E0.

4.10.8 Amplitude (AM)

This command gives the user control over the amplitude of the output signal which is generated by Model 8201. The amplitude may be programmed by sending a command using the following format:

AMn

Where n is the selected amplitude in volts in engineering format e.g.(D.DDEsignD). The exponent and the sign are optional. The amplitude may range from 1.0E-3 to 15.0E+0.

4.10.9 Offset (OF)

The offset command gives the user control over the DC offset which is generated by Model 8201. The offset may be programmed by sending a command using the following format:

OFn

Where n is the selected offset in volts in engineering format e.g.(signD.DDEsignD). The exponent and the sign are optional. The offset may range from -6.70 to +6.70.

****
** NOTE **
****

The offset is amplitude dependent. The peak amplitude plus the offset should not exceed 15 volts into open circuit or 7.5 volt into 50 ohms. If the Model 8201 receives an improper offset value, an "OFSS Err" message will be displayed for one second and the entire string will be ignored. Changing the amplitude's internal attenuator will automatically change the offset range. Refer to paragraph 3.6.10 for allowable amplitude - offset windows.

4.10.10 Symmetry (SY)

This command gives the user control over the duty cycle of the output signal which is generated by Model 8201. The symmetry may be programmed by sending a command using the following format:

SYn

Where n is the selected symmetry in percent in engineering format e.g.(DDEsignD). The exponent and the sign are optional. The symmetry may range from 10% to 90%.

****
** NOTE **
****

The symmetry limits are automatically checked against the frequency, not to exceed the minimum of positive or negative transition of less than 25 nSec. If the selected symmetry exceed this limit, an error message will be displayed and the entire string will be ignored. more details on error messages are given in paragraph 3.5.4.2.

4.10.11 Pulse Width (PW)

The pulse width command selects the width of the pulse in the pulse mode. The pulse width may be programmed by sending a command of the following format:

PWn

Where n is the selected pulse width in seconds in engineering format e.g.(DDEsignD). The exponent and the sign are optional. The pulse width may range from 25E-9 to 25E-3 seconds.

4.10.12 Pulse Delay (PD)

This command gives the user control over the delay between the pulse generated by the Model 8201 and the synchronous signal from the SYNC output terminal. This command also gives the user control over the delay between the two pulses in the double pulse mode of operation. The pulse delay may be programmed by sending a command using the following format:

PDn

Where n is the selected pulse delay in seconds in engineering format e.g.(signDDEsignD). The exponent and the sign are optional. The pulse delay may range from 50E-9 to 25E-3 seconds.

4.10.13 Trigger Period (TP)

This command gives the user control over the period of the internal triggering stimulus which is generated repeatedly by the Model 8201. The trigger period may be programmed by sending a command using the following format:

TPn

Where n is the selected trigger period in seconds in engineering format e.g.(signDDEsignD). The exponent and the sign are optional. The period may range from 0.05E-3 to 1000E0 seconds.

4.10.14 Burst (TB)

The burst command gives the user control over the number of burst cycles that the Model 8201 will generate, when triggerd, in the burst operating mode. The burst count may be programmed by sending a command using the following format:

Tn

Where n is the selected burst count in engineering format e.g.(DDDDDDEsigD). The exponent and the sign are optional. The burst count may range from 2 to 500000.

4.10.15 Leading/Trailing Edge (LE,TE)

The LE and TE commands are used to modify the rise and the fall times of the leading and trailing edges respectively. Rise and Fall times are independently selectable within 5 overlapping ranges. Table 3-4 summarizes the rise/fall time ranges. When programming the rise and fall times, the operator must keep the following in mind:

1. Changing the rise time range automatically changes the fall time range. It is therefore suggested to first program the rise time and then proceed with programming the fall time. Also when programming the Model 8201 with one long string and TE appears before LE, The value for TE would no longer be expected correct.

2. In some cases, it is possible to select a rise time value within an overlapping range and thereby limiting the fall time span to an undesirable range. To avoid such error, program the required rise time value exactly as it is shown in Table 3-4. i.e if dynamic range no 4 is required, (see Table 3-4) and a rise time of 5 uSec is programmed, the number must be entered as follows: 5E-6. The same value could be entered as 5.0E-6 but then range number 3 would be selected instead.

3. The fall time value must be entered with the same exponent as was selected for the rise time and with the decimal point placed as required and summarized in Table 3-4. Following the above example, a fall time of 2 uSec in range no 4 should be programmed: 2E-6 otherwise the Model 8201 will detect a programming error.

4.10.16 Triggering (TT)

The "TT" and GET commands are used to trigger the Model 8201 over the IEEE bus (see GET 4.9.7). When in triggered mode, and a "TT" or GET command is sent through the bus, the Model 8201 will output one complete cycle of the selected waveform. When in the Burst mode Model 8201 will output a burst of waveforms. When in Internal Trigger mode a "TT" or GET command will be ignored.

Table 4-12. SRQ Mask Legal Commands

Bit Number	B3	B2	B1	B0 (LSB)
Command	Error	Pulse Error	Ready	Reading Done
Q0	NO	NO	NO	NO
Q1	NO	NO	NO	YES
Q2	NO	NO	YES	NO
Q3	NO	NO	YES	YES
Q4	NO	YES	NO	NO
Q5	NO	YES	NO	YES
Q6	NO	YES	YES	NO
Q7	NO	YES	YES	YES
Q8	YES	NO	NO	NO
Q9	YES	NO	NO	YES
Q10	YES	NO	YES	NO
Q11	YES	NO	YES	YES
Q12	YES	YES	NO	NO
Q13	YES	YES	NO	YES
Q14	YES	YES	YES	NO
Q15	YES	YES	YES	YES

****
** NOTE **
****

There are 16 legal SRQ mask commands that are possible with the Model 8201. Table 4-12 lists all combinations. e.g selecting Q5, Model 8201 will request service when one of reading done or pulse error occurs.

Status Byte Format: The status byte contains information relating to data and error conditions within the instrument. Table 4-13 lists the meaning of the various bits. The status byte is obtained by using the SPE,SPD polling sequence described in paragraph 4.9.8

Table 4-13. Status Byte Interpretation

Bit Number	B7(MSB)	B6	B5	B4	B3	B2	B1	B0 (LSB)
Interpretation	0	rqs	0	0	Error	Pulse Error	Ready	Reading Done

The various bits in the status byte are described below:

0. Reading done: Set after completing a measurement cycle in the EXT FREQ operating mode. The reading done bit is cleared after Model 8201 was addressed to talk in N11 mode.

1. Ready: Set after power-up. This bit is cleared when the Model 8201 receives a command and set again when the instrument have completed to decode the command (Model 8201 is ready for the next command string).

2. Pulse error: Set if an illegal inter-parameter set of parameters have been received and the function generator was set to operate in pulse mode of operation. This bit is - not - cleared by reading the pulse error status and will remain set as long as a pulse error is detected.

3. Error: Set if an illegal command have been received or improper parameter occured in the last measurement cycle. This bit is cleared by reading the error status string - N13.

6. Rqs: Model 8201 will set this bit if one or more conditions for service request occured and the SRQ mask for at least one of those service request condition was enabled. This bit is cleared by reading the Status Byte using the SPE,SPD polling sequence.

****
** NOTES **
****

1. Once the Model 8201 has generated a SRQ, its status byte should be read to clear the SRQ line. Otherwise the instrument will continuously assert the SRQ line.

2. The Model 8201 may be programmed to generate a SRQ for more than one condition simultaneously. For example, to set SRQ mask bits for a SRQ if an pulse error occurs and when the instrument is ready for the next string, the following command would be sent: Q6. All possible mask combinations are listed in Table 4-12.

3. If the instrument is programmed to generate a SRQ when reading is done, it will generate the SRQ only once when the reading is complete; the SRQ may be cleared by reading the status byte. The reading done bit in the status byte may then be cleared by requesting a normal reading from the instrument - N11.

4.11 READING FROM MODEL 8201

The Reading sequence is used to obtain, from Model 8201, various information strings such as frequency, amplitude, symmetry or operating modes. Each information string is made up of ASCII alpha and alphanumeric characters. For more details on the information strings format refer to paragraph 4.11.1.

The reading sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The Model 8201 is addressed to talk.
3. The controller sets ATN false.
4. The instrument sends the information string over the bus one byte at a time.
5. The controller recognizes that the string is terminated.
6. The controller sets the ATN line true.
7. The UNT (untalk) command is placed on the bus by the controller.

****
** NOTE **
****

Most controllers use the CR (Carriage Return) or LF (Line Feed) character to terminate their input sequences, but other techniques may be used as well to recognize the end of input sequence (for example the EOI line is low on the bus during the transfer of the last byte).

4.11.1 Data Control commands (N)

The Data Control commands allows access to information concerning present operating conditions of the instrument. When the data control command is given, the Model 8201 will transmit appropriate data string information the next time the intrument is addressed to talk. Model 8201 Data Control commands include:

N0	Send Frquency data string
N1	Send Amplitude data string
N2	Send Offset data string
N3	Send Symmetry data string
N4	Send Pulse Width data string
N5	Send Pulse Delay data string
N6	Send Trigger Period data string
N7	Send Burst data string
N8	Send Leading Edge data string
N9	Send Trailing Edge data string
N10	Send Pulse Period data string
N11	Send External Frequency data string
N12	Send Pulse Error data string
N13	Send Error Status string
N14	Send Machine Status string

Table 4-14 shows the general data string format for the first 12 commands.
Table 4-15 shows the interpretation for the pulse error status string - N12
Table 4-16 shows the interpretation for the error status string - N13 while
Table 4-17 shows the interpretation for the machine status string - N14.

****
** NOTES **
****

1. Data strings have fixed length of 11 ASCII characters for the N0 to N12 data strings without prefix and without the terminator. For the N13 data string the length of the string is 15 ASCII characters without the prefix and without the terminator. To the length of the strings add 4 ASCII characters if the data strings are sent with prefix (see paragraph 4.11.3). If the data string is sent with one or two terminators add to the length of the data strings one or two respectively.
2. To make sure the correct data string is received, the data string should be read immediately after sending the command, or incorrect data string may be transmitted.

Table 4-14. Data String Format

Command	Data String Foramat *
N0 - N11	(prefix)+1.23456E+0(CR LF)

* CR LF is normal terminator. The terminator may be changed (see paragraph 4.11.2). The prefixes are listed in Paragraph 4.11.3.

Table 4-15. Pulse Error String Interpretation

Prefix	Error 8	Error 7	Error 6	Error 5	Error 4	Error 3	Error 2	Error 1	
(PERR)	0	0	0	0	0	0	0	0	0 0 0 (term)

Table 4-16. Error String Interpretation

Prefix	Illegal Instruction	Illegal Parameter	OFST Error	Symmetry Error		No Store	No Opt			
(STAT)	0	0	0	0	0	0	0	0	0 0 0 (term)

****
** NOTE **
****

Reading N13 clears the error string status to 0

Table 4-17. Machine Status String Interpretation

	Prefix	D	V	E	P	G	T	B	TS	TM	U	X	Z	Q	(term)
Upon DCL/SDC	(82xx)	0	0	0	0	0	0	0	0	0	01	0	0	00	(term)
Upon power-up	(82xx)	Same as before power off										0	0	00	(term)

Prefix (82XX) defines option status as followes:

8201 - Programmable Function Generator (no option)
8241 - Rise/Fall Time option

****
** NOTE **
****

The Error Satatus Word is cleared by reading U1 Status Word. Reading this status word also cleares the ERROR bit in the SRQ status byte (see paragraph 4.10.16).

4.11.2 Programming the Terminator (Z)

To allow a wide variety of conrollers to be used, the terminator can be changed by sending the appropriate command over the bus. The default value is the commonly used carriage return, line feed (CR LF) sequence (mode Z0). The terminator sequence will assume this default value upon power-up, or after receiving a DCL or SDC.
The EOI line on the bus is usually set low by the device during the last byte of its data transfer sequence. In this way, the last byte is properly identified, allowing variable length data words to be transmitted. The Model 8201 will normally send EOI during the last byte of its data string or status word. The terminator for the Model 8201 may be programmed by sending one of the following commands:

Command	Terminator	
Z0	CR,LF	with EOI
Z1	CR,LF	without EOI
Z2	LF,CR	with EOI
Z3	LF,CR	without EOI
Z4	CR	with EOI
Z5	CR	without EOI
Z6	LF	with EOI
Z7	LF	without EOI
Z8	No terminator	with EOI
Z9	No terminator	without EOI

****
** NOTE **
****

Most controllers use the CR or LF character to terminate their input sequence. Using the NO TERMINATOR mode (Z8 or Z9) may cause the controller to hang up unless special programming is used.

4.11.3 Prefix (X)

The prefix from the data string may be suppressed using this command. When the prefix is suppressed the output data string is 4 byte shorter. The X command is also used to replace leading space character (ASCII 20 HEX) in the data string with character 0 (ASCII 30 HEX). For some controllers an attempt to read a number, instead of a string, will result a reading error because of its inability to read spaces before the first significant digit. To eliminate this problem the Model 8201 should be programmed to send data string with leading zeros. X command parameters include:

X0	Send data string with prefix, without leading zero
X1	Send data string witout prefix, without leading zero
X2	Send data string with prefix, with leading zero
X3	Send data string witout prefix, with leading zero

4.12 FRONT PANEL ERROR MESSAGES

The process of programming the Model 8201 involves the proper use of syntax. Syntax is defined as the orderly or systematic arrangement of programming commands or languages. The Model 8201 must receive valid commands with proper syntax or it will:

1. Ignore the entire commands string in which the invalid command appears.
2. Set appropriate bits in the status byte and error word.
3. Generate an SRQ if programmed to do so.
4. Display an appropriate front panel message.

4.12.1 ILL INS (Illegal Instruction) Error

An ILL INS error results when the Model 8201 receives an invalid command such as A0. This command is invalid because no such letter exist in the instruments programming language.
When such an error occurs, the following message will be displayed on the Model 8201 for about one second:

ILL InS

4.12.2 ILL PAR (Illegal Parameter) Error

An ILL PAR error occurs when the numeric parameter associated with a legal command letter is invalid. For example, the command D10 has an invalid option because the Model 8201 has no display mode associated with that number.
When such an error occurs, the following message will be displayed on the Model 8201 for about one second:

```
------------
  ILL PAr
------------

**********
** NOTE **
**********
```

There are more error messages associated with front panel programming. All error messages are discussed in details in Section 3 of this manal.

4.12.3 No Option Message

Option 40 - The option 40 must be installed in the instrument before the operator will have the capability to program the rise and fall times. When programming through the GPIB a device dependent commands which is associated with option 40 , and option 40 is not installed, the following message will be displayed:

```
----------------------
       no oPt
----------------------

**********
** NOTE **
**********
```

There is no additional modifications in software after options 40 is installed. When option is first installed, the internal circuitry will automatically sense its presence and will eliminate the no option message.

4.12.4 No Storage Message

It is possible that the Model 8201 will loose the entire setups storage due to one of the following events:

1. Back-up battery power was completely drained
2. RAM was replaced
3. A component in the back-up circuitry was replaced
4. A component associated with the data bus was replaced

When one of the previously described failure occurs, and the user attempts to recall a setup through the GPIB, the function generator will display a "no store" message.

SECTION 5

MAINTENANCE AND PERFORMANCE TESTS

5.1 INTRODUCTION

This section provides maintenance, service information, and performance tests for the Model 8201 and Lead/Trail control option (option 40). Fuse replacement procedure, line voltage selection and options installation procedure are also included.

****
** WARNING **
****

The procedures described in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps covered in this section may expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

5.2 LINE VOLTAGE SELECTION

The Model 8201 may be operated from either 115V o 230V nominal 50-60Hz power sources. A special transformer may be installed for 100V and 200V ranges. The instrument was shipped from the factory set for an operating voltage of 230V. To change the line voltage, proceed as follows:

****
** WARNING **
****

Disconnect the Model 8201 from the power cord and all other sources before changing the line voltage setting.

1. Using a flat-blade screwdriver, place the line voltage selection switch in the desired position. The voltages are marked on the selection switch.

2. Install a power line fuse consistent with the operating voltage. See paragraph 5.3.

****
** CAUTION **
****

The correct fuse type must be used to maintain proper instrument protection.

5.3 FUSE REPLACEMENT

The Model 8201 has a line fuse to protect the instrument from excessive current. This fuse may be replaced by using the procedure described in the following :

****
** WARNING **
****

Disconnect the instrument from the power line and from other equipment before replacing the fuse.

1. Place the end of a flat-blade screwdriver into the slot in the LINE FUSE holder on the rear panel. Push in and rotate the fuse carrier one quarter turn counterclockwise. Release the pressure on the holder and its internal spring will push the fuse and the carrier out of the holder.

2. Remove the fuse and replace it with the proper type using Table 5-1 as a guide.

****
** CAUTION **
****

Do not use a fuse with a rating higher than specified or instrument damage may occur. If the instrument persistently blows fuses, a problem may exist within the instrument. If so, the problem must be rectified before continuing operation.

Table 5-1. Line Fuse Selection

Power Line Voltage	Fuse Type
90 -125V	0.63 A, 250V, 5x20 mm
195-250V	0.315A, 250V, 5x20 mm

5.4 LEAD/TRAIL OPTION INSTALLATION (option 40)

The lead/trail option expands the capability of the Model 8201 by allowing to adjust the the rise and fall times of the output pulse. If purchased with the Model 8201, the option will be factory installed; however, the instrument may be easily upgraded in the field by installing the option as follows:

1. Remove the top cover of the instrument as described in the disassembly instructions in paragraph 5.7.

****
** WARNING **
****

Disconnect the line cord and test leads from the instrument before removing the top cover.

2. Remove the counter control board.
3. Slide the option board along the card guides and push the card down until it locks into place as shown in Figure 5-1.

****
** CAUTION **
****

Make sure that the option is plugged correctly to the main connector that is, when the option board is secured into place, no pin on the main board should by left free.

4. Solder the loose end of the two wires: one to the output board and one to the pulse generation board. Use Figure 5-1 to locate wires and connection points.
5. Insert a 4-40 screw through the supporting bracket to secure the board to its place and to prevent the option from loosening during transit.

6. Replace the top cover.

7. Turn on the power and wait until the power up procedure is complete. Then depress the button which is marked with the number 2 until the light next to LEAD turns on. The instrument is now ready to accept the rise time parameters. Procedures to operate the instrument in the pulse mode with variable rise and fall times are give in Section 3.

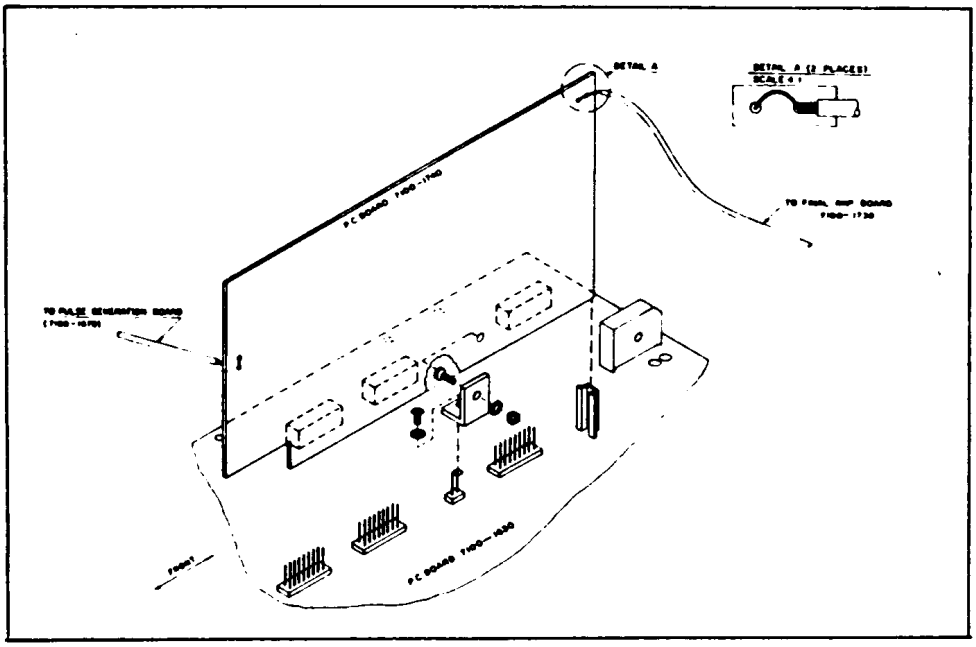

Figure 5-1. Lead/Trail Option (option 40) Installation.

5.5 DIASSEMBLY INSTRUCTIONS

If it is necessary to troubleshoot the instrument or replace a component, use the following disassembling procedure to remove the top cover:

1. Remove the two screws that secure the top cover to the rear panel.

2. Grasp the top cover at the rear and carefully lift it off the instrument. When the tabs at the front of the cover clear the front panel, the cover may be pulled completely clear.

3. When replacing the top cover, reverse the above procedure; be sure to install the tabs at the front panel before completely installing the cover.

5.6 SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

MOS devices are designed to operate at a very high impedance levels for low power consumption. As a result, any normal static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. When handling such devices, use precautions which are described in the following to avoid damaging them.

1. The MOS ICs should be transported and handled only in containers specially designed to prevent static build-up. Typically, these parts will be received in static-protected containers of plastic or foam. Keep these devices in their original containers until ready for installation.

2. Remove the devices from the protective containers only at a properly grounded work station. Also ground yourself with a suitable wrist strap.

3. Remove the devices only by the body; do not touch the pins.

4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or table.

5. Use only anti-static type solder sucker.

6. Use only grounded soldering irons.

7. Once the device is installed on the PC board, the device is normally adequately protected, and normal handling resume.

5.7 CLEANING

Model 8201 should be cleaned as often as operating condition require. Thoroughly clean the inside and the outside of the instrument. Remove dust from inaccessible areas with low pressure compressed air or vacuum cleaner. Use alcohol applied with a cleaning brush to remove accumulation of dirt or grease from connector contacts and component terminals. Clean the exterior of the instrument and the front panel with a mild detergent mixed with water, applying the solution with a soft, lint - free cloth.

5.8 REPAIR AND REPLACEMENT

Repair and replacement of electrical and mechanical parts must be accomplished with great care and caution. Printed circuit boards can become warped, cracked or burnt from excessive heat or mechanical stress. The following repair techniques are suggested to avoid inadvertent destruction or degradation of parts and assemblies.

Use ordinary 60/40 solder and 35 to 40 watt pencil type soldering iron on the circuit board. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the circuit from the base material. Keep the soldering iron in contact with the PC board for a minimum time to avoid damage to the components or printed conductors. To desolder components use a commercial " solder sipper ", or better, solder removing SOLDER - WICK, size 3. Always replace a component with its exact duplicate as specified in the parts list.

5.9 PERFORMANCE CHECKS

The following performance checks verify proper operation of the instrument, and should normally be used :

a) as part of incoming inspection of instrument specifications;
b) as part of troubleshooting procedure;
c) after any repair or adjustment, before returning instrument to regular service.

5.9.1 Environmental Conditions

Tests should be performed under laboratory conditions having an ambient temperature of 25 +/-5 Deg C and a relative humidity of less than 80%. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

5.9.2 Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure accuracy, turn on the power to the Model 8201 and allow it to warm-up for at least 30 minutes before beginning the performance tests procedure.

5.9.3 Recommended Test Equipment

Recommended test equipment for troubleshooting, calibration and performance checking is listed in table 5-2. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

Table 5-2. Required Test Equipment.

Instrument	Recommended Model	Specifications	Use *
Counter	6007	Rise Time/ Duty Cycl	P, A, T
DMM	4121	.1V- 100V,AC rms,DC	P, A, T
Function Generator	8120	1mHz - 12MHz	P
Synthesizer	Marconi 2019	80KHz-1040MHz	P, A
oscilloscope	Tek 465	100MHz band width	P, A, T
Sampling scope	HP 180C/1810A	1nSec resolution	P, A, T
Distortion analyser	K-H 6900	100Hz - 1MHz	P, A
Spectrum analyser	HP 182T/8557A	10KHz - 350MHz	P
50 ohm feedthrough Termination	Tek 011-0049-01	50ohm, 2W, 1%	P, A

* P= Performance Test, A= Adjustments, T= Troubleshooting

5.10 PERFORMANCE CHECKS PROCEDURE

5.10.1 FREQUENCY

SPECIFICATIONS

Accuracy : +/- 3% of full scale up to .999 Hz
+/- 1 count up to 20MHz

EQUIPMENT

Counter
BNC Cable with a 50 ohm Feedthrough Termination

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Amplitude	1.50V
Offset	0V
Symmetry	50%
Display Modify	FREQ
Operating Mode	Normal
Output	Squarewave

2. Set counter to frequency measurment.
3. Set 8201 frequency and verify counter frequency reading as follows:

8201 SETTING	COUNTER READING
.999 Hz	.996 Hz - 1.020 Hz
1.999 Hz	1.998 Hz - 2.000 Hz
19.99 Hz	19.98 Hz - 20.00 Hz
199.9 Hz	199.8 Hz - 200.0 Hz
1.999 KHz	1.998 KHz - 2.000 Khz
19.99 KHz	19.98 KHz - 20.00 KHz
1999 KHz	1998 KHz - 2000 KHz
1.999 MHz	1.998 KHz - 2.000 MHz
19.99 MHz	19.98 MHz - 20.00 MHz

5.10.2 AMPLITUDE

SPECIFICATIONS

Output Level	: 30V peak to peak max into open circuit 15V peak to peak max into 50 ohm
Accuracy (1KHz)	: +/- 2% of reading from 1.6V to 15.0V +/- 3% of reading from .16V to 1.5V +/- 4% of reading from 16mV to 150mV +/- 5% of reading from 1mV to 15.0mV

EQUIPMENT

DMM
50 ohm Feedthrough Termination
BNC Cable

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Frequency	1 KHz
Amplitude	15 V
Offset	0 V
Symmetry	50%
Display Modify	AMPL
Operating Mode	Normal
Output	Squarewave

2. Set DMM to ACV measurments (RMS).
3. Set 8201 amplitude and attenuators and verify DMM amplitude reading as follows:

8201 SETTING	DMM READING
Square 15.0 V	7.35 V - 7.65 V
Square 1.50 V	.728 V - .773 V
Square 150 mV	72.0 mV - 78.0 mV
Square 15.0mV	7.13 mV - 7.87 mV
Triangle 15.0 V	4.25 V - 4.41 V
Triangle 1.50 V	.420 V - .446 V
Triangle 150 mV	41.5 mV - 45.0 mV
Triangle 15.0mV	4.11 mV - 4.55 mV
Sine 15.0 V	5.22 V - 5.42 V
Sine 1.50 V	.514 V - .546 V
Sine 150 mV	51.1 mV - 55.3 mV
Sine 15.0mV	5.05 mV - 5.59 mV

5.10.3 OFFSET

SPECIFICATIONS

Range and Accuracy :

Offset Range	Offset accuracy
0 E 0 - +/- 6.70 E 0	1% +/-(1% of Ampl + 40mV)
0 E 0 - +/- 2.13 E 0	2% +/-(1% of Ampl + 10mV)
0 E-3 - +/- 670 E-3	2% +/-(1% of Ampl + 4mV)
0 E-3 - +/- 213 E-3	3% +/-(1% of Ampl + 1mV)
0 E-3 - +/- 67 E-3	3% +/-(1% of Ampl + 1mV)
0 E-3 - +/- 23.2 E-3	4% +/-(1% of Ampl + 1mV)

EQUIPMENT

DMM
Scope
50 ohm Feedthrough Termination
BNC Cable

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Frequency	1 KHz
Amplitude	1.6 V
Offset	5.0 V
Symmetry	50%
Display Modify	OFST
Operating Mode	Normal
Function	Sine

2. Set DMM to DCV measurment.

3. Set 8201 amplitude and verify DMM amplitude reading as follows:

8201 AMPLITUDE SETTING	8201 OFFSET SETTING	DMM READING
1.6 V	5.00 V	4.894 V - 5.106 V
.48 V	2.00 V	1.945 V - 2.055 V
.16 V	500 mV	484.4 mV - 515.6 mV
48 mV	200 mV	192.2 mV - 207.8 mV
16 mV	50 mV	47.3 mV - 52.7 mV
1 mV	20.0mV	18.2 mV - 21.8 mV

5.10.4 SQUAREWAVE CHARECTERISTICS

SPECIFICATIONS

Transition time : <12 nsec (10% to 90% of amplitude)
Abberation : <5% of amplitude

EQUIPMENT

Scope
Sampling Scope, terminated with 20db/50 ohm feedthrough attenuator
50 ohm Feedthrough Termination
BNC Cable

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Frequency	10 MHz
Amplitude	15 V
Offset	0 V
Symmetry	50%
Display Modify	FREQ
Operating Mode	Normal
Output	Squarewave

2. Set 6007 Counter to Rise and Fall Time measurment and verify Rise Time and Fall Time as followes: (Sampling scope may be used in absence of 6007 counter. Use 20db/50 ohm attenuator)

Rise Time	<12 nsec
Fall Time	<12 nsec

3. Set scope and verify as follows:

Pulse Overshoot	<5% of amplitude

5.10.5 SINE CHARECTERISTICS

SPECIFICATIONS

Total Harmonic distortion : <1% from 2 mHz to 19.9 Hz
<.5% from 20 Hz to 100 KHz
<1% from 100 KHz to 1 MHz

Harmonic Signals : More than 25dB below the carrier level from 1 MHz to 20 MHz

EQUIPMENT

Distortion Analyzer
Spectrum Analyser
BNC cable with 50 ohm Feedthrough termination

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Frequency	10 Hz
Amplitude	10 V
Offset	0 V
Symmetry	50%
Display Modify	FREQ
Operating Mode	Normal
Output	Sine

2. Set Distortion Analyzer to % Distortion measurements and verify distortion reading as follows:

8201 SETTING	DISTORTION ANALYZER READING
10.0 Hz	<1.0%
100 Hz	<0.5%
1.00 KHz	<0.5%
10.0 KHz	<0.5%
100 KHz	<0.5%
1.00 MHz	<1.0%

3. Tune Spectrum Analyser for minimum display amplitude and adjust gain so that fundamental corresponds to 0dB.
4. Change 8201 frequency setting to 10 MHz .
5. Verify that all harmonics are less than -25dB
6. Change 8201 frequency setting to 20 MHz.
7. Verify that all harmonics are less than -25dB.

5.10.6 SINE FLATNESS

SPECIFICATIONS

Level Flatness : <0.5dB up to 1.99 MHz
<1.5dB up to 20.0 MHz

EQUIPMENT

Scope
50 ohm Feedthrough termination
BNC cable

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Freuency	1.99 KHz
Amplitude	15 V
Offset	0 V
Symmetry	50%
Display Modify	FREQ
Operating Mode	Normal
Output	Sine

exactly 6 vertical divisions.

3. Change 8201 Frequency setting to 1.99MHz. Verify that peak to peak of displayed waveform is greater than 5.7 divisions.

4. Change 8201 Frequency setting to 20MHz. Verify that peak to peak of displayed waveform is greater than 5.1 divisions.

5.10.7 SYMMETRY

SPECIFICATIONS

Variable Range	:	10% to 90% +/-2% from 2mHz to 4 MHz. Not to exceed a positive or negative transition of less than 25 nSec above 4 MHz
Fixed Range	:	50% +/- 0.2% with symmetry switch in OFF position.

EQUIPMENT

6007 Counter
50 ohm Feedthrough Termination
BNC Cable

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Frequency	19.9 KHz
Amplitude	1.50 V
Offset	0 V
Symmetry	50%
Display Modify	SYM
Operating Mode	Normal
Output	Square wave

2. Set counter to Duty Cycle mesurments and verify that symmetry is 50% +/- 0.2%

3. Change symmetry setting and verify that symmetry range is 10% to 90%.

4. Verify with counter that symmetry accuracy from 10% to 90% is with in +/- 2% .

5. Set 8201 frequency setting to 1.99 MHz and repeat steps 2, 3 & 4.

5.10.8 TRIGGER, GATE, MANUAL

SPECIFICATIONS

Each trigger input cycle or manual button press generates a gated output signal or a single output cycle

EQUIPMENT

8120 Function Generator
Scope
2 x 50 ohm Feedthrough Termination
2 x BNC Cables

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Frequency	19.9 KHz
Amplitude	15 V
Offset	0 V
Symmetry	50%
Operating Mode	Gated
Trigger Level	Control set to mid-range
Trigger Slope	Positive
Output	Sine

2. Set external 8120 function generator to 1 KHz and 5 V positive pulse. Connect external 8120 function generator to TRIG IN BNC. Check on scope for 8201 output signal.
3. Disconnect external function generator and press the MANUAL push-button. Check on scope for signal present at 8201 output as long as MANUAL button is depressed.
4. Change 8201 setting to Triggered mode.
5. Reconnet external function generator to 8201 TRIG IN terminal.
6. Check on scope for 8201 output signal. A single waveshape is generated on every rising edge of the triggering signal.
7. Change 8201 setting to 10Hz.
8. Disconnect external function generator and press the MANUAL button. check on scope for a single pulse after each time the MANUAL button was depressed. Use TTL output of external function generator to trigger scope externaly whenever necessary.

5.10.9 BURST

SPECIFICATIONS

Each trigger input cycle or manual button press generates at the output a burst of waveforms

EQUIPMENT

8120 Function Generator
Scope
Counter
2 x 50 ohm Feedthrough Termination
2 x BNC Cables
PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Frequency	199 KHz
Amplitude	1.5 V
Offset	0 V
Symmetry	50%
Display Modify	BURST
Burst count	123456
Operating Mode	Burst
Trigger Level	Control set to mid-range
Trigger Slope	Positive
Output	Squarewave

2. Set external 8120 function generator to 1 KHz and triggered mode. Connect external 8120 function generator SYNC out to TRIG IN terminal on Model 8201
3. Set counter to trigger on positive going slope and in totalize mode of operation
4. Connect 8201 OUTPUT to the counter input and reset counter
5. Depress the manual trigger on the external function generator and observe that the counter counts and when completed counting displays 123456
6. Change 8201 burst count to 500000 and repeat steps 4 & 5. Observe that final count is now 500000

5.10.10 PULSE WIDTH

SPECIFICATIONS

Range	: 25 nSec to 25 mSec
Accuracy	: +/- (5% + 5 nSec)
EQUIPMENT	: 6007 Counter Scope 50 ohm Feedthrough Termination BNC Cable

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Period	100 mSec
Amplitude	1.50 V
Offset	0 V
Symmetry	50%
Lead	10nSec
Trail	10nSec
Display Modify	PLS WID
Operating Mode	Normal
Function	Pulse

2. Set Counter as follows: Time interval A to B measurment, Common, A - Positive Slope, B - Negative Slope, DC Coupling, Trigger Level A&B = 0V.
3. Connect 8201 to Channel A of the counter. Set 8201 Pulse Width and Frequency and verify counter reading as follows:

8201 PULSE WIDTH SETTING	8201 PERIOD SETTING	COUNTER READING
25.0 E-3	100 E-3	25.00 mSec +/- 1.25 mSec
2.6 E-3	10.0 E-3	2.600 mSec +/- .130 mSec
1.00 E-3	10.0 E-3	1.000 mSec +/- .050 mSec
100 E-6	1.00 E-3	100.0 uSec +/- 5.0 uSec
10.0 E-6	100 E-6	10.00 uSec +/- .50 uSec
1.00 E-6	10.0 E-6	1.000 uSec +/- .055 uSec

The following ranges are to be checked using an oscilloscope.

4. Connect 8201 OUTPUT to the oscilloscope input and verify measurements as follows:

8201 PULSE WIDTH SETTING	8201 PERIOD SETTING	OSCILLOSCOPE READING
100 E-9	1.00 E-6	100 nSec +/- 10 nSec
25 E-9	100 E-9	25 nSec +/- 6 nSec

5.10.11 DELAY

SPECIFICATIONS

Range : 50 nSec to 25 mSec
Accuracy : +/- (5% + 5 nSec)

EQUIPMENT : 6007 Counter
Scope
BNC cable and 50 ohm Feedthrough Termination

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Period	100 mSec
Amplitude	1.50 V
Offset	0 V
Symmetry	50%
Pulse Width	100 nSec
Lead	10 nSec
Trail	10 nSec
Display Modify	PLS DLY
Operating Mode	Delayed
Function	Pulse

2. Connect the SYNC output from the 8201 to Channel A of the counter. Connect the OUTPUT from the 8201 to Channel B of the counter. Set counter to Time Interval A to B measurement.
3. Set 8201 Pulse Delay and Frequency and verify counter reading as follows:

8201 PULSE DELAY SETTING	8201 PERIOD SETTING	COUNTER READING
25.0 E-3	100 E-3	25.00 mSec +/- 1.25 mSec
2.6 E-3	10.0 E-3	2.600 mSec +/- .130 mSec
2.0 E-3	10.0 E-3	2.000 mSec +/- .100 mSec
.20 E-3	1.00 E-3	200.0 uSec +/- 10.0 uSec
20 E-6	100 E-6	20.00 uSec +/- 1.0 uSec
2.0 E-6	10.0 E-6	2.00 uSec +/- .10 uSec

The following ranges are to be checked using an oscilloscope.

4. Connect 8201 OUTPUT to the oscilloscope input.
5. Change 8201 Operating Mode to Double and Pulse Width to 50 E-6
6. Set oscilloscope and verify measurements as follows:

8201 PULSE DELAY SETTING	8201 PERIOD SETTING	OSCILLOSCOPE READING
200 E-9	1.00 E-6	200.0 n+Sec +/- 15 nSec

5.10.12 RISE/FALL TIME

SPECIFICATIONS

Range : 10 nSec to 10 mSec
Accuracy : +/- (5% + 5 nSec)

EQUIPMENT : Oscilloscope
BNC cable and 50 ohm Feedthrough Termination

PROCEDURE

1. Set 8201 as follows:

CONTROL	POSITION
Period	10 mSec
Amplitude	1.50 V
Offset	0 V
Symmetry	50%
Pulse Width	50 mSec
Lead	10 nSec
Trail	10 nSec
Display Modify	TRAIL
Operating Mode	Normal
Function	Pulse

2. Connect OUTPUT from the 8201 to the oscilloscope.

3. Set 8201 and verify oscilloscope reading as follows:

8201 LEAD/ TRAIL SETTING	8201 PLS SETTING	8201 PER SETTING	OSCILLOSCOPE READING
1.000 E-3	5.0 E-3	10.0 E-3	1 mSec +/- 50 uSec
1000 E-6	5.0 E-3	10.0 E-3	1 mSec +/- 50 uSec
10 E-6	50 E-6	100 E-6	10 uSec +/- .5 uSec
10.0 E-6	50 E-6	100 E-6	10 uSec +/- .5 uSec
1.00 E-6	5.0 E-6	10.0 E-6	1 uSec +/- 50 nSec
100 E-9	.50 E-6	1.00 E-6	100 nSec +/- 5 nSec

5.10.13 EXTERNAL FREQUENCY

SPECIFICATIONS

The Model 8201 measure and display external signals with a fixed resolution of 6 digits.

Sensitivity : 600 mV peak to peak
Accuracy : 0.001%

EQUIPMENT

8120 Function generator
Synthsizer
50 ohm Feedthrough Termination
BNC Cable

1. Set 8201 as follows:

CONTROL	POSITION
Display Modify	X (don't care)
Operating Mode	External frequency
Trigger Level	Control set to mid-range
Trigger Slope	Positive
Output	X

2. Set synthesizer frequency to 10MHz
3. Connect the synthesizer output to the TRIGIN terminal on the Model 8201
4. Observe that the Model 8201 displayes 10.0000E6 +/- 10 counts. Also observe that the decimal point blinks at the rate of the gate time (about 250mSec)
5. Diconnect the synthesizer from the Model 8201
6. Set 8120 frequency to 12 Hz
7. Connect the function geerator to the TRIG IN terminal on the Model 8201
8. Observe that the 8201 displayes about 12.0000E0. Note that exact accuracy is not important as 8120 is accurate only to 3%
9. Change the 8120 frequency setting to 1.2KHz and observe that the 8201 displays about 1.20000E3. As in step 8, exact accuracy is not important.

5.10.14 VCO CONTROL

SPECIFICATIONS

Amplitude : 0 V to 8.5 V DC +/- 20%.
VCO Control
Range : >1000:1 change from frequency setting at 1999 counts

EQUIPMENT

Power Supply
DMM
6003 Counter
50 ohm Feedthrough Termination
2 x BNC Cables

1. Set 8201 as follows:

CONTROL	POSITION
Frequency	1.999 MHz
Amplitude	1.50 V
Offset	0 V
Symmetry	50%
Display Modify	FREQ
Operating Mode	VCO
Output	Square wave

2. Apply power supply output to VCO IN connector and slowly increase power supply amplitude from 0 V to 10 V +/- 20% DC. Verify with counter that output frequency changes from 1.999 MHz to about 2 KHz.

****
** NOTE **
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Performance verification of VCO operation should be carried out with a very clean DC voltage. A noisy Power supply output will cause phase modulation in the 8201 output.

5.10.15 MODULATION - FM

SPECIFICATIONS

Modulating
Signal : DC to 20 KHz external, in Normal Mode
Amplitude : +/-100 mV p-p to >1% deviation from center frequency

EQUIPMENT

Function generator
Scope
50 ohm Feedthrough Termination
2 x BNC Cables

1. Set 8201 as follows:

CONTROL	POSITION
Frequency	100KHz
Amplitude	1.50V
Offset	0V
Symmetry	50%
Display Modify	FREQ
Operating Mode	VCO
Output	Sine

2. Set 8120 function generator to output a sine wave with an amplitude of 200mV and frequency of 1 KHz.
3. Connect 8120 output to the VCO IN terminal on the Model 8201
4. Connect the OUTPUT terminal on the Model 8201 to the scope
5. Set scope and verify that the sine wave from the 8201 is frequency modulated around center frequency
6. Change amplitude setting on the 8120 and observe that the modulation depth of the 8201 signal changes.

5.120.16 MODULATION - PWM

SPECIFICATIONS

Modulating
Signal : DC to 20 KHz external, in Pulse Output Mode.
Amplitude : +/- 250 mV p-p +/- 20% produces >10% deviation from pulse width setting.

EQUIPMENT

Function generator
Scope
50 ohm Feedthrough Termination
2 x BNC Cables

1. Set 8201 as follows:

CONTROL	POSITION
Period	10.0 E-3
Amplitude	1.50 V
Offset	0 V
Symmetry	50%
Pulse Width	1.00 E-3
Display Modify	FREQ
Operating Mode	Normal
Output	Pulse

2. Set 8120 function generator to output a sine wave with an amplitude of 250 mV and frequency of 1 KHz.
3. Connect 8120 output to the PWM Connector on Model's 8201 rear panel.
4. Connect the OUTPUT terminal on the Model 8201 to the oscilloscope
5. Set oscilloscope and verify that the pulse output from the 8201 is width modulated around the center pulse width setting.
6. Reduce amplitude setting on the 8120 and observe that the modulation depth of the 8201 signal changes.

SECTION 6

THEORY OF OPERATION

6.1 INTRODUCTION

This section contains an overall functional description of the function generator as well as detailed circuit analysis of the various sections of the instrument. Information pertaining to the standard IEEE interface, and Lead/Trail option (option 40) are also included.

Information is arranged to provide a description of individual functional circuit blocks. As an aid to understanding, the descriptinns are keyed to accompanying block diagrams and simplified schematics. Detailed schmatics and componenet layout drawings are located at the end of this instruction maual.

6.2 OVEALL FUNCTIONAL DESCRIPTION

The Model 8201 is a fully programmable function generator with 3 standard output functions and two pulse functions. All parameters are adjustable through front panel touch switches or through IEEE programming. Option 40 - Rise/Fall time control is available with the Model 8201. The Model 8201 utilizes very fast discrete analog circuitry to achieve its high performance. Microprocessor and digital circuits control the performance of the analog circuits and permit direct interfacing to the front panel keyboard and display and to the IEEE- 488 GPIB.

A simplified block diagram of the instrument is shown in Figure 6-1. The heart of the function generator is the current generator where two identical currents with opposite polarities are created. These two currents are switched in, on and off, and charge a capacitor causing a voltage ramp up or down which in turn is used to output the triangle and the square waveforms. The triangle waveform is also utilized to generate the sinewave output by using a sine shaper. The three basic waveforms are then amplified or attenuated through the output amplifier and fed to the OUTPUT BNC connector with the capability to drive 50ohms. The triggering circuit control the current generator so as to start the output waveform or to stop it via an external signal. The burst generator is controled by the triggering circuit. The analog signals are controlled by D to A converters. The D to A converters receive the controlling information through serial to parallel converters, directed by the microcontroller.

6.3 ANALOG CIRCUITRY

The following paragraphs contain a description of the current generator, voltage controlled oscillator, sine shaper, trigger circuit, final amplifier and attenuators, counter circuit, pulse generation circuit and rise/fall time control circuit. These circuits may be found on schematic diagrams located at the end of this manual.

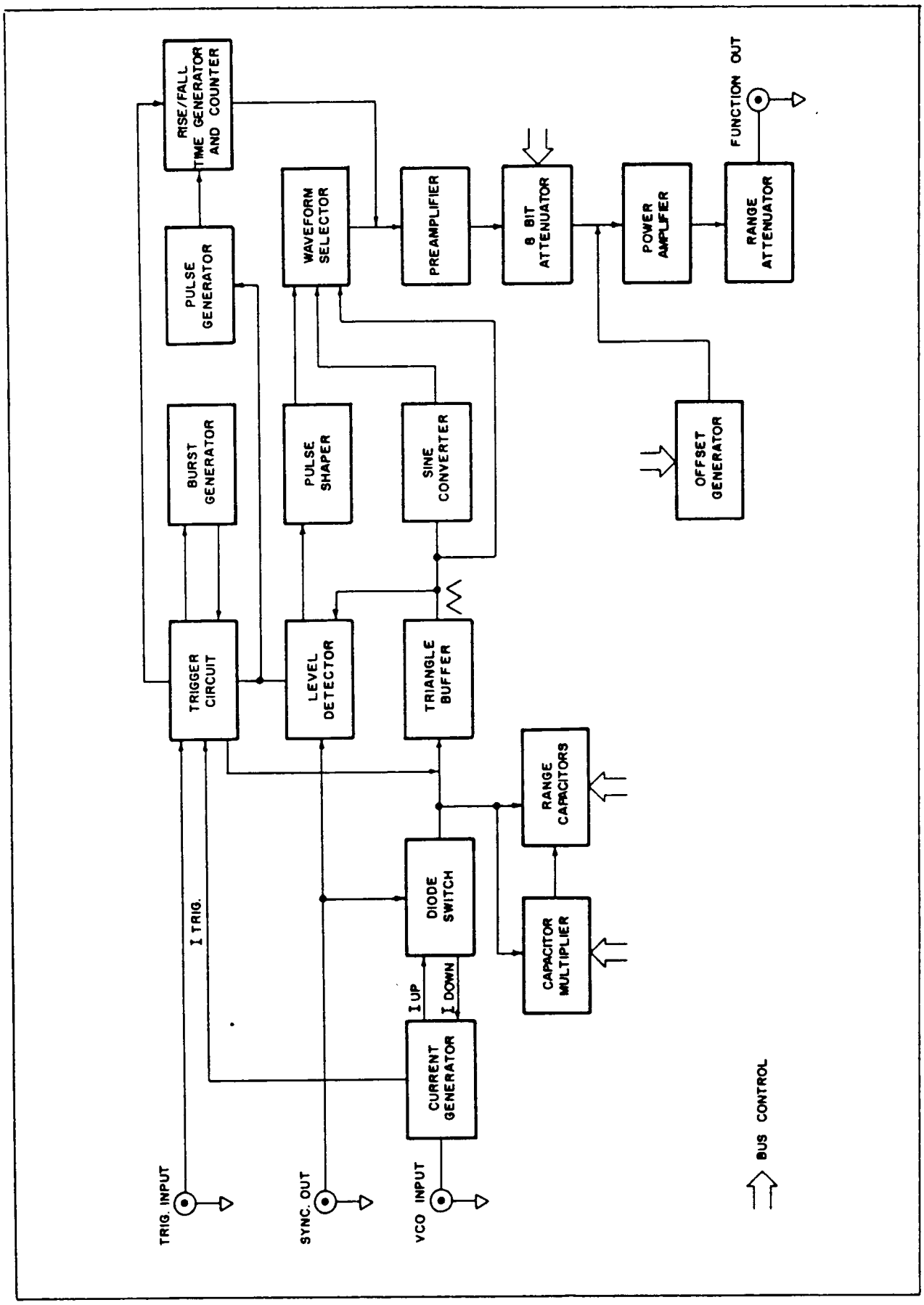

Figure 6-1. Model 8201 Simplified Simplified Block Diagram.

6.3.1 CURRENT GENEATOR

The current generator generates the necessary currents for the VCO and the trigger circuits. Figure 6-2 is a simplified diagram of the current generator. The current generator comprised of the following: Reference source, DAC, up current source, down current source and trigger current source. Each one is discussed in detail below.

REFERENCE SOURCE - The reference source generates the voltage for the DAC. The reference comprises a zener diode CR10, operational amplifier U24 and their associated components. When used as a voltage controlled oscillator, an external voltage is applied to the VCO input terminal. This voltage is then fed through U24 to the current generator.

DAC - The DAC (digital to analog converter) includes U27 (when option 20 is installed, U27 is replaced by U26) and operational amplifier U28. Shift registers U23 and U25 control the digital information to the data inputs of U27. The refernnce for the DAC is provided from the output of the reference source.

UP CURRENT SOURCE -The output of the DAC from U28 pin 6 is applied through the divider R33, R34 and R35 to U31. U31 ogether with U32 and Q7 form a controllable gain amplifier which is digitally controlled by shift register U30. The voltage from the collector of Q7 is then applied to the current generator U33,Q6 and R36 which supply the up current to the VCO.

DOWN CURRENT SOURCE - The output of the DAC from U28 pin 6 is applied through the divider R31, R32 and R36 to U36. U36 together with U37 and Q13 form a controllable gain amplifier which is digitally controlled by shift register U36. The voltage from the collector of Q14 is then applied to the current generator U39, Q15 and R46 which supply the down current to the VCO.

TRIGGER CURRENT SOURCE - The trigger current source is comprised of inverter U29, Q10 and a current generator formed by U34, Q11 and R43. The same controllable gain amplifier which supplies the up current source, supplies the current to the trigger current source. The trigger current source is doubled and inverted for comparison with the up current source.

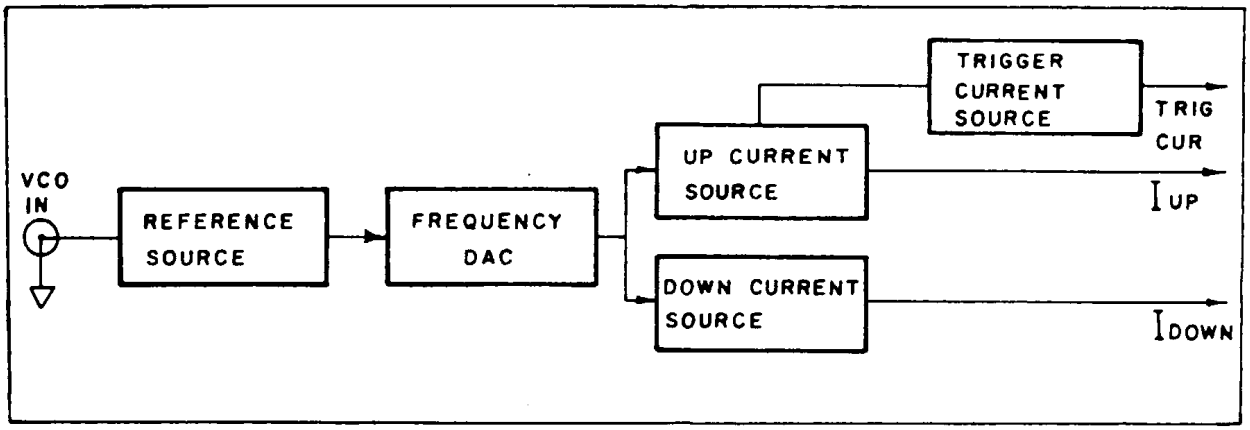

Figure 6-2. Current Generator Simplified Block Diagram.

6.3.2 VOLTAGE CONTROLLED OSCILLATOR

Figure 6-3 is a simplified block diagram of the VCO section. Refer to this Figure in the following description. Assuming that the diode bridge switch is operating in such a way that I up is flowing to the range capacitor. The capacitor is charged with this current which creates a positive going voltage ramp. This voltage ramp is fed through the impedance converter internal to the triangle buffer. This buffer isolates the capacitors from the level detector and provides sufficient voltage amplitude for the level detector. When the voltage ramp reaches a predetermined threshhold level, the level detector operates the diode switch so that the current now flow through the I down source. This causes the same reaction as described above but with opposite direction. The following paragraph describe the voltage controlled oscillator in depth.

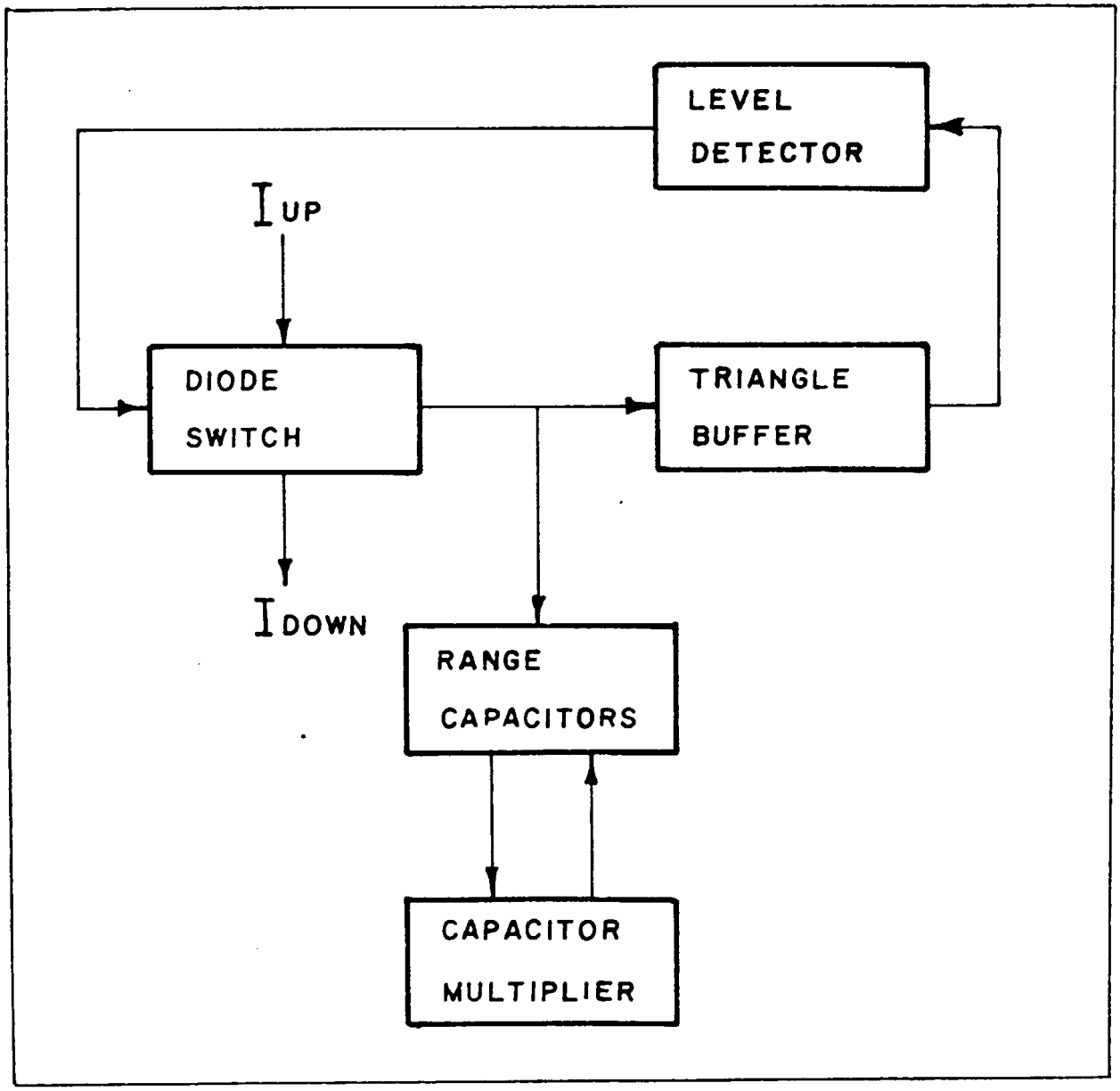

Figure 6-3. VCO Simplified Block Diagram.

DIODE SWITCH - The diode switch consists on the following parts: CR15, CR16, CR17, CR18, CR21 and CR22. The up current is supplied through R70 and the down current is supplied through R71. CR15 and CR16 as well as CR17 and CR18 are connected in series to reduce the feedthrough from the switch drive signal to the range capacitors.

TRIANGLE BUFFER - The triangle buffer includes impedance converter FET Q18, transistors Q19, 20, 21 and Q22 and their associated components.

LEVEL DETECTOR - The level detector consists of U46 and Q23 through Q27. The positive threshold is set by R86 and R95 and the negative threshold is set by R84 and R94. The signals which are then used to switch the diode switch are taken from Q26 and Q27. Q25 with CR31 and CR32 translate the rectangular waveform from the collector of Q24 to a TTL level signal which is then sent to the trigger circuitry.

RANGE CAPACITORS - The frequency of the main output is being generated by charging capacitors wiich also create the triangle waveform. The range capacitors C44, C45, C47, C48, C51, C52, C53 and 54 and are used for the 20Hz to 20MHz ranges. U51 receives the serial data from the digital circuit, converts the serial data to parallel information which is fed to the quad comperator U5. The outputs of the quad comperator are then fed to the bases Q38 through Q41 which in turn selec the correct capacitor combination.

CAPACITOR MULTIPLIER - The capacitor multiplier is used for the 2mHz to 19.9Hz ranges. The function of this circuit is to generate an equivalent large capacitance. The larger values of capacitors are required to generate lower frequencies. The capacitor multiplier consists of U53 ,U54 and their associated components. The multiplier ratio is selected by changing the ranging resistors in the negative feedback path of U54. The ranging resistors are selected by Q43 and U55. The switching control is provided by the serial to parallel converter U51.

6.3.3 SINE SHAPER

The sine shaper consists of a series of differential stages which are formed by the transistor arrays U47, U48 and U49. The differential stages are connected in paralleland receive the drive signal from the triangle buffer output. This circuit takes advantage of the nonlinearity of the transistors and by biasing them to different dc levels, the output of the common collector is shaped to a sinewave. The sinewave is then amplified and rebiased to oscillate around 0V with the differential amplifier which is formed by Q34, U47c, U47b and their associated components.

6.3.4 TRIGGER CIRCUIT

The trigger circuit is active when one of the trigger modes is selected. As long as a triggering signal is not present, the input to the triangle buffer is latched to a certain dc level. Figure 6-4 is a simplified block diagram of the clamp circuit. Refer to this Figure and to the schematic diagrams at the end of this manual throughout the following description. The clamp circuitry in triggered mode or gated mode as well as the trigger logic are described in detail in the following paragraphs.

CLAMP CIRCUIT - When no trigger mode is selected, U64b pin 13 receive a "0" level which sets the transistors Q49 in off state and Q50 in on state. Since the current through Q50 is higher than 2 I up, the difference of the two currents will pass through CR23 and CR24 forcing the voltage at the collector of Q50 to be approximately 1.4V. The voltage of 1.4V will back bias diodes CR19 and CR20 which in turn will not affect the free-running oscillator. When one of the trigger modes is selected, U64b pin 13 receives a "1" level which sets the transistors Q49 in on state and Q50 in off state. Since the current, at the junction of CR19 and CR20, is 2 I up and the current through CR20 is I up, the voltage drop accross CR19 is equale to the voltage drop accross CR20 This clamps the input of the triangle buffer to a level which is set by the clamp voltage generator.
Figure 6-5 shows the waveforms of the clamp circuit in triggered operating mode and Figure 6-6 shows the waveforms of the clamp circuit in gated operating mode.

TRIGGER LOGIC - The triggering signal from the TRIG IN terminal is divided by 4 by R216 and R217 andthen routed to the comperator U71. CR46, CR47 and CR48 protect the comperator input from overloas. Large signals will clamp to +/-5V. The second input of the comperator receives 0V when he selected trigger level is 0V or approximately .4V when the selected trigger level is TTL. R221and R222 provide the best hysteresis window. The triggering slope is selected by applying a "0" or "1" at pins 8 and 13 respectively. The outputs of the comperator are applied through a NAND gate U68d through selector U69 to the clear input of U64b pin 13. U67b, U68c and U69c select one of two signals to be routed to the counter section: the signal from the VCO or the signal from the TRIG IN terminal. U2, R229 and C106 form a pulse stretcher which advises the microcontroller of the status of the triggering signal through CR49 and CR50 . U68a, U68b ,and U70a select one of two signals to be routed to the pulse shaper : the signal from the VCO or the output from the optional pulse generator (Model 8201 only). U70b outputs a TTL siganl which is synchronous with the main generator output waveform.

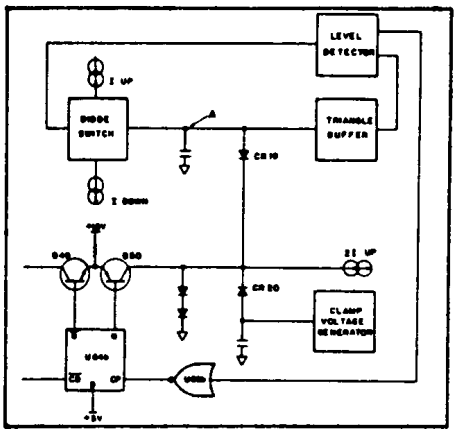

Figure 6-4. Clamp Circuit Simplified Block Diagram.

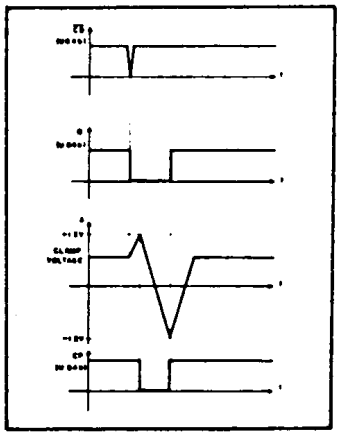

Figure 6-5. Clamp Circuit Waveforms in Triggered Operating Mode.

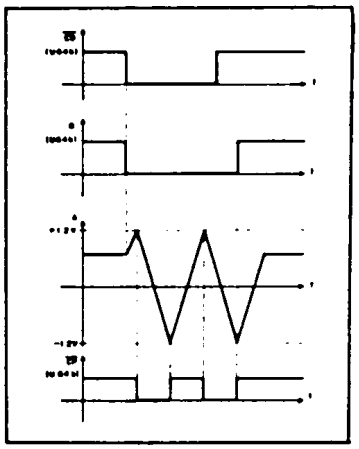

Figure 6-6. Clamp Circuit Waveforms in Gated Operating Mode.

6.3.5 BURST CIRCUIT

The burst circuit comprises programmable counters U59, U60, U61, U62 and U63. Serial to parallel converters U64, U65, U66, U67 and their associated components perform the digital control. Figure 6-7 shows the most important waveforms during the burst operation. In short, the operation of the burst is similar to the triggered mode of operation except the number of triggers to generate the burst is controlled by the microcontroller and programmable counters U59 to U63.

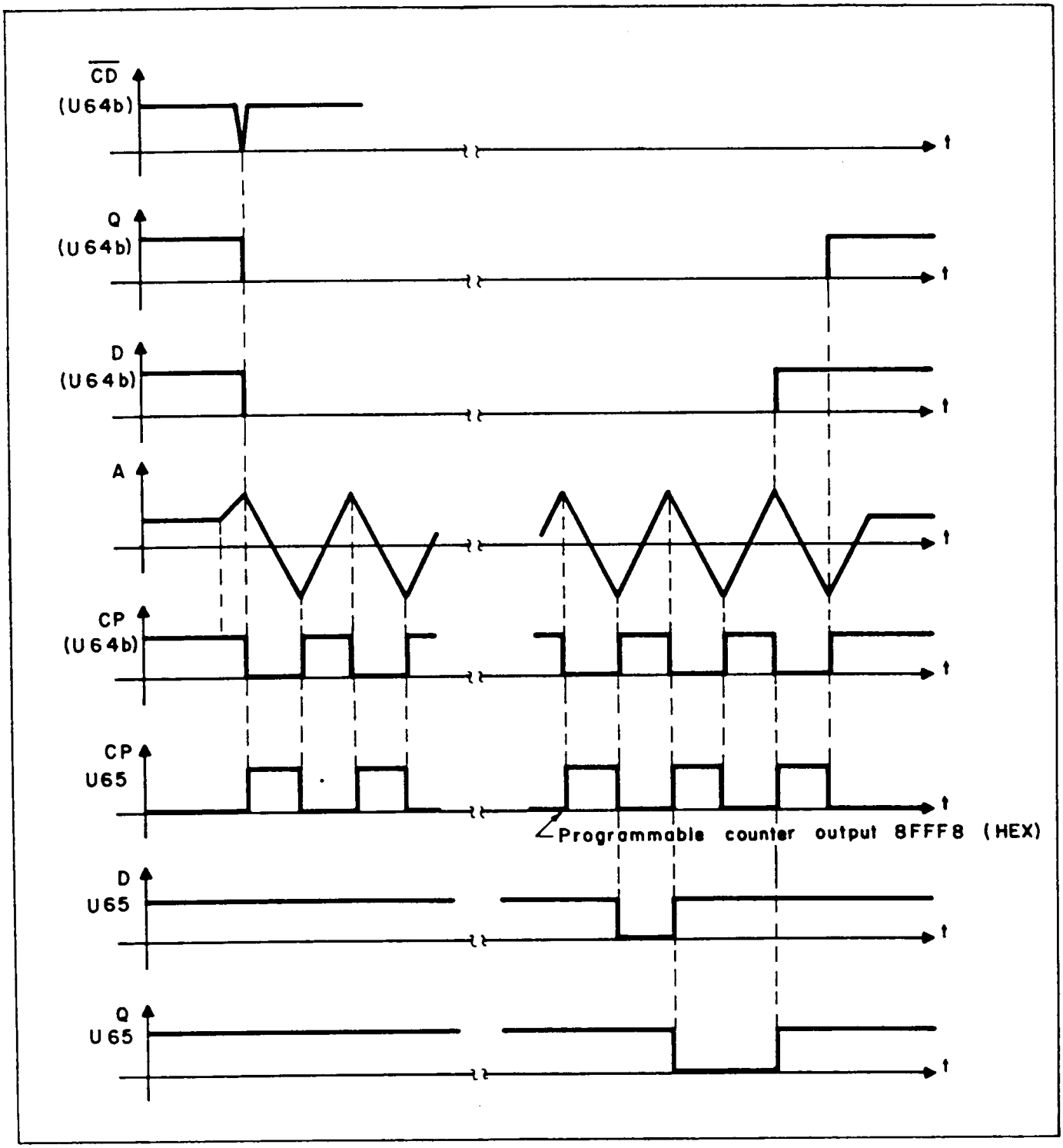

Figure 6-7. Burst Operation Waveforms.

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** NOTE **
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The Model 8201 will respond to a "TT" or GET commands, sent through the bus, only when the front panel trigger setting is as follows: Trigger mode - INT & TRIGRD, trigger slope - Positive Going Edge and Trigger level - set between 1 to 10V. Otherwise the "TT" and GET commands will be ignored.

4.10.17 SRQ Mode (Q) and Serial Poll status byte format

The SRQ command controls which of a number of conditions within the Model 8201 will cause the instrument to request service from the controller with the SRQ line command. Once a SRQ is generated, the Model 8201 status byte can be checked, via Serial Polling (see paragraph 4.9.8), to determine if it was the Model 8201 that requested service. Other bits in the status byte could also be set depending on certain data or error conditions.

The Model 8201 can be programmed to generate SRQ under one or more of the following conditions.

1. If a reading has been completed.
2. If an error condition occurs.
3. If Model 8201 is ready to recive Device-Dependent commands.

SRQ Mask: In order to facilitate SRQ programming, the Model 8201 uses an internal mask to generate the SRQ. When a particular mask bit is set, the Model 8201 will send a SRQ when those conditions occur. Bits within the mask can be controlled by sending the ASCII letter "Q" followed by a decimal number to set the appropriate bits. Table 4-11 lists the commands to set the various mask bits, while Table 4-12 lists all legal SRQ Mask commands.

Table 4-11. SRQ Mask Commands

Command	Sets Bit Number	Condition to Generate SRQ
Q1	B0 (LSB)	Reading done
Q2	B1	Ready
Q4	B2	Pulse error
Q8	B3	Error

6.3.6 PULSE SHAPER

The function of the pulse shaper is to convert the signal from the level detector to pulses with very fast rise and fall times and with precise amplitude. The pulse shaper is located on the final assembly board. Refer to the schematics at the end of this manual and throughout the following description.

The pulse from the trigger circuit is routed via U1 to the pulse shaper. The pulse shaper consists of Q3, Q4, Q5 and Q6, positive current generator Q7 and negative current generator Q8. When is squarewave function the output of the pulse shaper, when in squarewave function, alternates between the positive current source and the negative current source. When in positive pulse function, the output alternates between the positive current source and ground and when in negative pulse function, the output alternates between the negative current source and ground.

The positive current source consists of U2, Q7 and their associated components. R19 adjusts the positive current. Q11 controls Q9 when positive or negative pulse is selected. The negative Current source consists of U3, Q8 and their associated components. R22 adjusts the negative current amplitude. Q12 controls Q10 when positive or negative pulse is selected.

6.3.7 PREAMPLIFIER

The preamplifier consists o U7, Q13, Q14, Q15 and Q16 and their associated components. U4 is a serial to parallel oonverter which operates the quad comperator U5 which in turn operates signal selector U6.U6 selects one of the following signals: triangle, sinewave or pulses from the pulse shaper. The sigal from the selector is fed in parallel to a low frequency amplifier U7 and its associated componets and through C17 and C18 to the high frequency amplifier. The output of the premplifier, at the junction of R52 and R53 is then routed to the attenuator.

6.3.8 ATTENUATOR

The attenuator is controlled by 3 quad comperators U9, U10 and U11. The data which is required to operate the comperators is converted from serial to parallel by U8. The attenuator is connected in a binary fashion and comprises FETs Q17 through Q32. One or more switches are on at a time which in turn changes the equivalent resistance from the preamplifier to the power amplifier. This adjusts the amplitude level to the correct level for routing to the output power amplifier.

6.3.9 OFFSET GENERATOR

The offset generator generates a DC voltage which is summed to the selected waveform. The DC voltage is generated by D to A converter U14 and operational amplifier U16. The exact voltage level is controlled by CR23 and is adjusted by R120. The D to A converter is controlled by serial to parallel converter U13. U18 is connected as a comperator which when commanded from U15 turns FET switch Q44 on or off. This changes the polarity of the DC offset. The DC offset amplitude is coupled through R126 to the output power amplifier.

6.3.10 POWER AMPLIFIER

The output amplifier consists of low frequency amplifier U12, high frequency amplifier Q33 through Q37 and class B power amplifier Q38 through Q43. The signal is coupled to the low frequency amplifier through R82 and to the high frequency amplifier through C41 and C42. The output from the power amplifier at the junction of R102 and R103 is connected through a 50 ohm resistance to the decade attenuator.

6.3.11 POST AMPLIFIER ATTENUATOR

The post amplifier attenuator is the final stage through which the signal is fed. Attenuation ranges from 0dB to 60dB. U15 receives serial information from the microcontroller serial bus, converts the serial information to parallel and operates relays K1, K2 and K3 through buffer U19. The relays select one of the divider networks which are formed by the resistors R110 through R118. Relay K4 disconnects the output signal from the output terminal when a disable command is given through the IEEE bus. In line fuse F1 protects the output circuits from external voltages inadvetently applied to the output BNC connector.

6.3.12 POWER SUPPLY

For the following discussions, refer to the power supply schematic later in this manual. The power supply consists of a main power transformer, three bridge rectifiers, four regulators and a 5V regulator which is formed by U14, Q3, Q4 and Q5, and their associated components.

The LINE fuse and the Line Selector are accessible at the rear panel. The LINE VOLTAGE SELECT switch select 115V or 230V operation.

CR6 is used as a fullwave rectifier to provid a sufficiant DC voltage for the +24V and -24V regulators U17 and U18 eespectively.

CR5 is used as a fullwave rectifier to provid a sufficiant DC voltage for te +15V and -15V regulators U15 and U16 respectively.
U14 receives a reference voltage of 5 from the 15V supply. This reference is then buffered by U14 amplifier and applied through Q5 to the series regulator Q4. Q3 and R12 form a protection circuit against accidental shots or overload.

6.4 PULSE GENERATION CIRCUIT

The pulse generation circuit reshapes the basic rectangular waveform and generates, through controlling circuit, pulses with variable pulse width and duty cycle, double pulses as well as delayed pulses. A block diagram is given in Figure 6-8. Refer to this diagram throughout the following discussions.

A TTL wave is routed from the SYNC output on the main board to the input of the pulse generation circuit. This signal applied to a differential circuit formed by U5d and then routed via the gate - U5a, U5b and U6d to a selector which is formed by U6a, U6b and U6c. This signal then triggers a D flip-plop circuit - U8b which turns off Q9. This sequence initiates a current charge to a selected capacitor. The voltage ramp which is generated when the capacitor is charged is buffered by Q8 and Q6 and routed to a schmidt trigger formed by Q1 through Q5 and their associated components. When the ramp voltage reaches the upper limit of the schmidt trigger (approx 1.8V), the collector of Q1 changes state to "0" and resets the D flip-flop U8b. Q9 is then turned on which forces a short across the charged capacitor. At this time the output of the schmidt trigger changes state to "1". This completes one cycle and prepares the circuit for the next trigger to come from the main board.

In double pulse mode, the pulses after the differential circuit are applied, in parallel, to a delay circuit which is very much similar to the circuit described before. The pulse from U8a is routed via the short pulses shaper formed by U7a and U7b and through the selector U6a, U6b and U6c to the pulse generation circuit. This generates a new dealyed pulse in reference to the first pulse. The delay is equal to the pulse duration which is generated by the delay section.

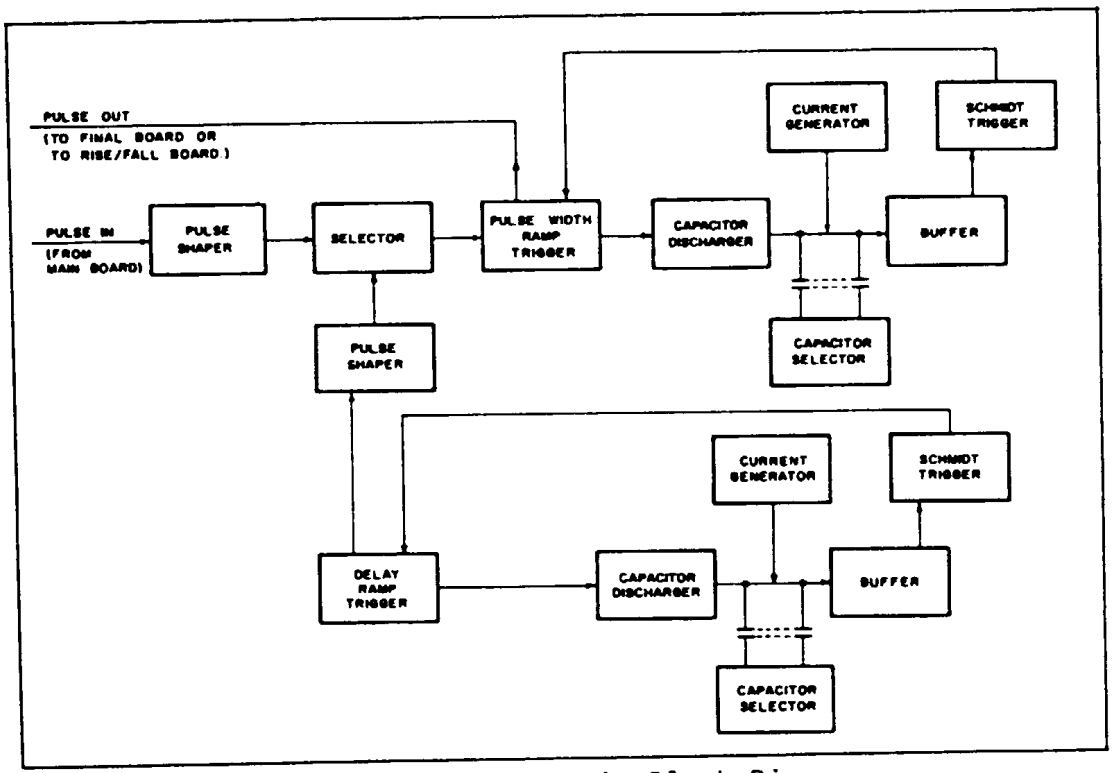

Figure 6-8. Pulse Generation Circuit Block Diagram.

6.4.1 RISE/FALL TIME CONTROL CIRCUIT

The rise/fall time circuit transforms the regular pulse waveform to a more complex waveform which may have one rise time and a different fall time. When a pulse waveform is selected to have the best rise time e.g 10nSec, this circuit becomes inactive. Figure 6-9 is the block diagram for the rise/fall time circuit.In general this circuit is comprised of the following blocks: Pulse shaper, Positive and negative current generators, positive and negative current switches, positive and negative level limiters capacitors and capacitors selector and a buffer. Each of these circuit is discussed in details in the following.

A TTL pulse from the pulse generation circuit is routed to the pulse shaper - U9 which translates the signal to ECL logic which in turn drives the current switches.
The positive current generator consists of a D/A converter U13, operational amplifiers U15 and U16 and their associated components. U17 U18, Q22 and Q23 form a current mirror to compensate the current for the positive level limiter. The negative current generator consists of a D/A converter U14, operational amplifiers U19, U21 and U22 transistors Q24,Q26,Q27 and their associated components. U20 and Q25 form a current mirror to compensate the current for the negative level limiter.

The positive current switch consists of Q13, Q15 and their associated components where, the negative current switch consists of Q12, Q13 and their associated componenets.
The positive current limiter comprises U8, Q18, Q19 and their associated componenets where, the negative current limiter comprises U7, Q16, Q17 and their associated componenet.

The range capacitors are switched in and out by the transistors Q2 through Q5. The switch transistors are controlled by the quad buffer - U6. The output buffer consists of Q6, Q7, Q8, Q9, Q10 and their associated componenets. The waveform with the modified rise and fall times is then routed via a DMOS switch to the function selector on the final amplifier board.

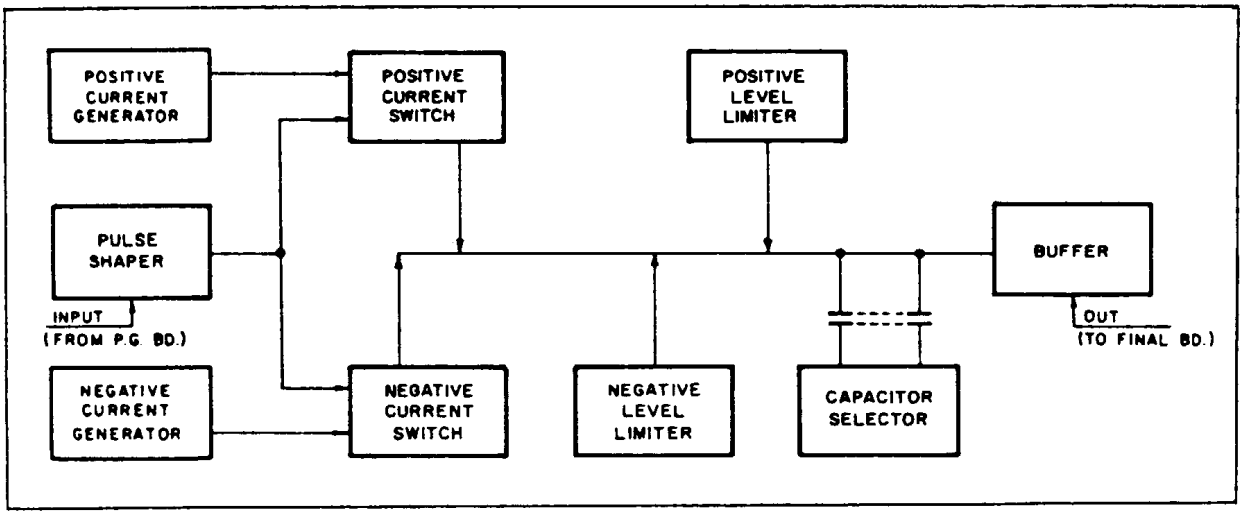

Figure 6-9. Rise/Fall Time Control Circuit Block Diagram.

6.4.2 COUNTER CIRCUIT

The counter circuit is located on the rise/fall time control circuit board. Refer to the schematics at the back of this manual throughout the following discussions.

COUNTER - The counter includes a 10MHz quartz crystal controlled reference XTAL 1, divided by two -U3b, two binary counters U1 and U2 and their associated components. The signal from the trigger circuit is divided by two to limit the high frequency going to the binary counters. Gating and resetting signals are applied to the counter from the microcontroller section. The data from the counters is then transmitted directly to the microprocessor on the data bus. The frequency accuracy of the clock is adjusted by C22.

6.5 DIGITAL CIRCUITRY

Model 8201 operation is supervised by the internal microcomputer. The MCU controls the parameter selection process, front panel switching, the display, and IEEE operation which are all performed under software control. This section briefly describes the operation of the various sections of the microcomputer and its associated digital circuitry. A simplified block diagram is included for user reference. For more complete circuit details refer to the digital schematics at the en of this manual.

A block diagram of the microcomputer is shown in Figure 6-8. Circuit operation centers around the microcontroller unit (MCU), U1. The 8031 is an 8-bit microcotroller capable of directly addressing up to 64K bytes of progarm memory (ROM) and up to another 64 bytes of data memory (RAM). The microcontroller works with a 10 Mhz clock which is divided by U2 o provide clocks for the various sections of the instrument.

Software for the MCU is containe in two EPROMs U5 and U6 each containing 16K bytes of memory space. Temporary storage is provided by RAM U7 which can store up to 1024 bytes of information.

6.5.1 DISPLAY AND KEYBOARD INTERFACE

Interfacing between the MCU, the keyboard and the display is performed by the Keyboard/Display interface U1 (located on the display assembly). The information for the 7 segment LEDs is sent through buffer U2 and limiting resistors RN1. U3 and U4 multiplex the digits and LED and drive the high current transistors Q1 to Q11 which in turn drive the anode of the appropriate LED. U5 together with sense lines R0 to R7 determine which of the button was depressed.

6.5.2 IEEE-488 INTERFACE

The instrument has a built in IEEE-488 interface that permits the instrument to be controlled through the system controller. Commands may be given over the bus and data may be requested from the instrument as well.
The IEEE interface is made up of U11, (General Purpose Interface Adapter), and U12 and U13, which are interface bus drivers. On the MCU side of the GPIA, data trasmission is handeled much like any other bus transaction. The output of the U11 is standard IEEE format and is buffered by the two IEEE bus drivers U12 and U13. The bus divers are necesarry to bring the drive capabilitiy of the interface up to the normal IEEE maximum of 15 devices.

SECTION 7

ADJUSTMENTS AND TROUBLESHOOTING

7.1 INTRODUCTION

This section contains information necessary to adjust and troubleshoot the Model 8201 and the Lead/Trail option (option 40).

****
** WARNING **
****

The procedures described in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps covered in this section may expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

7.2 ADJUSTMENTS

7.2.1 Environmental Conditions

Adjustments should be performed under laboratory conditions having an ambient temperature of 24 +/-5 Deg C and a relative humidity of less than 70%. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

7.2.2 Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure long-term calibration accuracy, turn on the power to the Model 8201 and allow it to warm-up for at least 30 minutes before beginning the adjustment procedure.

7.2.3 Recommended Test Equipment

Recommended test equipment for calibration is listed in Table 5-3. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

7.2.4 Adjustment Procedures

All adjustments are performed with the POWER switch ON. The top cover should be removed to allow access to test points and adjustments. Between adjustments, always leave top cover on the unit to keep internal temperature.

****
** WARNING **
****

Take special care to prevent contact with live circuits or power line area which could cause electrical shock resulting in serious injury or death. Use an isolated tool when making adjustments. Use plastic or nylon screwdriver when adjusting the time base trimmer as other material will cause confusion in this adjustment.

Refer to the component layout in Section 9 when necessary for determining adjustment points. Follow the procedure in the sequence indicated because some of the adjustments are interrelated and dependent on the proceeding steps.

Verify that Model 8201 is functioning according to the performance checks. Make sure that all results are within or close to the range of the required specifications, otherwise refer to the troubleshooting procedures given later in this section.

Center all trimmers and if necessary, remove selected components and clear the holes to allow a selection of new components.

Perform the following adjustment procedure. If an adjustment can not be made, to obtain a specific result, refer t the troubleshooting procedures.

****
*** NOTE ***
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Unless otherwise specified, set Model 8201 controls as follows and terminate the OUTPUT with a 50 ohm feedthrough termination.

CONTROL	POSITION
Frequency/Period	As required by procedure
Amplitude	1.5 V
Offset	0 V
Symmetry	50%
Pulse Width	5.0 uSec
Pulse Delay	5.0 uSec
Burst	2 Counts
Lead	10 nSec
Trail	10 nSec
Operating Mode	Normal (all lights off)
Trigger	Continuous (all lights off)
Output	Squarewave

7.3 ADJUSTMENT PROCEDURE

7.3.1 POWER SUPPLY ADJUSTMENT

EQUIPMENT : DMM

PROCEDURE

1. Set DMM to DC measurements. Measure and record the -15V supply voltage with 10mV resolution.
2. Adjust R18 so that the +15V supply would be the same as the voltage level recorded in step 1.

7.3.2 DISTORTION ADJUSTMENT

EQUIPMENT : Distortion Analyzer
Oscilloscope

PROCEDURE

1. Change 8201 Operating Mode setting to VCO.
2. Change 8201 Output setting to Sine.
3. Change 8201 Frequency setting to 1.999KHz.
4. Set the oscilloscope to 1V/Div. and DC coupling and adjust the trace line, vertically, to be exactly at the center of the screen (0V).
5. Connect the OUTPUT terminal to the oscilloscope and adjust R151 to get a symmetrical waveform, about the 0V line, on the screen.
6. Disconnect the OUTPUT from the oscilloscope and connect the OUTPUT to the distortion analyzer.
7. Adjust R34, R163 and R165, repeatedly, until the distortion reading on the analyzer is less than 0.2%. Note that each one of these resistors contribute a small amount to the distortion correction. It is up to the service technician to find the most effective sequence to perform this step.
8. Disconnect the OUTPUT from the analyzer and repeat steps 3 and 4.

7.3.3 FREQUENCY ADJUSTMENT

EQUIPMENT : 6003 Counter
Oscilloscope

PROCEDURE

1. Change 8201 Operating Mode Setting to VCO.
2. Change 8201 Frequency setting to 1.999KHz.
3. Change 8201 Amplitude setting to 1.0V.
4. Connect the OUTPUT terminal to the counter input.
5. Set counter to frequency measurements and adjust R53 for a reading of 1.999KHz +/-10Hz on the counter display.
6. Change 8201 Frequency setting to 19.99KHz and check that the reading on the counter is 19.99KHz +/-30Hz. If reading is not within the specified value readjust R53 so that the error in 1.999KHz and 19.99KHz is the same.
7. Change 8201 Frequency setting to 2.00MHz.
8. Set counter and adjust C45 to give a reading of 2.00MHz +/- 30KHz on the counter display.
9. Set the oscilloscope to 20mV/Div and DC coupling and adjust the trace line, vertically, to be exactly at the center of the screen 0V). Connect a 10:1 high frequency probe, with a very short ground lead, to the junction of R81 and R82. Adjust the vertical gain of the oscilloscope so that the peak to peak amplitude on the screen will be exactly 6 divisions.
   Change 8201 frequency setting to 20.00MHz and select C63 and C66 (approximately 15PF each) until peak to peak trace is 6 divisions +/- 1 small division. Note that the trace should be vertically symmetrical about the 0V line.
10. Readjust C45 to give a reading of 20.0MHz +/- 300KHz on the counter display.
11. Change 8201 Frequency setting to 2.00MHz.
12. Check with counter if reading is 2.00MHz +/- 30KHz. If reading is not within the specified value readjust C45 so that the error in 2.00MHz and 20.00MHz is the same.
13. Change 8201 Frequency setting to 1999KHz.
14. Set counter and select C52 (approximately 330PF) to give a reading of 1999KHz +/- 3KHz on the counter display.
15. change 8201 Frequency setting to 1.999MHz.
16. Select C48 (approximately 47PF) to give a reading of 1.999MHz +/- 30KHz on the counter dispaly.

7.3.4 LOW FREQUENCY ADJUSTMENT

EQUIPMENT : Counter

PROCDURE

1. Change 8201 Frequency setting to 9.9Hz.
2. Connect the 8201 OUTPUT terminal to the counter.
3. Adjust R188 to 9.9Hz +/- .1Hz.

7.3.5 LOW FREQUENCY DISTORTION ADJUSTMENT

EQUIPMENT : Distortion analyzer
Counter

PROCEDURE

1. Change 8201 Frequency setting to 9.9 Hz.
2. Change 8201 Output setting to sine.
3. Connect 8201 OUTPUT terminal to the distortion analyzer input.
4. Adjust R192 to minimum distortion.
5. Disconnect the 8201 OUTPUT from the distortion analyzer and reconnect it to the counter input.
6. Change 8201 Output setting to squarewave.
7. Verify that the frequency reading on the counter is 9.9Hz +/- .1HZ. If reading is not within range, repeat steps 7.3.6 and 7.3.7 until all adjustments are within the specified range.

7.3.6 TRIGGER INPUT SENSITIVTY ADJUSTMENT

EQUIPMENT : Function Generator
Oscilloscope

PROCEDURE

1. Change 8201 Trigger setting to Gated.
2. Change 8201 Trigger Slope setting to positive going edge.
3. Adjust 8201 Trigger Level control to 0V (approximately center position).
4. Set external function generator to output a triangle with 0.6V peak to peak amplitude.
5. Apply the function generator output to the Model 8201 TRIG IN terminal.
6. Set the oscilloscope and connect the probe to U68 pin 11 and select R222 (approximately 560K) for a trace on the oscilloscope with duty cycle ratio of 50% +/- 10%.
7. Change 8201 Trigger Slope setting to negative going slope.
8. Connect the probe as in step 6 and select R221 (approximately 560K) for a trace on the oscilloscope with a duty cycle ratio of 50% +/- 10%.

7.3.7 AMPLITUDE ADJUSTMENT

EQUIPMENT : DMM (RMS)
Oscilloscope

PROCEDURE

1. Change 8201 Amplitude setting to 15V.
2. Change 8201 Frequency setting to 1KHz.
3. Set DMM to ACV measurements and connect 8201 OUTPUT to the DMM.
4. Set Output waveform and perform adjustments as in the following table:

Output Waveform	Adjustment	Required DMM reading
Sine	R58	5.31V +/- 20mV
Triangle	R56	4.33V +/- 20mV
Square	R19, R22	7.50V +/- 20mV

5. Adjust R19 and R22 so that, when observed on an oscilloscope, the square wave is symmetrical around the 0 V vertical line.

7.3.8 OFFSET ADJUSTMENT

EQUIPMENT : DMM

PROCEDURE

1. Set DMM to DCV measurements and connect 8201 OUTPUT to the DMM.
2. Change 8201 Output setting to SINE.
3. Change 8201 Amplitude setting to 1.6V.
3. Change 8201 Display Modify setting to OFST.
4. Change 8201 Offset setting to 5.00V.
5. Adjust R120 to give a reading of 5.00V +/- 50mV on the DMM.
6. Change 8201 Offset setting to -5.00V.
7. Verify that DMM reading is -5.00mV +/- 50mV.

7.3.9 SQUARE WAVE RESPONSE ADJUSTMENT

EQUIPMENT : Oscilloscope

PROCEDURE

1. Temporarily install C26 - 10P and C9 - 18P.
2. Change 8201 Frequency setting to 1.000MHz.
2. Change 8201 Amplitude setting to 15.0V.
3. Connect 8201 OUTPUT terminal to the oscilloscope input.
4. Set oscilloscope to 20uSec/Div and adjust the Vertical control to display the square waveform in exactly 6 vertical divisions.
5. Change oscilloscope setting to 5nsec/Div.
6. Adjust C47 for the best rise/fall times and for minimum aberrations. If necessary replace C26 for best pulse response.
7. Change 8201 Amplitude setting to 1.50V and verify that the response is within the limits. If necessary, select C9 for best pulse response.

7.3.10 SINE FLATNESS ADJUSTMENTS

EQUIPMENT : Oscilloscope

PROCEDURE

1. Change 8201 Function setting to Sine.
2. Change 8201 Frequency setting to 100.0KHz.
3. Change 8201 Amplitude setting to 15.0V.
4. Connect 8201 OUTPUT to the oscilloscope.
5. Adjust oscilloscope controls to display the Sinewave with exactly 6 vertical divisions peak to peak.
6. Change 8201 Frequency setting to 20.00MHz.
7. Select C10 (approximately 10PF) to give so that the sinewave amplitude on the screen will be within the range of 5.1 to 5.3 vertical divisions.

7.3.11 TRIANGLE FLATNESS ADJUSTMENTS

EQUIPMENT : Oscilloscope

PROCEDURE

1. Change 8201 Function setting to Triangle.
2. Change 8201 Frequency setting to 100.0KHz.
3. Change 8201 Amplitude setting to 15.0V.
4. Connect 8201 OUTPUT to the oscilloscope.
5. Adjust oscilloscope controls to display the triangle with exactly 6 vertical divisions peak to peak.
6. Change 8201 Frequency setting to 20.00MHz.
7. Select C11 (approximately 15PF) to give so that the triangle amplitude on the screen will be within the range of 5.1 to 5.3 vertical divisions.

7.3.12 REFERENCE OSCILLATOR ADJUSTMENT

EQUIPMENT : Synthesizer

PROCEDURE

1. Change 8201 Operating Mode setting to EXT FRQ.
2. Change 8201 Trigger Level setting to 0V.
3. Change 8201 Trigger Slope setting to positive going edge.
4. Set synthesizer to output 9MHz and an amplitude of 1V RMS. Connect the synthesizer output to 8201 TRIG IN terminal.
5. Adjust C8 to give a display reading of 9.00000E6 +/- 1 count on the display. If adjustment can not be made within one count, select C9 (approximately 20PF) to bring C8 within range.

7.3.13 PULSE WIDTH AND DELAY ADJUSTMENT

EQUIPMENT : Oscilloscope
DMM
Counter

PROCEDURE

1. Change 8201 setting as follows: Function to Pulse, Period to 100 mSec, Pulse Width to 2.6 E-3, Pulse Delay to 2.6 E-3.
2. Connect DMM between U12 pin 15 to case ground and adjust R68 to give a DMM reading of 2.40 V +/- 20 mV.
3. Connect DMM between U13 pin 15 to case ground and adjust R72 to give a DMM reading of 2.40 V +/- 20 mV.
4. Connect 8201 OUTPUT connector to oscilloscope. Set Oscilloscope and adjust R35 to give a pulse width of 2600 uSec +/- 70 uSec.
5. Change 8201 Pulse Width setting to 25.0 E-3. Set oscilloscope and verify that the pulse width is within the range of 25.00 mSec +/- .7 mSec. If not within range, readjust R35 and repeat steps 4 and 5 until both pulse width ranges are within range.
6. Disconnect 8201 output from the oscilloscope and reconnect to Channel B of the counter. Connect SYNC output from 8201 to Channel A of the counter. Set counter to Time Interval A to B measurement with both channels at positive triggering slope.
7. Change 8201 Operating Mode setting to DELAYED.
8. Adjust R54 to give a counter reading of 2600 uSec +/- 70 uSec.
9. Change 8201 Pulse Delay setting to 25.0 E-3. Set counter and verify that the pulse delay is within the range of 25.00 mSec +/- .7 mSec. If not within range, readjust R54 and repeat steps 8 and 9 until both pulse width ranges are within range.

10. Change 8201 setting as follows: Period to 10.0E-6, Pulse Width to 1.00 E-6, Pulse Delay to 2.0 E-6.
11. Connect 8201 output connector to the oscilloscope. Adjust C8 for a pulse width of 1.00 uSec +/- 20 nSec on the oscilloscope.
12. Change 8201 Operating Mode setting to DOUBLE. Adjust C22 for a pulse delay of 2.00 uSec +/- 40 uSec on the oscilloscope.

13. Change 8201 setting as follows: Period to 1.0 E-6, Pulse Width to 100 E-9, Pulse Delay to .20 E-6, Operating Mode normal.
14. Set oscilloscope and verify that pulse width is within the range of 100 nSec +/- 5 nSec. If necessary, readjust C8 to bring pulse width within range. Repeat steps 15 and 18.
15. Set 8201 Operating Mode to DOUBLE. Set oscilloscope and verify that pulse delay is within the range of 200 nSec +/- 10 nSec. If necessary, readjust C22 to bring pulse delay within range. Repeat steps 16 and 19.

16. Change 8201 setting as follows: Period to 100 E-6, Pulse Width to 10 E-6, Pulse Delay to 20 E-6, Operating Mode normal.
17. Connect 8201 output to the counter. Set counter for pulse width measurement. Select C13 to give a counter reading of 10.00 uSec +/- .2 uSec.
18. Set 8201 Operating Mode to DELAYED. Connect 8201 SYNC and OUTPUT connectors to the counter as described in step 6. Set counter and select C27 to give a time interval reading of 20.00 uSec +/- .4 uSec.

19. Change 8201 setting as follows: Period to 1.0 E-3, Pulse Width to 100 E-6, Pulse Delay to 200 E-6, Operating Mode normal.
20. Connect 8201 output to the counter. Set counter for pulse width measurement. Select C14 to give a counter reading of 100.0 uSec +/- 2 uSec.
21. Set 8201 Operating Mode to DELAYED. Connect 8201 SYNC and OUTPUT connectors to the counter as described in step 6. Set counter and select C28 to give a time interval reading of 200.0 uSec +/- 4 uSec.

7.3.14 RISE/FALL TIME ADJUSTMENT

EQUIPMENT : Oscilloscope
DMM

PROCEDURE

1. Change 8201 setting as follows: Function to Pulse, Period to 100 E-6, Pulse Width to 50 E-6.
2. Temporarily connect the junction of R14 and C19 to ground. Connect DMM probes between the junction of R21 - R22 and ground and select R17 for a DMM reading of 0 V +/- 20 mV. Remove the temporary short.
3. Set R55 and R56 to mid-position.
4. Connect oscilloscope probe to the junction of R21 and R22 and adjust R34 and R31 to have an amplitude of +/- 1.9 V symmetrical around the 0 V vertical line.
5. Connect 8201 OUTPUT connector to the oscilloscope. Set oscilloscope and adjust R24 to give an amplitude of 1.50 Vp-p into 50 ohms.
6. Set oscilloscope and adjust R55 for a rise time of 10 uSec +/- .3 uSec.
7. Set oscilloscope and adjust R56 for a fall time of 10 uSec +/- .3 uSec.

8. Change 8201 setting as follows: Period to 10.0 E-3, Pulse width to 5.0 E-3, Rise Time to 1000 E-6, Fall Time to 1000 E-6.
9. Set oscilloscope and verify that rise and fall times are within the range of 1000 uSec +/- 30 uSec. If necessary readjust R55 and R56 to bring rise and fall times within range. Repeat steps 6 and 7.

10. Change 8201 setting as follows: Period to 10.0 E-6, Pulse Width to 5.0 E-6, Rise Time to 1000 E-9, Fall Time to 1000 E-9.
11. Set oscilloscope and adjust C19 to give a rise/fall times of 1000 nSec +/- 30 nSec.
12. Change rise and fall time setting to 100 E-9 and verify that rise and fall times are within the range of 100 nSec +/- 7 nSec. If not within range, readjust C19 and repeat steps 10 to 12 until both measurements are within range.

13. Change 8201 setting as follows: Period to 1.00 E-3, Pulse Width to .50 E-3, Rise Time to 100.0 E-6, Fall Time to 100.0 E-6.
14. Set oscilloscope and select C22 to give a rise/fall times of 100 uSec +/- 3 uSec. Do not solder C22 yet.
15. Change rise and fall time setting to 10.0 E-6 and verify that rise and fall times are within the range of 10 uSec +/- .3 uSec. If not within range, reselect C22 and repeat steps 13 to 15 until both measurements are within range. Solder C22 permanently.

16. Change 8201 setting as follows: Period to 100 E-6, Pulse Width to 50 E-6, Rise Time to 10.00 E-6, Fall Time to 10.00 E-6.
17. Set oscilloscope and select C21 to give a rise/fall times of 10 uSec +/- .3 uSec. Do not solder C21 yet.
18. Change rise and fall time setting to 1.00 E-6 and verify that rise and fall times are within the range of 1 uSec +/- 30 nSec. If not within range, reselect C21 and repeat steps 16 to 18 until both measurements are within range. Solder C21 permanently.

7.4 TROUBLESHOOTING

The troubleshooting instructions contained in this section are intended for qualified personnel having a basic understanding of analog and digital circuitry. The individual should also be experienced at using typical test equipment as well as ordinary troubleshooting procedures. The information presented here has been written to assist in isolating a defective circuit or circuit section; isolation of the the specified component is left to the technician.

7.4.1 Recommended Test Equipment

The success or failure in troubleshooting a complex piece of equipment like the Model 8201 depends not only on the skill of the technician, but also relies heavily on accurate, reliable test equipment. Table 6-2 lists the recommended test equipment for a complete troubleshooting and adjustment of the Model 8201. However, it is also possible to troubleshoot Model 8201 with the minimum equipment which is listed in Table 7-1. Other equipment such as logic analyzer, and in-circuit emulator etc, could also be helpful in difficult situation.

7.4.2 Power-Up Self Diagnostics

An advanced feature of the Model 8201 is its self diagnosing capabilities. Upon power-up the Model 8201 performs a set of tests which is described in paragraph 3.4. If the Model 8201 locks up due to ROM or RAM fail, there is a little point in attempting to troubleshoot elsewhere unless the microcontroller circuit is operating properly.

Table 7-1. Recommended minimum Test Equipment For Troubleshooting

Instrument	Recommended Model	Specifications
Oscilloscope	Tektronics 465	100 MHz bandwidth
Multimeter	3121	.1% basic DC accuracy
Function Generator	8120	12 MHz pulse, sine, triangle, triggerd

7.5 TROUBLESHOOTING PROCEDURE

7.5.1 Power Supply Checks

It is highly suggested that the first step in troubleshooting the Model 8201, as well as any similar equipment, would be to check the power supply. If the various supply voltages within the instrument are not within the required limits, troubleshooting the remaining circuits can be very difficult. Table 7-2 shows the various checks that can be made to the power supplies within the Model 8201. In addition to the normal voltage checks, it is also a good idea to check the various supplies with an oscilloscpe to make sure no noise or ringing is present.
In case of a "dead short" between one of the supplies to the common ground, it would be best to disconnect the entire supply section from the remaining of the circuitry and then identify if the problem is in the power supply or in the remaining of the circuitry. Model 8201 is equipped with such points which are located on the bottom side of the main PC board. To access these points, it is necessary to rèmove the bottom cover and then to remove the solder from the quick-disconnect points.

Table 7-2. Power Supply Checks

Step	Item/Component	Required Condition	Remarks
1	S1 Line Switch	Set to 115V or 230V	See paragraph 2
2	F1 Line Fuse	Continuity	Remove fuse to check
3	J1 Line Power	Plugged into live receptacle; power on	
4	+15V Supply	+15V +/-5%	
5	U15 Input	+18V minimum	Positive output of CR5
6	-15V Supply	-15V +/-5%	
7	U16 Input	-18V minimum	Negative output of CR5
8	+24V Supply	+24V +/-5%	
9	U17 Input	+27V minimum	Positive output of CR6
10	-24V Supply	-24V +/-5%	
11	U18 Input	-27V minimum	Negative output of CR6
12	+5V Supply	+5V +/- 5%	Collector of Q4
13	Input to +5V Supply	+7V minimum	Positive output of CR4
14	Reference to +5V Supply	+5V +/- 5%	Input 3 to U14

7.5.2 Digital Circuitry and Display Checks

Problems with the digital and display circuitry could cause erratic operation, false outputs or false display readings. Check the various components associated with the digital circuitry, including the IEEE-488 interface, using the information in Table 7-3.

Table 7-3. Digital Circuitry and Display Checks

Step	Item/Component	Required Condition	Remarks
1	U1 pin 19	0 to +4V square wave	Microprocessor clock
2	U1 pin 14	0 to +4V square wave	Microprocessor timer
3	U1 pin 3	0 to +4V 1.25MHz sqware wave	Keyboard and display control clock (on the display board)
4	U11 pin 3	0 to +4V 5MHz square wave	IEEE interface clock
5	U2 pin 1	0 to +4V 1.5KHz square wave	Beeper clock
		Some tests here could fail due to digital problems	
6	U1 pin 9 Reset input	Stays high for about 1Sec and then goes low	Turn off instrument then back on
7	U1 pin 30	0 to +4V 168nSec pulses	ALE line
8	U1 pin 29	0 to +4V 276nSec negative going pulses	PSEN line
9	U1 pins 16, 17	0 to +4V 480nSec negative going pulses	RD WR line
10	U1 pins 21 to 28 and 2 to 39	0 to +4V variable pulse train	Address/Data bus
		Depress and hold the vernier button durng the next two tests. This will generate serial data on the RDX line	
11	Pin 2on U19,U23 U25,U30,U35,U51 U40,U44,U56,U57 and U58	0 to +4V variable pulse train	Serial data-in on main board assembly
	Pin 2 on U4,U13 U8 and U15	0 to +4V variable pulse train	Serial data-in on final board assembly
12	Pin 3 on U19,U23 U25,U30,U35,U51 U40,U44,U56,U57 and U58	0 to +4V burst of pulse train	Serial-parallel converters clocks
	Pin 3 on U4,U13 U8 and U15	0 to +4V burst of pulse train	Serial-parallel converters clocks
		Depress each one of the buttons, in turn, on the front panel throughout the next test. This will check all buttons on the front panel as well as the interupt line.	
13	U1 pin 13	0 to +4V variable negative going pulses	Keboard interupt line
14	U2 pins 10, 11, Collectors or Q1 to Q12	0 to +4V variable pulses	LEDs Sink lines (on the display board)

7.5.3 Current Generator and VCO Checks

The Current Generator and the VCO circuits form the analog "heart" of the Model 8201. Malfunction of these circuits will definitely cause problems with the output signal. When digital circuitry was verified to function properly and output signal is not generated or appear unsymmetrical, it is almost certain that the source of the problem is either in the Current Generator circuit or in the VCO circuit. Information for checking the Current Generator circuit is given in Table 7-4, where information for checking the VCO section is given is Table 7-5.

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** NOTE **
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Unless otherwise noted, the following front panel set-ups are required throughout the following checks:

Frequency	19.99 KHz
Amplitude	15.0 V
Offset	00.0 V
Symmetry	50%
Pulse Width	50 uSec
Pulse Delay	50 uSec
Rise Time	10 nSec
Fall Time	10 nSec
Operating Mode	Normal
Output	Squarewave

Table 7-4. Current Generator Checks

Step	Item/Component	Required Condition			Remarks
1	D/A Frequency converter Digital Input				Set frequency as stated and check levels (no options)
		pin No.	10.00KHz	19.00KHz	
	U26	4	0	1	
		5	1	1	
		6	1	0	
		7	1	1	
		8	0	0	
		9	0	1	
		10	0	0	
		11	0	1	
		12	1	1	
		13	0	1	
		14	0	0	
		15	0	0	

Table 7-4. Current Generator Checks (continued)

Step	Item/Component	Required Condition	Remarks
2	D/A converter analog output	Pin no: U28 6 — 10.00KHz: - 0.8 V — 19.99KHz: - 1.6 V	
3	D/A voltage reference	Pin No: U24 6 — +1.6 Vdc	
4	Up/Down current source D/A coverter digital inputs	U31-Up: Pin 4 Level 0; Pin 5 Level 0; Pin 6 Level 1; Pin 7 Level 1; Pin 8 Level 0; Pin 9 Level 0; Pin 10 Level 1; Pin 11 Level 0 — U36-Down: Pin 4 Level 0; Pin 5 Level 0; Pin 6 Level 1; Pin 7 Level 1; Pin 8 Level 0; Pin 9 Level 0; Pin 10 Level 1; Pin 11 Level 0	
5	Up/Down current source D/A analog output U31 and U36	Pin 15 + 1.7 Vdc	
6	Up current source	Accross R36 5 Vdc Accross R70 1 Vdc	
7	Down current source	Accross R46 5 Vdc Accross R71 1 Vdc	
8	Trigger current source	Accross R43 5 Vdc Accross R21 .8 Vdc	

Table 7-5. VCO Checks

Step	Item/Component	Required Condition	Remarks
			For the following checks use an oscilloscope
1	CR16 - cathode	Triangle +/- 1.2 V	
2	JTC R81 and R28	- " - +/- 1.2 V	
3	CR41 - cathode	Rectangular +/- 3 V	
4	U66 pin 5	- " - 0 to + 4 V	
5	U46 pin 1	+.5 V 0 V	
6	U46 pin 8	Same as in step 5 but inverted 0 to -.5 V	

7.5.4 Frequency Ranges and Capacitor Multiplier Checks

Problems in the Frequency Ranges may occur even if the current generator and the VCO circuits check out to be ok. If output signal is available, but the frequency accuracy of the signal is not within range, or totally wrong, it is suggested to verify the operation of the frequency ranges control as well as the operation of the capacitor multiplier. Table 7-6 has information necessary to troubleshoot the Frequency Ranges Controls, while Table 7-7 has information necessary to identify problems in the capacitor multiplier circuits.

Table 7-6. Frequency Ranges Checks

Step	Item/Component	Required Condition								Remarks
	Range	U23	U51							Set frequency as stated
	pin no	7	4	5	6	7	14	13	12	11 and Symmetry = 50%
1	2.00 - 20.00E6	1	1	1	1	1	1	1	1	1
2	.200 - 1.999E6	1	1	1	1	0	1	1	1	1
3	200 - 1999E3	1	0	1	1	1	1	1	1	1
4	2.00 - 19.99E3	1	1	0	1	1	1	1	1	1
5	.200 - 1.999E3	1	1	1	0	1	1	1	1	1
6	200 - 1999E0	0	1	1	0	1	1	1	1	1
7	2.00 - 19.99E0	0	1	1	0	1	1	1	0	0
8	.200 - 1.999E0	0	1	1	0	1	0	1	0	1
9	200 - 1999E-3	0	1	1	0	1	1	0	0	1
10	2.00 - 19.99E-3	0	1	1	0	1	1	1	0	1
		U23	U51							Set frequency as stated
	pin no	7	4	5	6	7	14	13	12	11 and Symmetry = 25%
1	2.00 - 20.00E6	1	1	1	1	1	1	1	1	1
2	.200 - 1.999E6	0	1	1	1	1	1	1	1	1
3	200 - 1999E3	0	1	1	1	0	1	1	1	1
4	2.00 - 19.99E3	0	0	1	1	1	1	1	1	1
5	.200 - 1.999E3	0	1	0	1	1	1	1	1	1
6	200 - 1999E0	0	1	1	0	1	1	1	1	1
7	2.00 - 19.99E0	0	1	1	0	1	1	1	0	0
8	.200 - 1.999E0	0	1	1	0	1	0	1	0	1
9	200 - 1999E-3	0	1	1	0	1	1	0	0	1
10	2.00 - 19.99E-3	0	1	1	0	1	1	1	0	1

Table 7-7. Capacitor Multiplier Checks

Step	Item/Component	Required Condition	Remarks
1	U53 pin 6	Triangel +/- 0.8 V	
2	U54 pin 6	+2.5 V	
		-2.5 V	

7.5.5 Trigger Circuit Checks

The Trigger Circuit controls the various trigger options of the Model 8201. Circuits tested previously may appear fully functioning however, a problem in the trigger circuit may effect the operation of the instrument. Isolation of the Trigger Circuit from the other circuitry my be done by removing CR19. If the instrument starts to function normally, the problem is definitely within the trigger circuit. Using Table 7-8 will help to identify the problems within the Trigger Circuit.

Table 7-8. Trigger Circuit Checks

Step	Item/Component	Required Condition			Remarks
	Trigger Mode	U58 pin 14	U58 pin 13	U69 pin 2	
1	Normal	1	0	0	
2	Gated	1	0	1	
3	Triggered	1	1	1	
4	Burst	0	1	1	
	Trigger Source	U58 pin 11			
5	Ext Trig	1			
6	Int Trig	0			
	Trigger Slope	U58 pin 12			
7	Positive Going	1			
8	Negative Going	0			
11	Burst control input to programmable counter	U59 pin 9 1 pin 10 0 pin 1 0 pin 15 0 U61 pin 9 0 pin 10 0 pin 1 0 pin 15 0 U63 pin 9 1 pin 10 0 pin 1 0 pin 15 0		U60 pin 9 0 pin 10 0 pin 1 0 pin 15 0 U62 pin 9 0 pin 10 0 pin 1 0 pin 15 0	Change Burst setting to 2

Table 7-8. Trigger Circuit Checks (continued)

Step	Item/Component	Required Condition	Remarks
			Change Burst setting to 500,000
12		U59 pin 9 0 U60 pin 9 0 pin 10 0 pin 10 1 pin 1 0 pin 1 0 pin 15 0 pin 15 1 U61 pin 9 1 U62 pin 9 1 pin 10 1 pin 10 1 pin 1 1 pin 1 1 pin 15 0 pin 15 0 U63 pin 9 1 pin 10 0 pin 1 1 pin 15 0	

7.5.6 Sine Shaper Checks

The Sine Shaper converts the triangular wave form to sine. Problems in the Sine Shaper will cause sine distortions. Problems in the Sine Shaper circuit may be identified using Table 7-9.

Table 7-9 Sine Shaper Checks

Step	tem/Component	Required Condition	Remarks
			Change Output function to Sine
1	JCT R117 and R118	Triangle +/-1.2 V	
2	U50 pin 6	-9.2 Vdc	
3	Accross R167	Approx. 0 V	
4	U47 pin 12 U48 pin 11 U48 pin 12 U49 pin 11 U49 pin 12	Sinewave 2.6 V to 5 V	
5	JCT R158 and R159	Sinewave +/-3 V	

7.5.7 Function Selector Checks

Problems with the Function Selector circuit will cause false output wave forms at the OUTPUT BNC terminal. Problems in the Function Selector circuit may be located using the checks given in Table 7-10.

Table 7-10. Function Selector Checks

Step	Item/Component	Required Condition	Remarks
			Change Output function setting as stated.
		U44 pin 4 6 11	
1	Sine	0 0 1	
2	Triangle	0 0 0	
3	Rectangular	0 1 0	
4	Pulse	1 0 0	Rise/Fall times set to 10 E-9
5	Pulse	0 0 0	Modify rise time to 20 E-9
			Change Output function setting as stated. Perform checks on final board assembly
	U4	Pin number 6 7 14 13	
1	Sine	1 0 0 0	
2	Triangle	0 1 0 0	
3	Rectangular	0 0 1 1	
4	Pulse	0 0 1 1	Rise/Fall times set to 10 E-9
5	Pulse	0 0 1 0	Modify Rise time to 20 E-9

7.5.8 Amplitude Control Checks

The signal generated by the VCO and the sine converter needs to be adjusted, in amplitude, so that the magnitude of the signal is correctly applied to the preceding circuits. Problems in the amplitude control will result in an incorrect amplitude level at the OUTPUT BNC terminal. Isolation of the problem within the amplitude control circuit can be done using Table 7-11.

****
** NOTE **
****

All checks in the following Tables are performed on the final board assembly - mounted on the right side support.

Table 7-11. Amplitude Control Checks

Step	Item/Component		Required Condition		Remarks
			5.0 V	15.0 V	
1	Parallel Digital data				Change Amplitude setting as stated
	U8	pin 4	0	1	
		pin 5	1	1	
		pin 6	0	1	
		pin 7	1	1	
		pin 14	0	1	
		pin 13	1	1	
		pin 12	0	1	
		pin 11	1	1	If U8 checks ok, check on U9, U10 and U11 respectively

7.5.9 Offset Control Checks

The Offset generator and it's control circuit generate a DC signal which is then summed to the output signal. Problems in the offset circuit may cause an incorrect offset output or no offset at all. Identify problems in the offset circuit using the information given in Table 7-12

Table 7-12. Offset Control Checks

Step	Item/Component		Required Condition	Remarks
1	D/A Converter digital inputs			Change Amplitude setting to 1.6 V. Change Offset setting to +5.00 V
	U14	pin 4	1	
		pin 5	0	
		pin 6	1	
		pin 7	0	
		pin 8	1	
		pin 9	0	
		pin 10	1	
		pin 11	0	
		pin 12	1	
		pin 13	0	
2	D/A Converter analog output	U14 pin 6	-4 Vdc	
3	D/A Converter reference input	U14 pin 15	approx 5 V	
4	Polarity control	U18 pin 6	approx -14 Vdc	
		U18 pin 6	approx +14 Vdc	Change Offset setting to -5.00 V

7.5.10 Pulse Shaper Checks

The rectangular waveform which is generated by the VCO and the Trigger circuits, has a relatively low slew rate. In order to generate a square wave at the OUTPUT terminal with the specified rise/fall times, it is necessary to speed the rise/fall times using the pulse shaper circuit. Any problem related to the squarewave signal should be traced back to the Pulse Shaper circuit. Information as to how to isolate a problm in the pulse shaper circuit may be found in Table 7-13.

Table 7-13. Pulse Shaper Checks

Step	Item/Component	Required Condition	Remarks
1	U1 pins 12,13	Rectangular waveform +3.2 V to +4.2 V	
2	Base of Q5 and Q6	Recangular waveform - 4 V to -5 V	
3	U2 pin 2	approx +9 Vdc	
4	U3 pin 2	approx -9 Vdc	

7.5.11 Pre-Amplifier and Attenuators control checks

Problems in the pre-amplifier circuit and the attenuator control circuit may cause problems, related to the signal, at the OUTPUT BNC terminal. Table 7-14 lists check to be made on the per-amplifier and attenuator control circuits respectively.

Table 7-14. Pre-Amplifier and Attenuators Control Checks

Step	Item/Component	Required Condition	Remarks
			Change Output function setting to Sine
1	Pre amplifier output JCT R52 and R53	Sine +/-4 V	
2	Attenuator control Gates of: Q17, Q19 Q21 and Q23	+24 Vdc	
3	Cathodes of: CR6, CR7, CR8 and CR9	-15 Vdc	
4	U9 pins: 1, 2, 13 and 14	+24 Vdc	
5	Base of Q13	approx +10 Vdc	
6	Base of Q14	approx -10 Vdc	
7	U7 pin 7	approx +3.7 Vdc	

7.5.12 Post Amplifier Range Control Checks

A defective post amplifier range selector may cause an amplitude accuracy error at the OUTPUT BNC terminal. Problems in the post amplifier range control circuit may be identified using the information given in Table 7-15.

Table 7-15. Post Amplifier Range Control Checks

Step	Item/Component	Required Condition						Remarks
	Range	U15 pin no	4	5	6	7	14	Set Amplitude ranges as stated
1	4.8 E0 - 15.0 E0		0	0	0	0	0	
2	1.6 E0 - 4.8 E0		0	0	0	0	1	
3	.48 E0 - 1.50 E0		0	1	0	0	1	
4	.16 E0 - .47 E0		0	0	0	1	1	
5	48 E-3 - 150 E-3		0	1	0	1	1	
6	16 E-3 - 47 E-3		0	0	1	1	1	
7	1.0 E-3 - 15.0 E-3		0	1	1	1	1	
8	Output Disable (IEEE command)		1	1	1	1	1	If U15 checks out ok, check output of U19 respectively

7.5.13 Power Amplifier Checks

The power amplifier circuit is the last section of which the signal passes just before it is being routed to the OUTPUT BNC terminal. Problems in the power amplifier section may result in distorted signal, low slew rate, or no signal at all. Isolate the problem in the power amplifier circuit using the information in Table 7-16.

Table 7-16. Power Amplifier Checks

Step	Item/Component	Required Condition	Remarks
			Change Output function setting to Sine
1	Base of Q33	approx +20 Vdc	
2	Base of Q34	approx -20 Vdc	
3	U12 pin 7	approx +4.6 Vdc	Measure in reference to GND
4	Q36	Approx 3 V	measure between collector to emitter
5	JCT R102 and R103	0 Vdc	

7.5.14 PULSE GENERATION CHECKS

The function of the pulse generation circuit is to add control, to the square wave output, over the pulse width and pulse delay. This circuit also generates a second pulse for the double pulse mode of operation. Problems in the pulse generation board will normally be detected when the output function is set to pulse or pulse complement. Refer to Table 7-17 when troubleshooting the pulse generation board.

Table 7-17. Pulse Generation Checks

Step	Item/Component	Required Condition	Remarks
1	Pulse mode control		Set Operating Mode and Output function as stated.

Operating mode - Function	U15 pin no 4	5
Normal - Sine	0	0
Normal - Pulse	1	0
Delayed - Pulse	0	1
Double - Pulse	1	1

2 Pulse width ranges

Pulse Width Range	U2 14	12	12	11	U1 7	13
25 - 100 E-9	0	0	0	0	0	1
.11 - 1.00 E-6	0	0	0	0	0	0
1.1 - 10.0 E-6	0	1	0	0	1	0
11 - 100 E-6	1	0	0	0	1	0
.11 - 1.00 E-3	0	0	0	1	1	0
1.1 - 25.0 E-3	0	0	1	0	1	0

3 Pulse delay ranges

Pulse Width Range	U2 4	5	6	7	U1 6	12
25 - 100 E-9	0	0	0	0	0	1
.11 - 1.00 E-6	0	0	0	0	0	0
1.1 - 10.0 E-6	0	1	0	0	1	0
11 - 100 E-6	1	0	0	0	1	0
.11 - 1.00 E-3	0	0	0	1	1	0
1.1 - 25.0 E-3	0	0	1	0	1	0

Table 7-17. Pulse Generation Checks (continued)

Step	Item/Component	Required Condition
4	General waveforms checks	
	Q6 emitter	Positive going ramps 0 - 1.8 V
	Q19 emitter	Positive going ramps 0 - 1.8 V
	U8 pin 11	Narrow TTL pulses
	pin 13	Narrow TTL pulses
	pin 8	Rectangular TTL pulses
	pin 3	Narrow TTL pulses
	pin 1	Narrow TTL pulses
	pin 6	Rectangular TTL pulses

7.5.15 RISE/FALL TIME CONTROL CHECKS

The Rise/Fall time board contains the necessary circuits to generate a control over the leading edge rise time and the trailing edge fall time. When the control over the edges is lost or functions improperly, the problem is most definitely within this board. To identify such problems, use Table 7-18.

Table 7-18. Rise/Fall Time Control Circuit Checks

Step	Item/Component	Required Condition	Remarks
1	Pulse mode control		Set rise time range as stated

	U1					
Rise Time Range	5	6	7	11	12	13
10 - 1000 E-9	0	0	0	0	0	0
.10 - 1.000 E-6	1	0	1	0	0	0
1.0 - 100.0 E-6	1	1	0	0	0	0
10 - 1000 E-6	1	0	0	1	0	0
.10 - 10.00 E-3	1	0	0	0	1	0

2	General waveforms	
	R21, R22 junction	rectangular waveforms from -1.9 V to +1.9 V
	U9 pin 7	rectangular waveforms from 3.2 V to 4.2 V

SECTION 8

P A R T S L I S T

8.1 GENERAL

This section contains information for ordering replacement parts. the replacement parts are available from the vendors listed.
Mechanical parts are shown separately on Figure 8-1.

8.2 ORDERING INFORMATION

When ordering replacement parts, always include the following information:

a) Instrument Model number.
b) Instrument Serial number.
c) part number.
d) Part description.
e) Circuit designation (where applicable).

8.3 MAINTENANCE KIT

A maintenance Kit is available. This Kit contains a complement of spare parts which will maintain up to ten Model 8201 Function Generators. A list of the Kit parts is available upon request.
will do its best to improve the instrument and make changes in style of components and replacement parts. Replacement parts may differ in appearance from those found in your instrument but are always equal or superior in performance.

8.4 PARTS DESCRIPTION

In the following Parts List Tables, unless otherwise noted, resistors power rating is 1/4W, resistance is given in ohms, and capacitance is given in UF.

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY

Dwg Ref	Description					a	p/n
R1	res	comp	3.3K	5%	1/4W		0100-0332
R2	res	comp	3.3K	5%	1/4W		0100-0332
R3	res	comp	8.2K	5%	1/4W		0100-0822
R4	res	comp	5.6K	5%	1/4W		0100-0562
R5	res	comp	1K	5%	1/4W		0100-0102
R6	res	comp	10K	5%	1/4W		0100-0103
R7	res	comp	100	5%	1/4W		0100-0101
R8	res	comp	1K	5%	1/4W		0100-0102
R9	res	comp	4.7K	5%	1/4W		0100-0472
R11	res	comp	1K	5%	1/4W		0100-0102
R12	res	comp	.27	5%	2W		0103-0R27
R13	res	comp	1K	5%	1/4W		0100-0102
R14	res	comp	100	5%	1/4W		0100-0101
R15	res	mtf	4.02K	1%	1/4W		0104-4021
R16	res	mtf	15K	1%	1/4W		0104-1502
R17	res	mtf	2.49K	1%	1/4W		0104-2491
R18	res	trim	500				0203-0501
R19	res	mtf	249	1%	1/4W		0104-2490
R20	res	comp	1K	5%	1/4W		0100-0102
R21	res	comp	39	5%	1/4W		0100-0390
R24	res	comp	1K	5%	1/4W		0100-0102
R26	res	comp	10K	5%	1/4W		0100-0103
R29	res	comp	10K	5%	1/4W		0100-0103
R30	res	comp	27K	5%	1/4W		0100-0273
R31	res	mtf	7.5K	1%	1/4W		0104-7501
R32	res	mtf	2.49K	1%	1/4W		0104-2491
R33	res	mtf	7.5K	1%	1/4W		0104-7501
R34	res	trim	2K				0203-0202
R35	res	mtf	1.5K	1%	1/4W		0104-1501
R36	res	mtf	499	1%	1/4W		0104-4990
R37	res	mtf	2K	1%	1/4W		0104-2001
R38	res	mtf	4.99K	1%	1/4W		0104-4991
R39	res	mtf	556	.2%	1/4W		0106-5560
R40	res	comp	22K	5%	1/4W		0100-0223
R41	res	mtf	4.99K	1%	1/4W		0104-4991
R42	res	mtf	4.99K	1%	1/4W		0104-4991
R43	res	mtf	249	1%	1/4W		0104-2490
R44	res	mtf	4.99K	1%	1/4W		0104-4991
R45	res	mtf	4.99K	1%	1/4W		0104-4991
R46	res	mtf	499	1%	1/4W		0104-4990

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY(continued)

Dwg Ref	Description					p/n
R47	res	mtf	2K	1%	1/4W	0104-2001
R48	res	mtf	4.99K	1%	1/4W	0104-4991
R49	res	comp	22K	5%	1/4W	0100-0223
R50	res	mtf	556	.2%	1/4W	0106-5560
R51	res	comp	1.5K	5%	1/4W	0104-1501
R52	res	mtf	4.99K	1%	1/4W	0104-4991
R53	res	trim	5K			0203-0502
R54	res	mtf	2K	1%	1/4W	0104-2001
R55	res	comp	1K	5%	1/4W	0100-0102
R63	res	mtf	4.99K	1%	1/4W	0104-4991
R65	res	comp	33	5%	1/4W	0100-0330
R66	selected value					
R68	res	comp	82	5%	1/4W	0100-0820
R69	res	comp	82	5%	1/4W	0100-0820
R70	res	comp	100	5%	1/4W	0100-0100
R71	res	comp	100	5%	1/4W	0100-0100
R72	res	comp	39	5%	1/4W	0100-0390
R73	res	mtf	100	1%	1/4W	0104-1000
R74	res	mtf	121	1%	1/4W	0104-1210
R75	res	comp	2.7K	5%	1/4W	0100-0272
R76	res	comp	39	5%	1/4W	0100-0390
R77	res	comp	1.2K	5%	1/4W	0100-0122
R78	res	copp	1.2K	5%	1/4W	0100-0122
R79	res	comp	39	5%	1/4W	0100-0390
R80	res	comp	2.7K	5%	1/4W	0100-0272
R81	res	comp	10	5%	1/4W	0100-0100
R82	res	comp	10	5%	1/4W	0100-0100
R83	res	comp	1.2K	5%	1/4W	0100-0122
R84	res	mtf	365	1%	1/4W	0104-3650
R85	res	comp	39	5%	1/4W	0100-0390
R86	res	mtf	365	1%	1/4W	0104-3560
R87	res	comp	1.2K	5%	1/4W	0100-0122
R88	res	comp	39	5%	1/4W	0100-0390
R89	res	comp	10K	5%	1/4W	0100-0103
R90	res	comp	1.2K	5%	1/4W	0100-0122
R91	res	comp	39	5%	1/4W	0100-0390
R92	res	comp	39	5%	1/4W	0100-0390
R93	res	comp	68	5%	1/4W	0100-0680
R94	res	mtf	4.53K	1%	1/4W	0104-4531

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY(continued)

Dwg Ref	Description					p/n
R95	res	mtf	4.53K	1%	1/4W	0104-4531
R96	res	comp	3.9K	5%	1/4W	0100-0392
R97	res	comp	15	5%	1/4W	0100-0150
R98	res	comp	270	5%	1/4W	0100-0271
R99	res	mtf	464	1%	1/4W	0104-4640
R100	res	comp	820	5%	1/4W	0100-0821
R101	res	comp	820	5%	1/4W	0100-0821
R102	res	mtf	976	1%	1/4W	0104-9760
R103	res	mtf	976	1%	1/4W	0104-9760
R104	res	comp	3.9K	5%	1/4W	0100-0392
R105	res	comp	15K	5%	1/4W	0100-0153
R106	res	comp	15K	5%	1/4W	0100-0153
R107	res	comp	7.5K	5%	1/4W	0100-0752
R108	res	comp	7.5K	5%	1/4W	0100-0752
R109	res	comp	10K	5%	1/4w	0100-0103
R110	res	comp	10K	5%	1/4W	0100-0103
R113	res	comp	100K	5%	1/4W	0100-0104
R114	res	comp	33	5%	1/4W	0100-0330
R115	res	comp	22K	5%	1/4W	0100-0223
R116	res	comp	33K	5%	1/4W	0100-0333
R117	res	comp	220	5%	1/4W	0100-0221
R118	res	comp	33	5%	1/4W	0100-0330
R119	res	comp	33	5%	1/4W	0100-0330
R120	res	comp	33	5%	1/4W	0100-0330
R121	res	comp	100	5%	1/4W	0100-0101
R122	res	comp	100	5%	1/4W	0100-0101
R123	res	comp	100	5%	1/4W	0100-0101
R124	res	comp	100	5%	1/4W	0100-0101
R125	res	comp	100	5%	1/4W	0100-0101
R126	res	comp	39	5%	1/4W	0100-0390
R127	res	comp	39	5%	1/4W	0100-0390
R128	res	comp	39	5%	1/4W	0100-0390
R129	res	mtf	1.13K	1%	1/4W	0104-1131
R130	res	mtf	7.32K	1%	1/4W	0104-7231
R131	res	mtf	619	1%	1/4W	0104-6190
R132	res	mtf	825	1%	1/4W	0104-8250
R133	res	mtf	1.87K	1%	1/4W	0104-1871
R134	res	mtf	140	1%	1/4W	0104-1400
R135	res	mtf	140	1%	1/4W	0104-1400
R136	res	mtf	261	1%	1/4W	0104-2610
R137	res	mtf	261	1%	1/4W	0104-2610
R138	res	mtf	115	1%	1/4W	0104-1150
R139	res	mtf	115	1%	1/4W	0104-1150
R140	res	mtf	127	1%	1/4W	0104-1270
R141	res	mtf	127	1%	1/4W	0104-1270
R142	res	mtf	154	1%	1/4W	0104-1540
R143	res	mtf	154	1%	1/4W	0104-1540

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY(contineed)

Dwg Ref	Description					p/n
R144	res	comp	100	5%	1/4W	0100-0101
R145	res	mtf	100	1%	1/4W	0104-1000
R146	res	mtf	499	1%	1/4W	0104-4990
R147	res	mtf	499	1%	1/4W	0104-4990
R148	res	mtf	1.5K	1%	1/4W	0104-1501
R149	res	mtf	1.5K	1%	1/4W	0104-1501
R150	res	mtf	4.02K	1%	1/4W	0104-4021
R151	res	trim	2K			0203-0202
R152	res	comp	51	5%	1/4W	0100-0510
R153	res	comp	51	5%	1/4W	0100-0510
R154	res	comp	820	5%	1/4W	0100-0821
R155	res	comp	22	5%	1/4W	0100-0220
R156	res	comp	100	5%	1/4W	0100-0101
R157	res	comp	100	5%	1/4W	0100-0101
R158	res	comp	10	5%	1/4W	0100-0100
R159	res	comp	10	5%	1/4W	0100-0100
R160	res	comp	560	5%	1/4W	0100-0561
R161	res	comp	560	5%	1/4W	0100-0561
R162	res	mtf	4.99K	1%	1/4W	0104-4991
R163	res	trim	1K			0203-0503
R164	res	mtf	9.09K	1%	1/4W	0104-9091
R165	res	trim	50K			0203-0503
R166	res	mtf	4.99K	1%	1/4W	0104-4991
R167	res	comp	15	5%	1/4W	0100-0150
R168	res	mtf	49.9	1%	1/4W	0104-49R9
R170	res	comp	3.3K	5%	1/4W	0100-0332
R171	res	comp	3.3K	5%	1/4W	0100-0332
R172	res	comp	1K	5%	1/4W	0100-0102
R173	res	comp	1K	5%	1/4W	0100-0102
R174	res	comp	1K	5%	1/4W	0100-0102
R175	res	comp	1K	5%	1/4W	0100-0102
R176	res	comp	1M	5%	1/4W	0100-0105
R177	res	comp	1M	5%	1/4W	0100-0105
R178	res	comp	1M	5%	1/4W	0100-0105
R179	res	comp	1M	5%	1/4W	0100-0105
R180	res	comp	10K	5%	1/4W	0100-0103
R181	res	comp	22K	5%	1/4W	0100-0223
R182	res	mtf	1K	1%	1/4W	0104-1001
R183	res	mtf	10K	1%	1/4W	0104-1002
R184	res	mtf	100K	1%	1/4W	0104-1003
R185	res	mtf	1M	1%	1/4W	0104-1004
R186	res	comp	100K	5%	1/4W	0100-0104
R187	res	mtf	10K	1%	1/4W	0104-1002
R188	res	trim	10K			0203-0103
R189	res	mtf	47.5K	1%	1/4W	0104-4752
R190	res	comp	100	5%	1/4w	0100-0101
R191	res	comp	100	5%	1/4W	0100-0101
R192	res	trim	10K	10	turns	0203-0103A

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY(continued)

Dwg Ref	Description					p/n
R193	res	comp	100	5%	1/4W	0100-0101
R194	res	mtf	1.1K	1%	1/4W	0104-1101
R195	res	comp	10K	5%	1/4W	0100-0103
R196	res	comp	39	5%	1/4W	0100-0390
R197	res	comp	39	5%	1/4W	0100-0390
R198	res	comp	270	5%	1/4W	0100-0271
R199	res	comp	270	5%	1/4W	0100-0271
R200	res	comp	270	5%	1/4W	0100-0271
R201	res	comp	270	5%	1/4W	0100-0271
R202	res	comp	270	5%	1/4W	0100-0271
R208	res	comp	1K	5%	1/4W	0100-0102
R209	res	mtf	2.49K	1%	1/4W	0104-2491
R210	res	comp	47	5%	1/4W	0100-0470
R211	res	ccomp	470	5%	1/4W	0100-0471
R212	res	mtf	470	5%	1/4W	0100-0471
R213	res	mtf	365	1%	1/2W	0104-3650A
R214	res	comp	82	5%	1/4W	0100-0820
R215	res	comp	82	5%	1/4W	0100-0820
R216	res	mtf	7.5K	1%	1/4W	0104-7501
R217	res	mtf	2.49K	1%	1/4W	0104-2491
R218	res	comp	100K	5%	1/4W	0100-0104
R219	res	comp	100K	5%	1/4W	0100-0104
R221	selected value					
R222	selected value					
R223	res	comp	22K	5%	1/4W	0100-0223
R224	res	comp	33K	5%	1/4W	0100-0333
R225	res	mtf	7.5K	1%	1/4W	0104-7501
R226	res	comp	1K	5%	1/4W	0100-0102
R227	res	comp	10K	5%	1/4W	0100-0103
R230	res	comp	100K	5%	1/4W	0100-0104
R231	res	comp	100K	5%	1/4W	0100-0104
R232	res	comp	100K	5%	1/4W	0100-0104
R233	res	comp	100K	5%	1/4W	0100-0104
R300	res	pot	5K (trigger level)			0205-1502
C1	cap	cer	0.1u			1500-0104
C2	cap	cer	0.1u			1500-0104
C3	cap	tant	3.3u			1540-0335
C4	cap	cer	0.1u			1500-0104
C5	cap	cer	0.1u			1500-0104
C6	cap	cer	0.1u			1500-0104
C7	cap	elect	100u/25V			1533-0107
C8	cap	tant	10u/25V			1540-0106
C9	cap	cer	27p			1500-0270
C10	cap	elect	2200u/16V			1533-0228
C11	cap	elect	2200u/16V			1533-0228
C12	cap	elect	1000u/35V			1534-0108
C13	cap	elect	1000u/35V			1534-0108

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY(continued)

Dwg Ref	Description	p/n
C14	cap elect 1000u/50V	1535-0108
C15	cap elect 1000u/50V	1535-0108
C16	cap elect 220u/16V	1532-0227
C17	cap elect 100u/35V	1534-0107
C18	cap elect 100u/35V	1534-0107
C19	cap elect 100u/35V	1534-0107
C20	cap elect 100u/35V	1534-0107
C21	cap tant 10u/25V	1540-0106
C22	cap tant 10u/25V	1540-0106
C23	cap cer 0.1u	1500-0104
C24	cap cer 0.1u	1500-0104
C26	cap cer 1n	1500-0102
C27	cap cer 33p	1500-0330
C28	cap cer 33p	1500-0330
C29	cap tant 10u/25V	1540-0106
C30	cap cer 33p	1500-0330
C31	cap cer 33p	1500-0330
C33	cap cer 1n	1500-0102
C34	cap cer 33p	1500-0330
C35	cap cer 33p	1500-0330
C36	cap cer 1n	1500-0102
C37	cap tant 10u/25V	1540-0106
C38	cap tant 10u/25V	1540-0106
C44	selected value	
C45	cap trim 5.5-18p	1550-0180
C46	cap cer 0.1u	1500-0104
C47	cap mica 820p +/-5%	1510-0821
C48	selected value	
C50	cap poly 4700p +/-2%	1520-0472
C51	cap poly 4700p +/-2%	1520-0472
C52	selected value	
C53	ca poly 100n 1%	1520-0104
C54	cap poly 1u 1%	1522-0105
C55	cap myler 2.2 +/-5% 63V	1522-0106
C56	cap cer 0.1u	1500-0104
C57	cap cer 0.1u	1500-0104
C58	cap cer 0.1u	1500-0104
C59	cap cer 0.1u	1500-0104
C60	cap cer 0.1u	1500-0104
C61	cap mica 47p	1510-0470
C62	cap mica 33p	1510-0330
C63	selected value	
C64	cap mica 47p	1510-0470
C65	cap mica 33p	1510-0330
C66	selected value	
C67	cap cer 0.1u	1500-0104
C68	cap tant 10u/25V	1540-0106
C69	cap tant 10u/25V	1540-0106
C73	cap cer 0.1u	1500-0104

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY(continued)

Dwg Ref	Description			p/n
C74	cap	mica	220p	1510-0221
C76	cap	cer	0.1u	1500-0104
C78	cap	cer	0.1u	1500-0104
C84	cap	cer	0.1u	1500-0104
C85	cap	cer	0.1u	1500-0104
C87	cap	cer	0.1u	1500-0104
C88	cap	cer	0.1u	1500-0104
C89	cap	tant	10u/25V	1540-0106
C90	cap	cer	0.1u	1500-0104
C91	cap	cer	0.1u	1500-0104
C92	cap	cer	0.1u	1500-0104
C93	cap	cer	0.1u	1500-0104
C100	cap	cer	0.1u	1500-0104
C101	cap	cer	6.8p	1500-06R8
C102	cap	cer	0.1u	1500-0104
C103	cap	cer	0.1u	1500-0104
C104	cap	mica	62p	1510-0620
C105	cap	elect	100u/25V	1533-0107
C107	cap	cer	100p	1500-0101
C108	cap	cer	33p	1500-0330
C109	cap	cer	33p	1500-0330
C110	cap	cer	1.5p	1500-01R5
C111	cap	cer	1.5p	1500-01R5
C112	cap	cer	0.1u	1500-0104
C113	cap	cer	0.1u	1500-0104
C115	cap	cer	0.1u	1500-0104
C116	cap	cer	0.1u	1500-0104
C300	cap	cer	0.1u	1500-0104
Y1	crystal		10MHz	0800-3000
CR1	diode		1N753A	0300-2020
CR2	diode		1N4151	0300-0040
CR3	diode		1N4151	0300-0040
CR4	diode		KBL005	0300-5020
CR5	bridge		WL04	0300-5010
CR6	bridge		WL04	0300-5010
CR7	diode		1N4151	0300-0040
CR8	diode		1N5340	0300-2140
CR10	diode		1N825A	0300-2110
CR11	diode		1N4151	0300-0040
CR12	diode		1N4151	0300-0040

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY(continued)

Dwg Ref	Desription		p/n
CR15	diode	BAR 10	0300-1020
CR16	diode	BAR 10	0300-1020
CR17	diode	BAR 10	0300-1020
CR18	diode	BAR 10	0300-1020
CR19	diode	1N4151	0300-1040
CR20	diode	1N4151	0300-1040
CR21	diode	BAR 10	0300-1020
CR22	diode	BAR 10	0300-1020
CR23	diode	1N4151	0300-0040
CR24	diode	1N4151	0300-0040
CR25	diode	1N754A	0300-2030
CR26	diode	1N754A	0300-2030
CR27	diode	BAR 10	0300-1020
CR28	diode	BAR 10	0300-1020
CR29	diode	1N753A	0300-2020
CR30	diode	1N753A	0300-2020
CR31	diode	1N4151	0300-0400
CR32	diode	1N4151	0300-0040
CR34	diode	1N4151	0300-0040
CR35	diode	1N759A	0300-2050
CR36	diode	1N4151	0300-0040
CR37	diode	1N4151	0300-0040
CR38	diode	1N758A	0300-2040
CR39	diode	1N4151	0300-0040
CR40	diode	1N4151	0300-0040
CR41	diode	1N4151	0300-0040
CR46	diode	1N4151	0300-0040
CR47	diode	1N751A	0300-2001
CR48	diode	1N4151	0300-0040
CR51	diode	BAR 10	0300-1020
CR52	diode	1N4151	0300-0040
CR300	diode	1N751A	0300-2001
CR301	diode	1N751A	0300-2001
Q1	trans	2N4124	0400-0030
Q2	trans	2N4124	0400-0030
Q3	trans	2N4126	0400-0400
Q4	trans	MJE2955	0400-4030
Q5	trans	2N4124	0400-0030
Q6	trans	2N5087	0400-0190
Q7	trans	2N5210	0400-0191
Q8	trans FET	J109	0400-0250

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

Dwg Ref	Description	p/n
U57	ic CD4094	0500-0110
U58	ic CD4094	0500-0110
U59	ic 74LS193	0510-0315
U60	ic 74LS193	0510-0315
U61	ic 74LS193	0510-0315
U62	ic 74LS193	0510-0315
U63	ic 74LS193	0510-0315
U64	ic 74F74	0500-1260
U65	ic 74F74	0500-1260
U66	ic 74F02	0500-1200
U67	ic 74F10	0500-1240
U68	ic 74F00	0500-1190
U69	ic 74LS00	0510-0010
U70	ic 74S140	0500-2025
U71	ic NE529	0500-5410
U72	ic DG211	0500-9090
K1	relay 1 form A (BLU-BOY)	0900-0040
B1	bat 1/2 AA Litium battery	2600-0020
SP1	beeper AT-02	0900-0190
L6	bead Philips	4200-0000
L7	bead Philips	4200-0000

Table 8-2. Model 8201 PARTS LIST - FINAL AMPLIFIER BOARD ASSEMBLY

Dwg Ref	Description	p/n
R1	res comp 180 5% 1/4W	0100-0181
R2	res comp 180 5% 1/4W	0100-0181
R3	res comp 220 5% 1/4W	0100-0221
R4	res comp 220 5% 1/4W	0100-0221
R5	res comp 560 5% 1/4W	0100-0561
R6	res mtf 1K 1% 1/2W	0104-1001A
R7	res mtf 1K 1% 1/2W	0104-1001A
R8	res mtf 402 1% 1/4W	0104-4020
R9	res mtf 402 1% 1/4W	0104-4020
R10	res mtf 464 1% 1/2W	0104-4640A
R11	res mtf 464 1% 1/2W	0104-4640A
R12	res comp 33 5% 1/4W	0100-0330
R13	res comp 33 5% 1/4W	0100-0330
R14	res comp 33 5% 1/4W	0100-0330

Table 8-2. Model 8201 PARTS LIST - FINAL AMPLIFIER BOARD ASSEMBLY (continued)

Dwg Ref	Description					p/n
R15	res	comp	33	5%	1/4W	0100-0330
R16	res	comp	120	5%	1/4W	0100-0121
R17	res	comp	120	5%	1/4W	0100-0121
R18	res	mtf	10K	1%	1/4W	0104-1002
R19	res	trim	5K	1 turn		0203-0502
R20	res	mtf	15K	1%	1/4W	0104-1502
R21	res	mtf	10K	1%	1/4W	0104-1502
R22	res	trim	5K	1 turn		0203-0502
R23	res	mtf	15K	1%	1/4W	0104-1502
R24	res	comp	1K	5%	1/4W	0100-0102
R25	res	comp	1K	5%	1/4W	0100-0102
R26	res	mtf	1K	1%	1/4W	0104-1001
R27	res	mtf	1K	1%	1/4W	0104-1001
R28	res	comp	33K	5%	1/4W	0100-0333
R29	res	comp	33K	5%	1/4W	0100-0333
R30	res	comp	33K	5%	1/4W	0100-0333
R31	res	comp	1K	5%	1/4W	0100-0102
R32	res	comp	33K	5%	1/4W	0100-0333
R33	res	comp	33K	5%	1/4W	0100-0333
R34	res	comp	15K	5%	1/4W	0100-0153
R35	res	comp	560	5%	1/4W	0100-0561
R36	res	comp	1K	5%	1/4W	0100-0102
R37	res	comp	3.9K	5%	1/4W	0100-0392
R38	res	comp	2.7K	5%	1/4W	0100-0272
R39	res	comp	2.7K	5%	1/4W	0100-0272
R40	res	comp	820	5%	1/4W	0100-0821
R41	res	comp	100	5%	1/4W	0100-0101
R42	res	comp	10K	5%	1/4W	0100-0103
R43	res	mtf	2.49K	1%	1/4W	0104-2491
R44	res	mtf	2.49K	1%	1/4W	0104-2491
R45	res	comp	390	5%	1/4W	0100-0391
R46	res	comp	15	5%	1/4W	0100-0150
R47	res	comp	270	5%	1/4W	0100-0271
R48	res	comp	15	5%	1/4W	0100-0150
R49	res	comp	100	5%	1/4W	0100-0101
R50	res	comp	100	5%	1/4W	0100-0101
R51	res	mtf	681	1%	1/4W	0104-6810
R52	res	comp	2.7	5%	1/4W	0100-02R7
R53	res	comp	2.7	5%	1/4W	0100-02R7
R54	res	comp	220	5%	1/4W	0100-0221
R55	res	comp	220	5%	1/4W	0100-0221
R56	res	trim	100	1 turn		0203-0101A
R57	res	mtf	100	1%	1/4W	0104-1000
R58	res	trim	200	1 turn		0203-0201A
R59	res	mtf	402	1%	1/4W	0104-4020
R60	res	mtf	365	1%	1/4W	0104-3650

Table 8-2. Model 8201 PARTS LIST - FINAL AMPLIFIER BOARD ASSEMBLY (continued)

Dwg Ref	Description					p/n
R61	res	mtf	365	1%	1/4W	0104-3650
R62	res	mtf	732	1%	1/4W	0104-7320
R63	res	mtf	750	1%	1/4W	0104-7500
R64	res	mtf	732	1%	1/4W	0104-7320
R65	res	mtf	750	1%	1/4W	0104-7500
R66	res	mtf	365	1%	1/4W	0104-3650
R67	res	mtf	732	1%	1/4W	0104-7320
R68	res	mtf	750	1%	1/4W	0104-7500
R69	res	mtf	130	1%	1/4W	0104-1300
R70	res	mtf	12.1K	1%	1/4W	0104-1212
R71	res	comp	2.7	5%	1/4W	0100-02R7
R72	res	mtf	22.1K	1%	1/4W	0104-2212
R73	res	mtf	2K	1%	1/4W	0104-2001
R74	res	mtf	47.5K	1%	1/4W	0104-4752
R75	res	mtf	511	1%	1/4W	0104-5110
R76	res	mtf	90.9K	1%	1/4W	0104-9092
R77	res	mtf	5.11K	1%	1/4W	0104-5111
R78	res	comp	33K	5%	1/4W	0100-0333
R79	res	comp	3.3K	5%	1/4W	0100-0332
R80	res	comp	3.9K	5%	1/4W	0100-0392
R81	res	comp	220	5%	1/4W	0100-0221
R82	res	comp	220	5%	1/4W	0100-0221
R83	res	comp	470	5%	1/4W	0100-0471
R84	res	comp	2.7K	5%	1/4W	0100-0272
R85	res	comp	2.7K	5%	1/4W	0100-0272
R86	res	mtf	40.2K	1%	1/4W	0104-4022
R87	res	comp	3.9K	5%	1/4W	0100-0392
R88	res	comp	3.9K	5%	1/4W	0100-0392
R89	res	comp	100	5%	1/4W	0100-0101
R90	res	comp	100	5%	1/4W	0100-0101
R91	res	comp	5.6K	5%	1/4W	0100-0562
R92	res	mtf	115	1%	1/4W	0104-1151
R93	res	comp	150	5%	1/4W	0100-0151
R94	res	comp	18	5%	1/4W	0100-0180
R95	res	comp	15	5%	1/4W	0100-0150
R96	res	comp	270	5%	1/4W	0100-0271
R97	res	comp	1K	5%	1/4W	0100-0102
R98	res	comp	33	5%	1/4W	0100-0330
R99	res	comp	33	5%	1/4W	0100-0330
R100	res	comp	10	5%	1/4W	0100-0100
R101	res	comp	10	5%	1/4W	0100-0100
R102	res	comp	10	5%	1/4W	0100-0100
R103	res	comp	10	5%	1/4W	0100-0100
R104	res	comp	33	5%	2W	0103-0330
R105	res	comp	33	5%	2W	0103-0330
R106	res	mtf	750	1%	1/4W	0104-7500

Table 8-2. Model 8201 PARTS LIST - FINAL AMPLIFIER BOARD ASSEMBLY (continued)

Dwg Ref	Description					p/n
R107	res	mtf	750	1%	1/4W	0104-7500
R108	res	mtf	100	1%	1W	0104-1000B
R109	res	mtf	100	1%	1W	0104-1000B
R110	res	mtf	61.9	1%	1W	0104-61R9B
R111	res	mtf	61.9	1%	1W	0104-61R9B
R112	res	mtf	249	1%	1/2W	0104-2490A
R113	res	mtf	61.9	1%	1W	0104-61R9B
R114	res	mtf	61.9	1%	1W	0104-61R9B
R115	res	mtf	249	1%	1/2W	0104-2490A
R116	res	mtf	96.5	1%	1W	0104-96R5B
R117	res	mtf	96.5	1%	1W	0104-96R5B
R118	res	mtf	71.5	1%	1/2W	0104-71R5A
R119	res	comp	1.8K	5%	1/4W	0100-0182
R120	res	trim	2K	1 turn		0203-0202
R121	res	mtf	1K	1%	1/4W	0104-1001
R122	res	mtf	10K	1%	1/4W	0104-1002
R123	res	mtf	10K	1%	1/4W	0104-1003
R124	res	comp	33K	5%	1/4W	0100-0333
R125	res	comp	10K	5%	1/4W	0100-0103
R126	res	mtf	597	1%	1/4W	0104-5790
R127	res	comp	10K	5%	1/4W	0100-0103
R128	res	comp	10K	5%	1/4W	0100-0103
R129	res	comp	3.3K	5%	1/4W	0100-0332
R130	res	comp	100K	5%	1/4W	0100-0104
R131	res	comp	100K	5%	1/4W	0100-0104
R132	res	comp	100K	5%	1/4W	0100-0104
R133	res	comp	100K	5%	1/4W	0100-0104
R134	res	comp	15K	5%	1/4W	0100-0153
R135	res	comp	1K	5%	1/4W	0100-0103
R136	res	mtf	249	1%	1/4W	0104-2490
R137	res	comp	10K	5%	1/4W	0100-0103
R138	res	comp	10K	5%	1/4W	0100-0103
C1	cap	cer	0.1			1500-0104
C2	cap	cer	0.1			1500-0104
C3	cap	cer	1n			1500-0102
C4	cap	cer	0.1			1500-0104
C5	cap	cer	0.1			1500-0104
C6	cap	cer	0.1			1500-0104
C7	cap	cer	0.1			1500-0104
C8	cap	cer	selected			
C9	cap	cer	selected			
C10	cap	cer	selected			
C11	cap	cer	selected			
C12	cap	cer	0.1			1500-0104

Table 8-2. Model 8201 PARTS LIST - FINAL AMPIFIER BOARD ASSEMBLY (continued)

Dwg Ref	Description	p/n
C13	cap cer 0.1	1500-0104
C14	cap cer 0.1	1500-0104
C15	cap cer 0.1	1500-0104
C16	cap cer 15P	1500-0104
C17	cap cer 0.1	1500-0104
C18	cap cer 0.1	1500-0104
C19	cap cer 0.1	1500-0104
C20	cap cer 0.1	1500-0104
C21	cap cer 0.1	1500-0104
C22	cap cer 0.1	1500-0104
C23	cap cer 0.1	1500-0104
C24	cap cer 1n	1500-0102
C25	cap cer 10P	1500-0104
C26	cap cer (selected value)	
C27	cap cer 0.1	1500-0104
C28	cap cer 1n	1500-0102
C29	cap cer 0.1	1500-0104
C30	cap eer 0.1	1500-0104
C31	cap cer 0.1	1500-0104
C32	cap cer 0.1	1500-0104
C33	cap cer 0.1	1500-0104
C34	cap cer 1n	1500-0102
C35	cap cer 1n	1500-0102
C36	cap cer 1n	1500-0102
C37	cap cer 6.8P	1500-06R8
C38	cap cer 4.7P	1500-04R7
C39	cap cer 6.8P	1500-06R8
C40	cap cer 4.7P	1500-04R7
C41	cap cer 0.1	1500-0104
C42	cap cer 0.1	1500-0104
C43	cap cer 0.1	1500-0104
C44	cap cer 0.1	1500-0104
C45	cap cer 0.1	1500-0104
C46	cap cer 10P	1500-0100
C47	cap trim 5.5 - 18P	1550-0180
C48	cap cer 0.1	1500-0104
C49	cap cer 0.1	1500-0104
C50	cap cer 0.1	1500-0104
C51	cap cer 0.1	1500-0104
C52	cap mylar 0.1/100V	1521-0104
C53	cap tant 10/35V	1521-0106
C54	cap cer 0.1	1500-0104
C55	cap tant 10/35V	1540-0106
C56	cap mylar 0.1/100V	1521-0104
C57	cap cer 47P	1500-0470
C58	cap cer 0.1	1500-0104

Table 8-2. Model 8201 PARTS LIST - FINAL AMPLIFIER BOARD ASSEMBLY (continued)

Dwg Ref	Description	p/n
C59	cap cer 33P	1500-0330
C60	cap cer 33P	1500-0330
C61	cap cer 43P	1500-0430
C62	cap cer 1n	1500-0102
C63	cap cer 1n	1500-0102
C64	cap cer 1n	1500-0104
C65	cap cer 0.1	1500-0104
C66	cap cer 0.1	1500-0104
C67	cap cer 0.1	1500-0104
Q1	trans 2N3640	0400-0010
Q2	trans 2N3640	0400-0010
Q3	trans 2N3640	0400-0010
Q4	trans 2N3640	0400-0010
Q5	trans 2N3646	0400-0020
Q6	trans 2N3646	0400-0020
Q7	trans 2N4126	0400-0040
Q8	trans 2N4124	0400-0030
Q9	trans J109	0400-0250
Q10	trans J109	0400-0250
Q11	trans 2N4124	0400-0030
Q12	trans 2N4126	0400-0040
Q13	trans 2N3640	0400-0010
Q14	trans 2N3646	0400-0020
Q15	trans 2N3646	0400-0020
Q16	trans 2N3640	0400-0010
Q17	trans SD214	0400-0231
Q18	trans PN4392	0400-4000
Q19	trans SD214	0400-0231
Q20	trans PN4392	0400-4000
Q21	trans SD214	0400-0231
Q22	trans PN4392	0400-4000
Q23	trans SD214	0400-0231
Q24	trans PN4392	0400-4000
Q25	trans PN4392	0400-4000
Q26	trans J175	0400-0252
Q27	trans PN4392	0400-4000
Q28	trans J175	0400-0252
Q29	trans PN4392	0400-4000
Q30	trans J175	0400-0252
Q31	trans PN4392	0400-4000
Q32	trans J175	0400-0252
Q33	trans 2N3646	0400-0020
Q34	trans 2N3640	0400-0010
Q35	trans 2N5160	0400-0080
Q36	trans MPS3827	0400-0282
Q37	trans 2N3866A	0400-0161

Table 8-2. Model 8201 PARTS LIST - FINAL AMPLIFIER BOARD ASSEMBLY (continued)

Dwg Ref	Description		p/n
Q38	trans	2N3904	0400-0120
Q39	trans	PN4122	0400-0050
Q40	trass	2N2219A	0400-4010
Q41	trans	2N2905A	0400-0150
Q42	trans	2N2219A	0400-4010
Q43	trans	2N2905A	0400-0150
Q44	trans	J109	0400-0250
Q45	trans	2N4124	0400-0030
Q46	trans	2N4126	0400-0040
Q47	trans	SD214	0400-0231
Q48	trans	SD214	0400-0231
CR1	dio	1N4151	0300-0040
CR2	dio	1N4151	0300-0040
CR3	dio	1N4151	0300-0040
CR4	dio	1N4151	0300-0040
CR5	dio	1N4151	0300-0040
CR6	dio	1N4151	0300-0040
CR7	dio	1N4151	0300-0040
CR8	dio	1N4151	0300-0040
CR9	dio	1N4151	0300-0040
CR10	dio	1N4151	0300-0040
CR11	dio	1N4151	0300-0040
CR12	dio	1N4151	0300-0040
CR13	dio	1N4151	0300-0040
CR14	dio	1N4151	0300-0040
CR15	dio	1N4151	0300-0040
CR16	dio	1N4151	0300-0040
CR17	dio	1N4151	0300-0040
CR18	dio	1N4151	0300-0040
CR19	dio	1N4151	0300-0040
CR20	dio	1N758A	0300-2040
CR21	dio	1N4151	0300-0040
CR22	dio	1N4151	0300-0040
CR23	dio	1N825A	0300-2210
CR24	dio	1N4151	0300-0040
CR25	dio	1N751A	0300-2001
U1	ic	10216	0500-4110
U2	ic	741C	0500-5631
U3	ic	741C	0500-5631
U4	ic	CA4094	0540-0110
U5	ic	LM339	0500-5040
U6	ic	SD5000	0500-5711
U7	ic	CA3096	0500-5790

Table 8-2. Model 8201 PARTS LIST - FINAL AMPLIFIER BOARD ASSEMBLY (continued)

Dwg Ref	Description		p/n
U8	ic	CA4094	0540-0110
U9	ic	LM339	0500-5040
U10	ic	LM339	0500-5040
U11	ic	LM339	0500-5040
U12	ic	CA3096	0500-5790
U13	ic	CA4094	0540-0110
U14	ic	AD7533	0560-0070
U15	ic	CA4094	0540-0110
U16	ic	LM308A	0500-5340
U17	ic	LM301A	0500-5300
U18	ic	741C	0500-5631
U19	ic	L204	0500-1160
U20	ic	LM311	0500-5330
F1	fuse	.315A fast-blo	1100-1190
RN1	res net	27k	0110-0273B
RN2	res net	33k	0100-0333B
K1	relay	RY6W OHK	0900-0070
K2	relay	RY6W OHK	0900-0070
K3	relay	RY6W OHK	0900-0070
K4	relay	RY6W OHK	0900-0070
L1	bead		4200-0000
L2	bead		4200-0000

Table 8-3. Model 8201 PARTS LIST _ DISPLAY BOARD ASSEMBLY

Dwg Ref	Description			p/n
R1	res comp	39	5% 1/4W	0100-0390
RN1	res net	MDP 16-03-150		0109-1500
RN2	res net	MDP 14-03-390		0108-0390
RN3	res net	MDP 14-03-390		0108-0390
C1	cap elec	100/16V		1532-0107
C2	cap cer	0.1		1500-0104
C3	cap cer	0.1		1500-0104
C4	cap cer	0.1		1500-0104

Table 8-3. Model 8201 PARTS LIST _ DISPLAY BOARD ASSEMBLY (continued)

Dwg Ref	Description		Tabor p/n
Q1	trans	2N4403	0400-0180
Q2	trans	2N4403	0400-0180
Q3	trans	2N4403	0400-0180
Q4	trans	2N4403	0400-0180
Q5	trans	2N4403	0400-0180
Q6	trans	2N4403	0400-0180
Q7	trans	2N4403	0400-0180
Q8	trans	2N4403	0400-0180
Q9	trans	2N4403	0400-0180
Q10	trans	2N4403	0400-0180
Q11	trans	2N4403	0400-0180
Q12	trans	2N4403	0400-0180
Q13	trans	2N4124	0400-0030
Q14	trans	2N4401	0400-0181
U1	ic	P8279	0500-2070
U2	ic	L204B (9668)	0500-1160
U3	ic	74LS138	0500-0270
U4	ic	74LS138	0500-0270
U5	ic	74LS138	0500-0270
S1	switch	push-button	2000-6160
.	.		.
.	.		.
S22	.		.
DS1	LED	HDSP-5501	1200-1080
.	.		.
.	.		.
DS8	.		.
DS9	LED	mini red	1000-0070
.	.		.
.	.		.
DS37	.		.
J1	connector 16 pin		3000-4013

Table 8-4. Model 8201 PARTS LIST - PULSE GENERATION BOARD ASSEMBLY

Dwg Ref	Description					p/n
R1	res	comp	33	5%	1/4W	0100-0330
R2	res	comp	2.2K	5%	1/4W	0100-0222
R3	res	comp	2.2K	5%	1/4W	0100-0222
R4	res	comp	33	5%	1/4W	0100-0330
R5	res	comp	150	5%	1/4W	0100-0151
R6	res	comp	33	5%	1/4W	0100-0330
R7	res	comp	33	5%	1/4W	0100-0330
R8	res	mtf	150	1%	1/4W	0104-0150
R9	res	mtf	150	1%	1/4W	0104-0150
R10	res	comp	10K	5%	1/4W	0100-0103
R11	res	comp	5.6K	5%	1/4W	0100-0562
R12	res	comp	470	5%	1/4W	0100-0471
R13	res	mtf	249	1%	1/4W	0104-2490
R14	res	mtf	249	1%	1/4W	0104-2490
R15	res	comp	220	5%	1/4W	0100-0221
R16	res	mtf	100	1%	1/4W	0104-1000
R17	res	comp	330	5%	1/4W	0100-0331
R18	res	comp	3.3K	5%	1/4W	0100-0332
R19	res	comp	selected value			
R20	res	comp	1K	5%	1/4W	0100-0102
R21	res	comp	selected value			
R22	res	comp	33	5%	1/4W	0100-0330
R23	res	comp	100	5%	1/4W	0100-0101
R24	res	comp	270	5%	1/4W	0100-0271
R26	res	comp	1K	5%	1/4W	0100-0102
R27	res	comp	1M	5%	1/4W	0100-0105
R28	res	comp	1K	5%	1/4W	0100-0102
R29	res	comp	1M	5%	1/4W	0100-0105
R30	res	comp	1K	5%	1/4W	0100-0102
R31	res	comp	1M	5%	1/4W	0100-0105
R32	res	comp	1K	5%	1/4W	0100-0102
R33	res	comp	1M	5%	1/4W	0100-0105
R34	res	comp	1K	5%	1/4W	0100-0102
R35	res	trim	100			0203-0101
R36	res	comp	33	5%	1/4W	0100-0330
R37	res	comp	150	5%	1/4W	0100-0151
R38	res	comp	33	5%	1/4W	0100-0330
R39	res	comp	33	5%	1/4W	0100-0330
R40	res	comp	330	5%	1/4W	0100-0331
R41	res	mtf	249	1%	1/4W	0104-2490
R42	res	mtf	150	1%	1/4W	0104-1500
R43	res	mtf	249	1%	1/4W	0104-2490
R44	res	mtf	150	1%	1/4W	0104-1500
R45	res	comp	220	1%	1/4W	0104-2200
R46	res	comp	470	5%	1/4W	0100-0471
R47	res	comp	5.6K	5%	1/4W	0100-0562

Table 8-4. Model 8201 PARTS LIST - PULSE GENERATION BOARD ASSEMBLY (continued)

Dwg Ref	Description					Tab	p/n
R48	res	comp	10K	5%	1/4W		0100-0103
R49	res	comp	3.3K	5%	1/4W		0100-0332
R50	res	comp	1K	5%	1/4W		0100-0102
R51	res	comp	selected value				
R52	res	comp	selected value				
R53	res	mtf	100	1%	1/4W		0104-1000
R54	res	trim	100				0203-0101
R55	res	comp	33	5%	1/4W		0100-0330
R56	res	comp	100	5%	1/4W		0100-0101
R57	res	comp	270	5%	1/4W		0100-0271
R59	res	comp	1K	5%	1/4W		0100-0102
R60	res	comp	1M	5%	1/4W		0100-0105
R61	res	comp	1K	5%	1/4W		0100-0102
R62	res	comp	1M	5%	1/4W		0100-0105
R63	res	comp	1K	5%	1/4W		0100-0102
R64	res	comp	1M	5%	1/4W		0100-0105
R65	res	comp	1K	5%	1/4W		0100-0102
R66	res	comp	1M	5%	1/4W		0100-0105
R67	res	comp	1K	5%	1/4W		0100-0102
R68	res	trim	500				0203-0501
R69	res	mtf	5.62K	1%	1/4W		0104-5621
R70	res	comp	1.2K	5%	1/4W		0100-0122
R71	res	mtf	5.62K	1%	1/4W		0104-5621
R72	res	trim	500				0203-0501
R73	res	mtf	2.49K	1%	1/4W		0104-2491
R74	res	mtf	4.02K	1%	1/4W		0104-4021
R75	res	mtf	442	1%	1/4W		0104-4420
R76	res	comp	10K	5%	1/4W		0100-0103
R77	res	comp	22K	5%	1/4W		0100-0223
R78	res	mtf	825	1%	1/4W		0104-8250
R79	res	comp	33K	5%	1/4W		0100-0333
R80	res	comp	33	5%	1/4W		0100-0330
R81	res	mtf	2.49K	1%	1/4W		0104-2491
R82	res	mtf	4.02K	1%	1/4W		0104-4021
R83	res	mtf	442	1%	1/4W		0104-4420
R84	res	comp	10K	5%	1/4W		0100-0103
R85	res	comp	22K	5%	1/4W		0100-0223
R86	res	mtf	825	1%	1/4W		0104-8250
R87	res	comp	33	5%	1/4W		0100-0330
R88	res	comp	22K	5%	1/4W		0100-0223
R89	res	comp	1k	5%	1/4W		0100-0102
R90	res	comp	22K	5%	1/4W		0100-0223
R91	res	comp	22K	5%	1/4W		0100-0223
R92	res	comp	22K	5%	1/4W		0100-0223
R93	res	comp	100K	5%	1/4W		0100-0104

Table 8-4. Model 8201 PARTS LIST - PULSE GENERATION BOARD ASSEMBLY (continued)

Dwg Ref	Description	p/n
C1	cap cer 0.1	1500-0104
C2	cap cer 0.1	1500-0104
C3	cap mica 220P	1510-0221
C4	cap cer 0.1	1500-0104
C5	cap cer 0.1	1500-0104
C6	cap cer 0.1	1500-0104
C7	cap cer 0.1	1500-0104
C8	cap trim 5.5 - 18P	1550-0180
C9	cap mica 47P	1510-0470
C10	cap cer 33P	1500-0330
C11	cap mica 330P	1510-0331
C12	cap mica 470P	1510-0471
C13	cap mica selected value	
C14	cap mica selected value	
C15	cap polycarb 4700P 2% KED210	1520-0472
C16	cap polycarb 4700P 2% KED210	1520-0472
C17	cap polycarb 100n 1% KED213	1520-0104
C18	cap polycarb 1 1% KED218	1520-0105
C19	cap cer 0.1	1500-0104
C20	cap cer 0.1	
C21	cap cer 0.1	
C22	cap trim 5.5 - 18P	1550-0180
C23	cap mica 47P	1510-0470
C24	cap cer 33P	1500-0330
C25	cap mica 330P	1510-0331
C26	cap mica 470P	1510-0471
C27	cap mica selected value	
C28	cap mica selected value	
C29	cap polycarb 4700P 2% KED210	1520-0472
C30	cap polycarb 4700P 2% KED210	1520-0472
C31	cap polycarb 100n 1% KED213	1520-0104
C32	cap polycarb 1 1% KED218	1520-0105
C33	cap Tant 10/25V	1540-0106
C34	cap mica 100P	1510-0101
C35	cap Tant 10/25V	1540-0104
C36	cap Tant 10/25V	1540-0104
C37	cap Tant 10/25V	1540-0104
C38	cap mica 47P	1540-0470
C39	cap mica 47P	1540-0470
Q1	trans 2N5771	0400-0075
Q2	trans 2N5771	0400-0075
Q3	trans BFY90 (2N5179)	0400-0070
Q4	trans BFY90 (2N5179)	0400-0070
Q5	trans 2N4124	0400-0030
Q6	trans 2N3646	0400-0020
Q7	trans 2N3646	0400-0020

Table 8-4. Model 8201 PARTS LIST - PULSE GENERATION BOARD ASSEMBLY (continued)

Dwg Ref	Description		p/n
Q8	trans	DN5566	0400-4050
Q9	trans	2N2369A	0400-0090
Q10	trans	2N3906	0400-0134
Q11	trans	2N3906	0400-0134
Q12	trans	2N3906	0400-0134
Q13	trans	2N3906	0400-0134
Q14	trans	2N5771	0400-0075
Q15	trans	2N2771	0400-0075
Q16	trans	BFY90 (2N5179)	0400-0070
Q17	trans	BFY90 (2N5179)	0400-0070
Q18	trans	2N4124	0400-0030
Q19	trans	2N3646	0400-0020
Q20	trans	DM5566	0400-4050
Q21	trans	2N3646	0400-0020
Q22	trans	2N2369A	0400-0090
Q23	trans	2N3906	0400-0134
Q24	trans	2N3906	0400-0134
Q25	trans	2N3906	0400-0134
Q26	trans	2N3906	0400-0134
Q27	trans	2N4124	0400-0030
Q28	trans	J109	0400-0250
Q29	trans	2N4124	0400-0020
Q30	trans	2N4126	0400-0040
Q31	trans	2N4124	0400-0020
Q32	trans	J109	0400-0250
Q33	trans	2N4124	0400-0020
Q34	trans	2N4126	0400-0040
Q35	trans	2N4124	0400-0020
Q36	trans	2N4124	0400-0020
Q37	trans	2N4124	0400-0020
CR3	dio	1N825A	0300-2110
CR4	dio	1N825A	0300-2110
CR5	dio	1N4151	0300-0040
CR6	dio	1N825A	0300-2110
CR7	dio	1N825A	0300-2110
CR8	dio	1N4151	0300-0040
CR9	dio	1N825A	0300-2110
CR10	dio	1N746A	0300-2000
CR11	dio	1N746A	0300-2000
CR12	dio	BAR10	0300-1020
CR13	dio	BAR10	0300-1020

Table 8-4. Model 8201 PARTS LIST - PULSE GENERATION BOARD ASSEMBLY (continued)

Dwg Ref	Description	p/n
L1	coil 1MH 1537 Delevan	0600-0103
L2	coil 1MH 1537 Dlelvan	0600-0103
K1	relay BLUEBOY	0900-0040
K2	relay BLUEBOY	0900-0040
U1	ic CD4094	0540-0110
U2	ic CD4094	0540-0110
U3	ic CD4094	0540-0110
U4	ic CD4094	0540-0110
U5	ic 74F00	0500-1190
U6	ic 74F00	0500-1190
U7	ic 74F00	0500-1190
U8	ic 74S74	0500-2010
U9	ic 74F00	0500-1190
U10	ic LM324	0500-5321
U11	ic LM324	0500-5321
U12	ic AD7533	0560-0070
U13	ic AD7533	0560-0070
U14	ic 741C	0500-5631
U15	ic LM741E	0500-5630
U16	ic 741C	0500-5631
U17	ic LM741E	0500-5630

Table 8-5. Model 8201 PARTS LIST - RISE/FALL TIME CONTROL BOARD ASSEMBLY

Dwg Ref	Description	p/n
R1	res comp 1K 5% 1/4W	0100-0102
R2	res comp 1K 5% 1/4W	0100-0102
R3	res comp 2.2K 5% 1/4W	0100-0222
R4	res comp 3.3K 5% 1/4W	0100-0332
R5	res comp 1.5K 5% 1/4W	0100-0152
R6	res comp 1.5K 5% 1/4W	0100-0152
R7	res comp 1.5K 5% 1/4W	0100-0152
R8	res comp 1.5K 5% 1/4W	0100-0152
R9	res comp 1M 5% 1/4W	0100-0105
R10	res comp 1M 5% 1/4W	0100-0105
R11	res comp 1M 5% 1/4W	0100-0105
R12	res comp 1M 5% 1/4W	0100-0105

Table 8-5. Model 8201 PARTS LIST - RISE/FALL TIME CONTROL BOARD ASSEMBLY (continued)

Dwg Ref	Description					p/n
R14	res	comp	33	5%	1/4W	0100-0330
R15	res	mtf	100	1%	1/4W	0104-1000
R16	res	mtf	121	1%	1/4W	0104-1210
R17	res	comp	selected value			
R18	res	comp	1.2K	5%	1/4W	0100-0122
R19	res	comp	2.7K	5%	1/4W	0100-0272
R20	res	comp	33	5%	1/4W	0100-0330
R21	res	comp	10	5%	1/4W	0100-0100
R22	res	comp	10	5%	1/4W	0100-0100
R23	res	comp	33K	5%	1/4W	0100-0333
R24	res	trim	100			0203-0101A
R25	res	mtf	249	1%	1/4W	0104-2490
R26	res	comp	39	5%	1/4W	0100-0390
R27	res	comp	33	5%	1/4W	0100-0330
R28	res	comp	1.2K	5%	1/4W	0100-0122
R29	res	comp	2.7K	5%	1/4W	0100-0272
R30	res	mtf	12.1K	1%	1/4W	0104-1211
R31	res	trim	2K			0203-0202A
R32	res	mtf	1K	1%	1/4W	0104-0102
R33	res	mtf	12.1K	1%	1/4W	0104-1212
R34	res	trim	2K			0203-0202A
R35	res	mtf	1K	1%	1/4W	0104-1001
R36	res	comp	33	5%	1/4W	0100-0330
R37	res	comp	33	5%	1/4W	0100-0330
R38	res	comp	33	5%	1/4W	0100-0330
R39	res	comp	33	5%	1/4W	0100-0330
R40	res	comp	100	5%	1/4W	0100-0101
R41	res	comp	100	5%	1/4W	0100-0101
R42	res	comp	1.2K	5%	1/4W	0100-0122
R43	res	comp	1.2K	5%	1/4W	0100-0122
R44	res	comp	330	5%	1/4W	0100-0331
R45	res	comp	330	5%	1/4W	0100-0331
R46	res	comp	510	5%	1/4W	0100-0511
R47	res	comp	220	5%	1/4W	0100-0221
R48	res	comp	220	5%	1/4W	0100-0221
R49	res	comp	51	5%	1/4W	0100-0510
R50	res	comp	51	5%	1/4W	0100-0510
R51	res	comp	100	5%	1/4W	0100-0101
R52	res	comp	100	5%	1/4W	0100-0101
R53	res	comp	1K	5%	1/4W	0100-0102
R54	res	mtf	6.19K	1%	1/4W	0104-6191
R55	res	trim	100			0203-0101A
R56	res	trim	100			0203-0101A
R57	res	mtf	6.19K	1%	1/4W	0104-6191
R58	res	mtf	6.19K	1%	1/4W	0104-6191

Table 8-5. Model 8201 PARTS LIST - RISE/FALL TIME CONTROL BOARD ASSEMBLY (continued)

Dwg Ref	Description					p/n
R59	res	mtf	1.21K	1%	1/4W	0104-1211
R60	res	mtf	1.21K	1%	1/4W	0104-1211
R61	res	mtf	499	1%	1/4W	0104-4990
R62	res	mtf	100	1%	1/4W	0104-1000
R63	res	mtf	1.21K	1%	1/4W	0104-1211
R64	res	comp	100	5%	1/4W	0100-0101
R65	res	mtf	249	1%	1/4W	0104-2490
R66	res	mtf	2K	1%	1/4W	0104-2001
R67	res	mtf	1.21K	1%	1/4W	0104-1211
R68	res	mtf	1.21K	1%	1/4W	0104-1211
R69	res	mtf	249	1%	1/4W	0104-2490
R70	res	mtf	1.21K	1%	1/4W	0104-1211
R71	res	mtf	499	1%	1/4W	0104-4990
R72	res	comp	100	5%	1/4W	0100-0101
R73	res	comp	100	5%	1/4W	0100-0101
R74	res	comp	22K	5%	1/4W	0100-0223
C1	cap	tant	10/25V			1540-0106
C2	cap	tant	10/25V			1540-0106
C3	cap	tant	10/25V			1540-0106
C4	cap	cer	0.1			1500-0104
C5	cap	cer	0.1			1500-0104
C6	cap	tant	10/25V			1540-0106
C7	cap	tant	10/25V			1540-0106
C8	cap	trim	5.5-18P			1550-0180
C9	cap	mica	selected value (22P typical)			
C10	cap	cer	0.1			1500-0104
C11	cap	cer	0.1			1500-0104
C12	cap	cer	0.1			1500-0104
C13	cap	cer	selected value			
C14	cap	cer	0.1			1500-0104
C15	cap	cer	0.1			1500-0104
C16	cap	cer	0.1			1500-0104
C17	cap	cer	0.1			1500-0104
C18	cap	cer	1n			1500-0102
C19	cap	trim	2-10P			1550-0100
C20	cap	mica	270P			1510-0271
C21	cap	cer	selected value (22P typical)			
C22	cap	cer	selected value			
C23	cap	poly	0.003/200V	2%	KED210	1522-0302
C24	cap	poly	0.0332/40V	2%	KED312	1522-3322
C25	cap	poly	0.332/40V	2%	KED218	1522-3323
C26	cap	tant	10/25V			1540-0106
C27	cap	tant	10/25V			1540-0106
C28	cap	cer	0.1			1500-0104
C29	cap	cer	0.1			1500-0104

Table 8-5. Model 8201 PARTS LIST - RISE/FALL TIME CONTROL BOARD ASSEMBLY (continued)

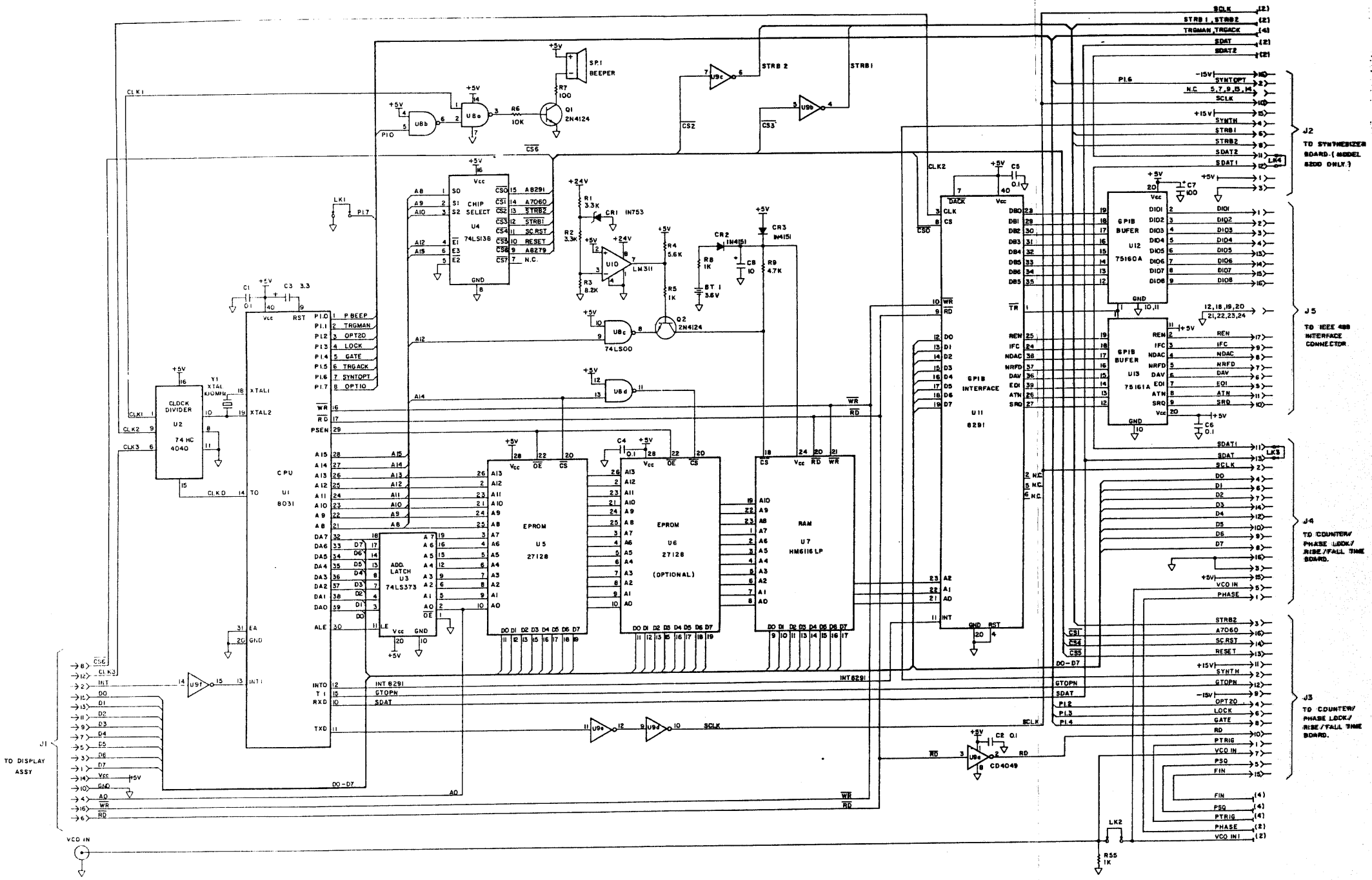
Dwg Ref	Description		p/n
CR1	dio	1N825A	0300-2110
CR2	dio	1N759A	0300-2050
CR3	dio	1N759A	0300-2050
CR4	dio	1N751A	0300-2001
CR5	dio	1N755A	0300-2160
CR6	dio	1N755A	0300-2160
CR7	dio	1N751A	0300-2001
CR8	dio	1N751A	0300-2001
Q1	trans	2N4124	0400-0040
Q2	trans	2N3904	0400-0120
Q3	trans	2N3904	0400-0120
Q4	trans	2N3904	0400-0120
Q5	trans	2N3904	0400-0120
Q6	trans	DN5566	0400-4050
Q7	trans	PN3640	0400-0010
Q8	trans	PN3646	0400-0020
Q9	trans	PN3646	0400-0020
Q10	trans	PN3640	0400-0010
Q11	trans	SD214	0400-0231
Q12	trans	2N5179	0400-0070
Q13	trans	2N5771	0400-0075
Q14	trans	2N5179	0400-0070
Q15	trans	2N5771	0400-0075
Q16	trans	2N5771	0400-0075
Q17	trans	2N5771	0400-0075
Q18	trans	2N5179	0400-0070
Q19	trans	2N5179	0400-0070
Q20	trans	2N5210	0400-0191
Q21	trans	2N5087	0400-0190
Q22	trans	2N5087	0400-0190
Q23	trans	2N5210	0400-0191
Q24	trans	2N5210	0400-0191
Q25	trans	2N5087	0400-0190
Q26	trans	2N5087	0400-0190
Q27	trans	2N5210	0400-0191
RL1	relay	blueboy	0900-0040
L1	coil	330MH	0600-0331
Y1	oscillator	10MHz	0800-7000

Table 8-5. Model 8201 PARTS LIST - RISE/FALL TIME CONTROL BOARD ASSEMBLY (continued)

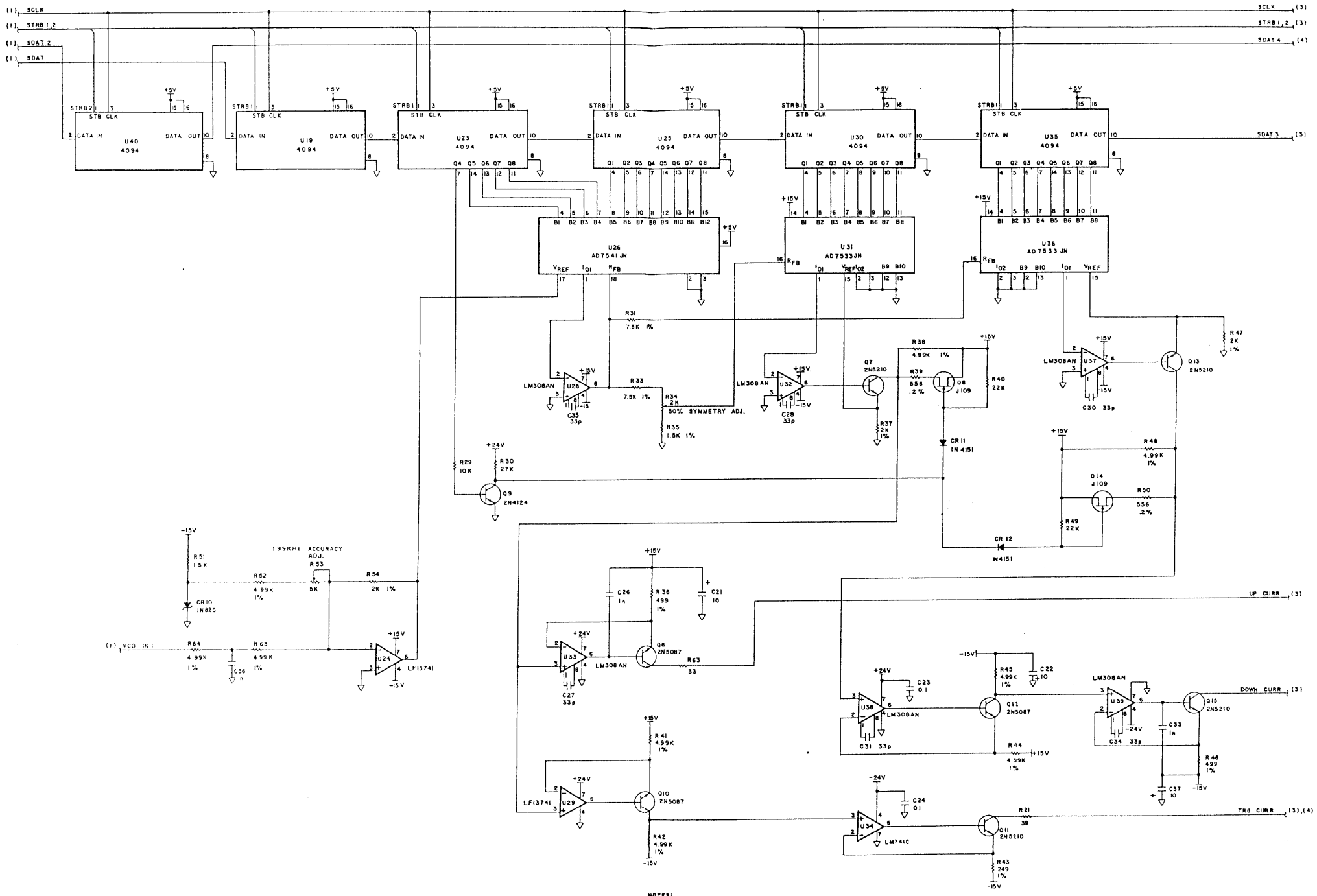
U1	ic	LS7060	0550-0020
U3	ic	LS7060	0550-0020
U4	ic	CD4094	0540-0110
U5	ic	LM311	0500-5321
U6	ic	LM324	0500-5321
U7	ic	CA3100	0500-5691
U8	ic	CA3100	0500-5691
U9	ic	MC10216	0500-4110
U10	ic	CD4094	0540-0110
U11	ic	CD4094	0540-0110
U12	ic	CD4094	0540-0110
U13	ic	AD7533	0560-0070
U14	ic	AD7533	0560-0070
U15	ic	LM741E	0500-5630
U16	ic	LM741E	0500-5630
U17	ic	LM741C	0500-5631
U18	ic	LM741C	0500-5631
U19	ic	LM741E	0500-5630
U20	ic	LM741C	0500-5631
U21	ic	LM741E	0500-5630
U22	ic	LM741E	0500-5630
J2	connector 16 pin		3000-3052
J3	connector 16 pin		3000-3052
J4	connector 16 pin		3000-3052

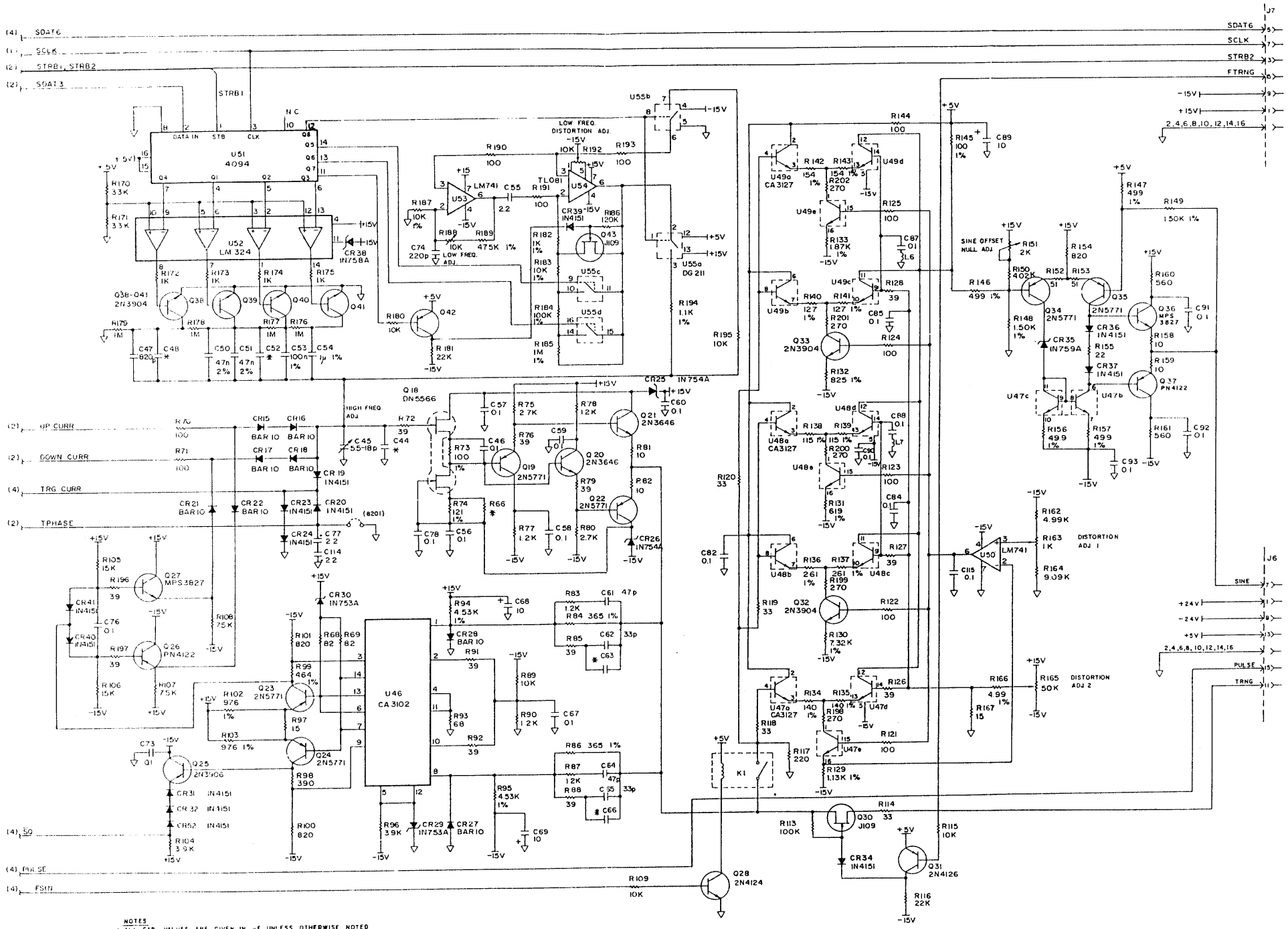
Table 8-6. Model 8201 PARTS LIST - COUNTER BOARD

Dwg Ref	Description	p/n
R47	res comp 1K 5% 1/4W	0100-0102
R48	res comp 1K 5% 1/4W	0100-0102
C19	cap tant 10/25V	1540-0106
C20	cap cer 0.1	1500-0104
C21	cap mica selected value	
C22	cap trim 5.5-18P	1505-0180
Y1	oscillator 10MHz	0800-7000
L1	coil 330MH	0600-0331
U9	ic LS7060	0550-0020
U10	ic LS7060	0500-0020
U11	ic 74LS74	0510-0110

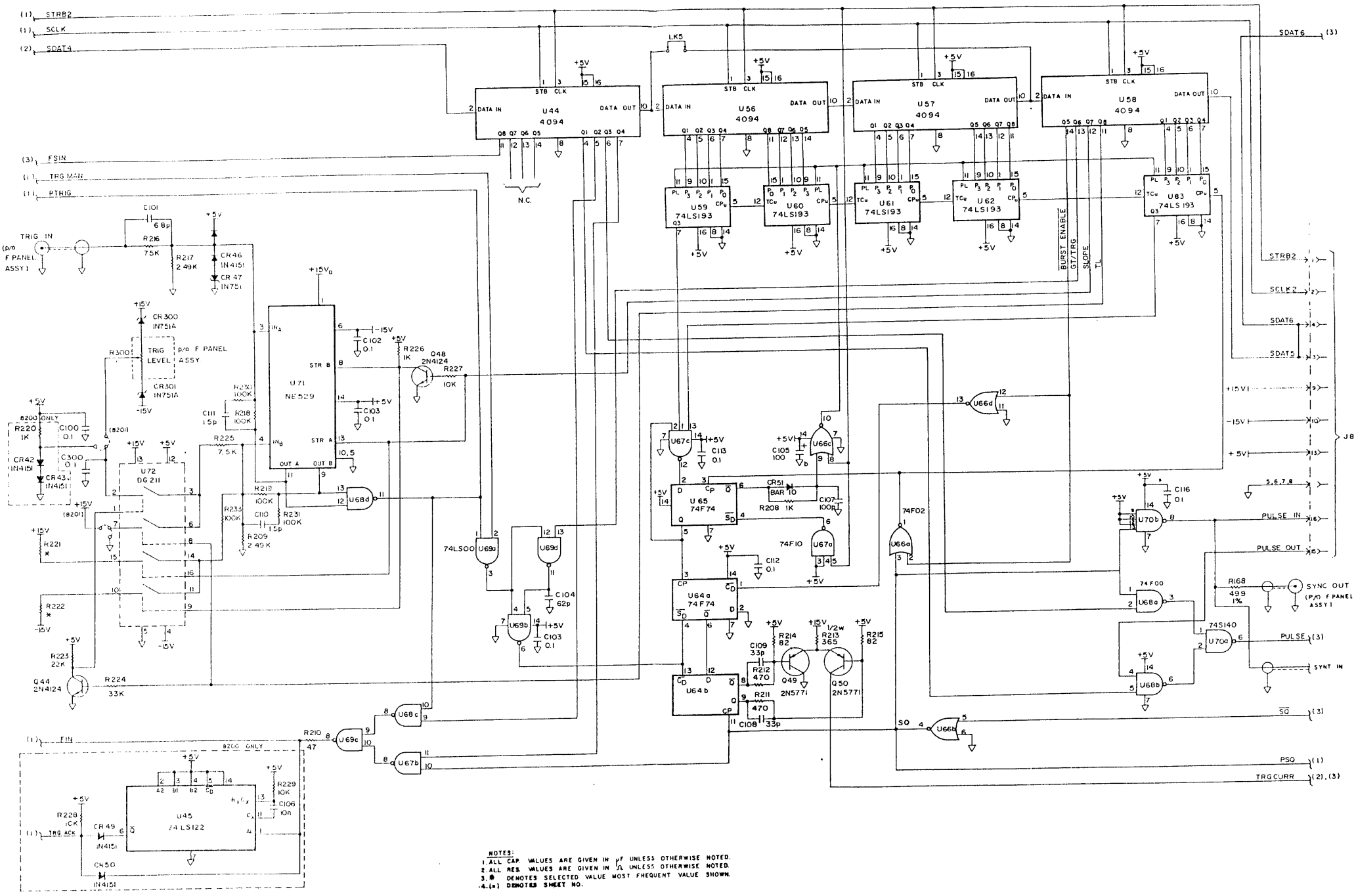


NOTES:
1 ALL CAP VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED.
2 ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED
3 * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN
4 (n) DENOTES SHEET NO.

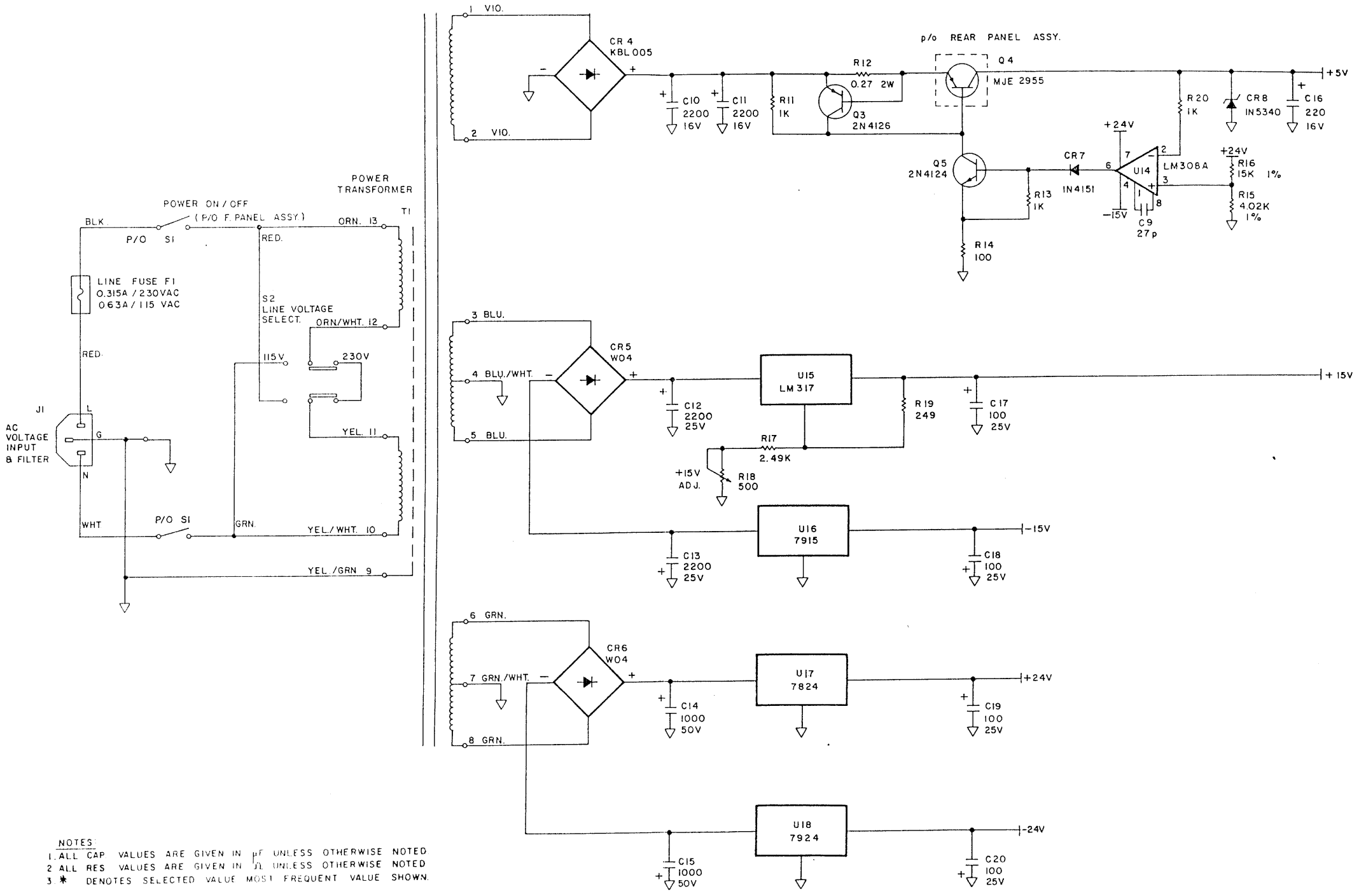

(1) SCLK
(1) STRB 1,2
(1) SDAT 2
(1) SDAT
SCLK (3)
STRB 1, 2 (3)
SDAT 4 (4)
SDAT 3 (3)
U40 4094
U19 4094
U23 4094
U25 4094
U30 4094
U35 4094
STB CLK
DATA IN
DATA OUT
+5V
U26 AD7541 JN
U31 AD7533JN
U36 AD7533 JN
R31 7.5K 1%
R33 7.5K 1%
R34 2K 50% SYMMETRY ADJ.
R35 1.5K 1%
R38 4.99K 1%
R39 556 .2%
R40 22K
R37 2K 1%
R47 2K 1%
R48 4.99K 1%
R50 556 .2%
R49 22K
LM308AN
U28
U32
U37
C35 33p
C28 33p
C30 33p
Q7 2N5210
Q8 J 109
Q13 2N5210
Q14 J 109
CR 11 IN 4151
CR 12 IN4151
+24V
R29 10K
R30 27K
Q9 2N4124
-15V
R51 1.5K
1.99KHz ACCURACY ADJ. R53
R52 4.99K 1%
5K
R54 2K 1%
CR10 IN825
(1) VCO IN
R64 4.99K 1%
R63 4.99K 1%
C36 1n
U24
LF13741
C26 1n
R36 499 1%
C21 10
U33
C27 33p
Q6 2N5087
R63 33
UP CURR (3)
C23 0.1
U38
C31 33p
R45 499K 1%
C22 10
Q12 2N5087
R44 4.99K 1%
U39
C34 33p
C33 1n
Q15 2N5210
DOWN CURR (3)
R46 499 1%
C37 10
R41 4.99K 1%
U29
Q10 2N5087
R42 4.99K 1%
C24 0.1
U34
LM741C
Q11 2N5210
R21 39
TRG CURR (3),(4)
R43 249 1%
NOTES:
1. ALL CAP. VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED.
2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.



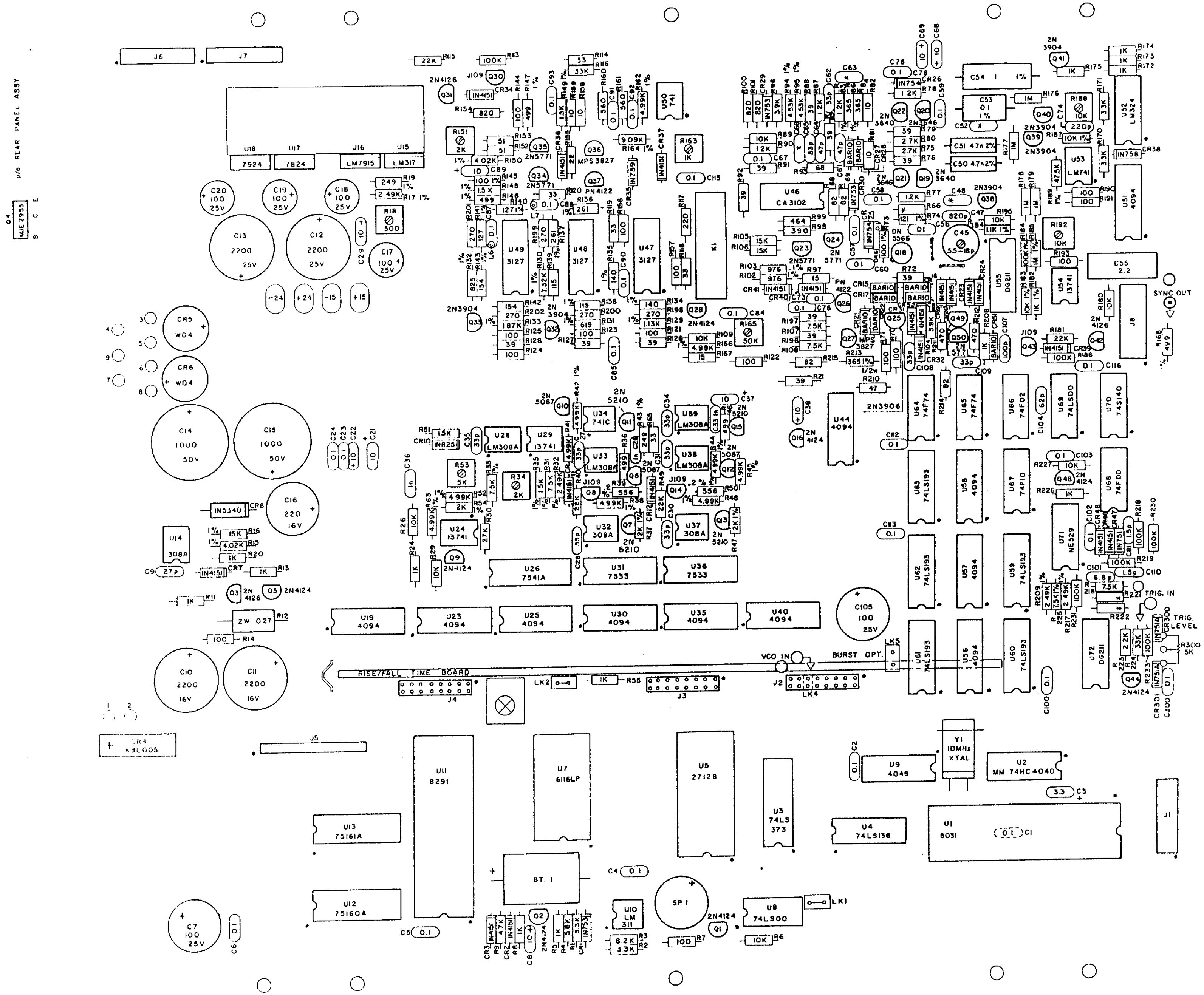
NOTES
1 ALL CAP VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED
2 ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED
3 * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.
4 (n) DENOTES SHEET NO.
5 X CR19, CR20 ARE MATCHED DIODES.



NOTES:
1. ALL CAP. VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED.
2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.
4. (n) DENOTES SHEET NO.

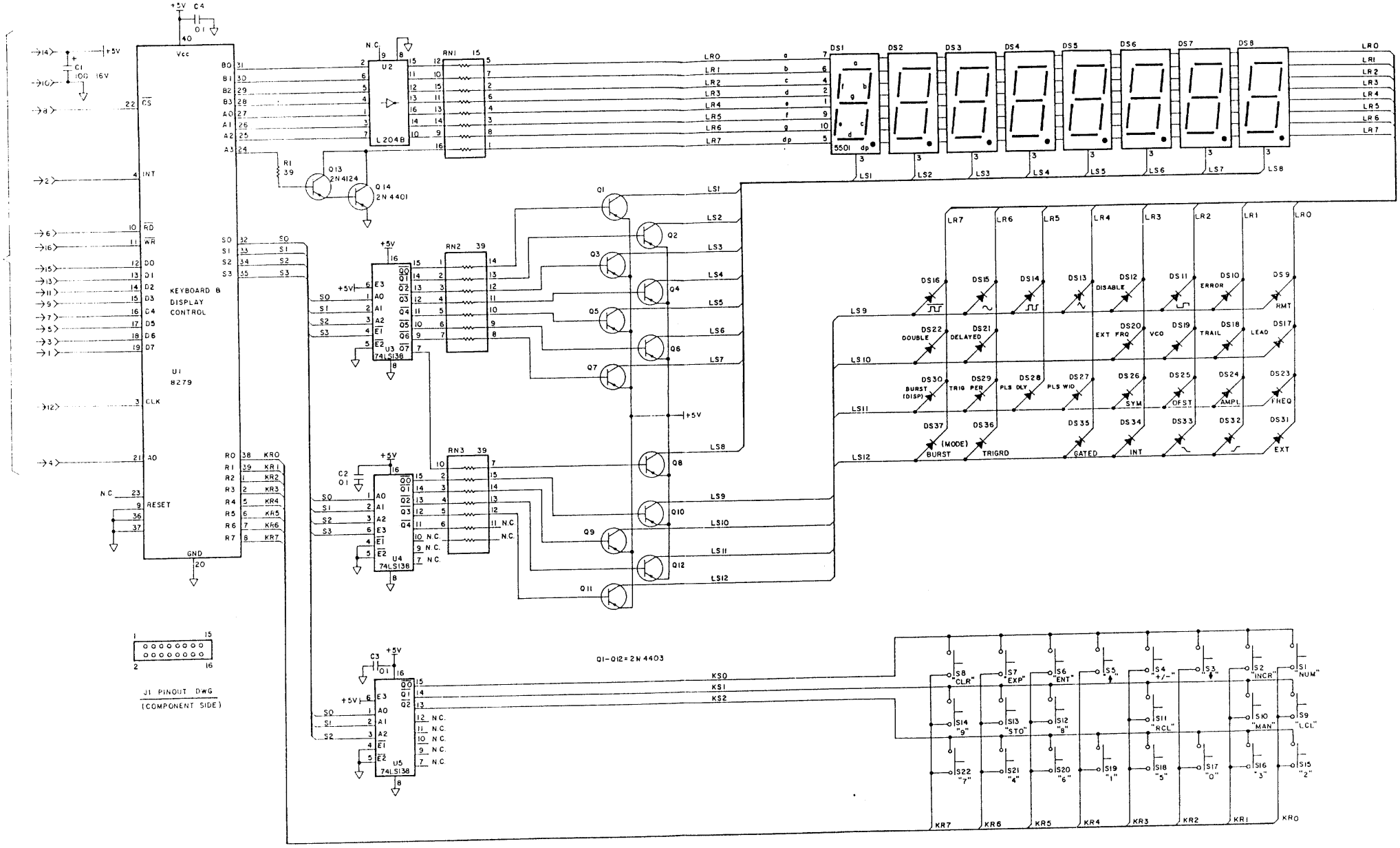


NOTES:
1. ALL CAP VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED.
2. ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES SELECTED VALUE. MOST FREQUENT VALUE SHOWN.

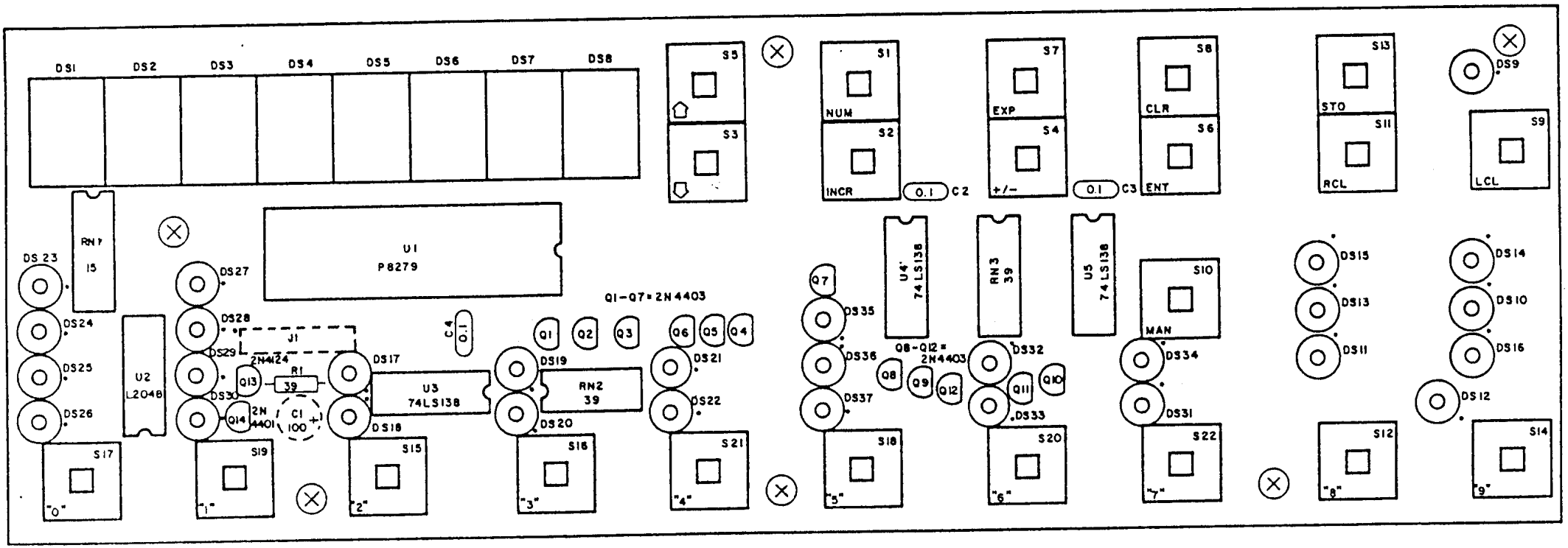


NOTES
1 ALL CAP VALUES ARE GIVEN IN µF UNLESS OTHERWISE NOTED
2 ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED
3 * DENOTES SELECTED VALUE, MOST FREQUENT VALUE SHOWN

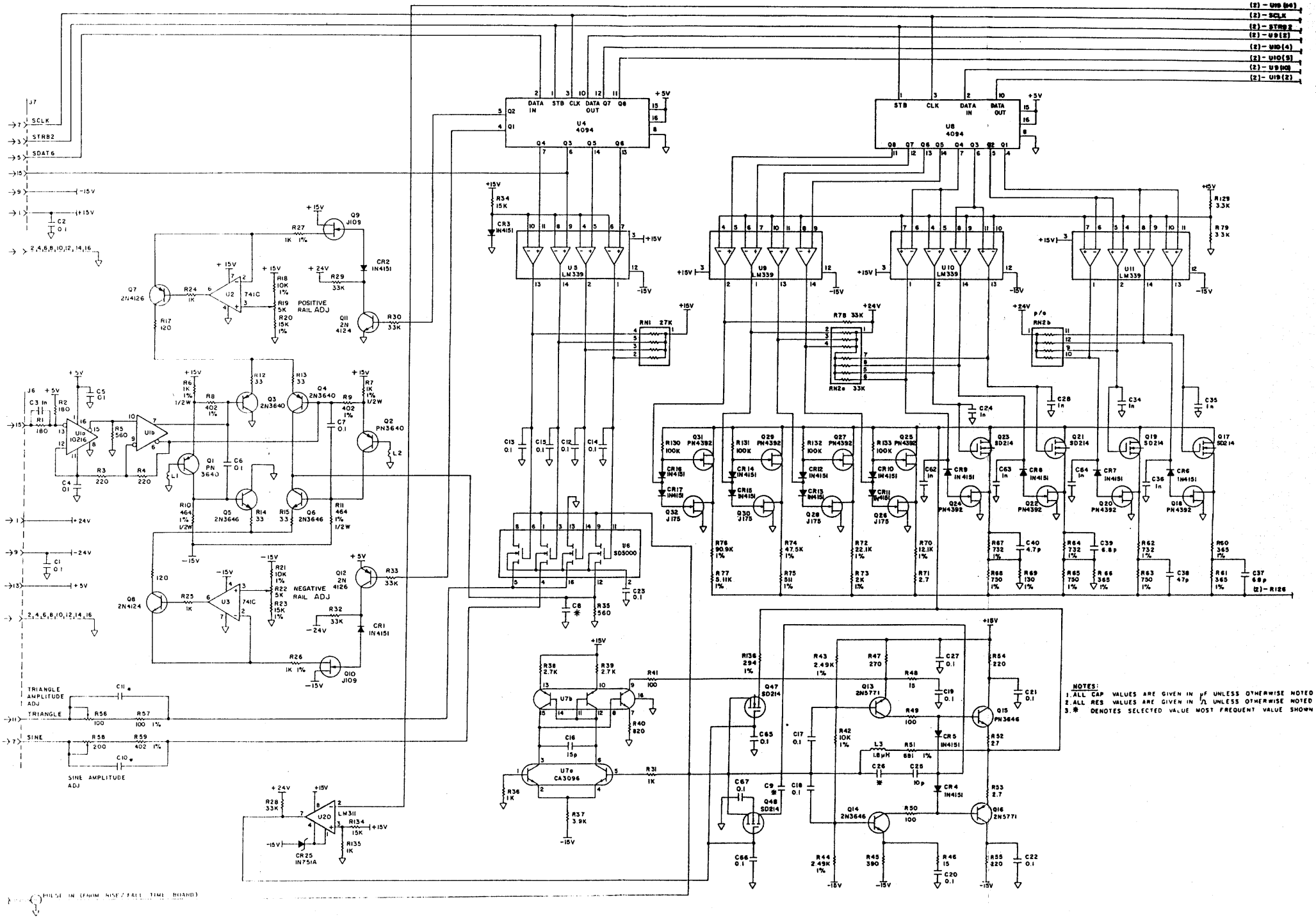
9-6 Main Board - Components Layout

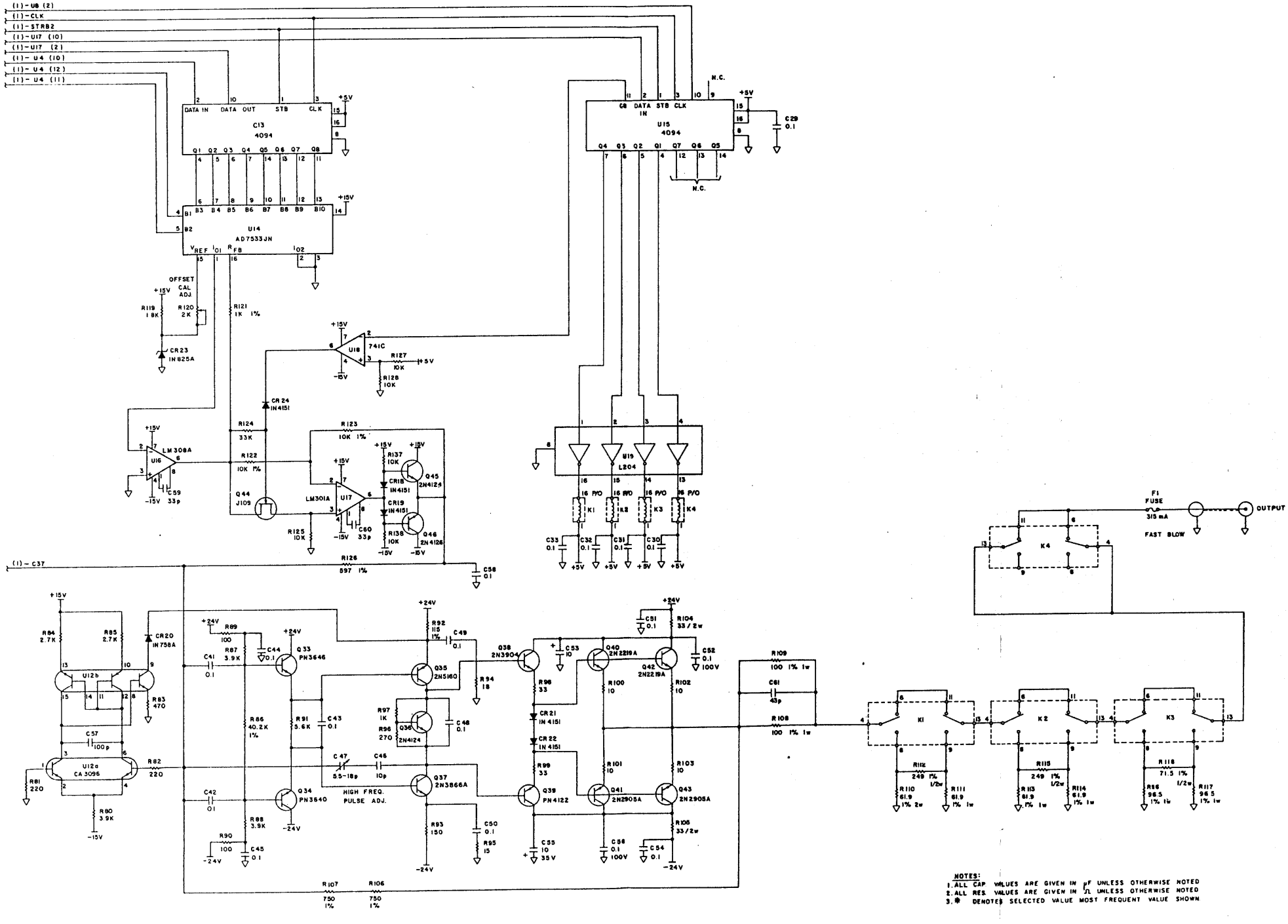


NOTES:
1 ALL CAP VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED
2 ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED
3 * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN
4 (n) DENOTES SHEET NO

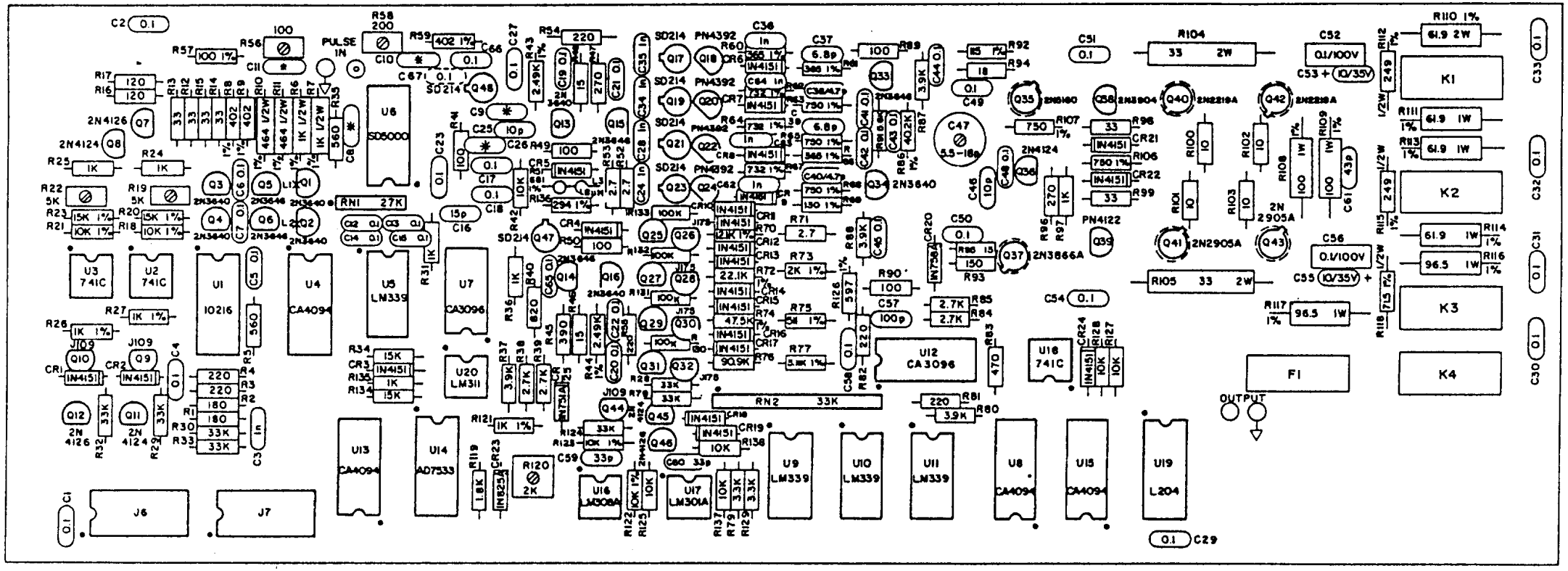


9-8 Keyboard and Display - Components Layout


J7
SCLK
STRB2
SDAT6
+15V
-15V
+24V
-24V
+5V
U4 4094
DATA IN
STB
CLK
DATA OUT
Q1
Q2
Q4
Q5
Q6
Q7
Q8
U8 4094
U5 LM339
U9 LM339
U10 LM339
U11 LM339
U2 741C
U3 741C
U10 10216
U10a
U10b
U7a CA3096
U7b
U6 SD3000
U20 LM311
POSITIVE RAIL ADJ
NEGATIVE RAIL ADJ
TRIANGLE AMPLITUDE ADJ
SINE AMPLITUDE ADJ
TRIANGLE
SINE
PULSE IN (FROM RISE/FALL TIME BOARD)
(2) - U19 D4
(2) - SCLK
(2) - STRB2
(2) - U9 (2)
(2) - U10 (4)
(2) - U10 (5)
(2) - U9 (10)
(2) - U19 (2)
NOTES:
1. ALL CAP VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED
2. ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN

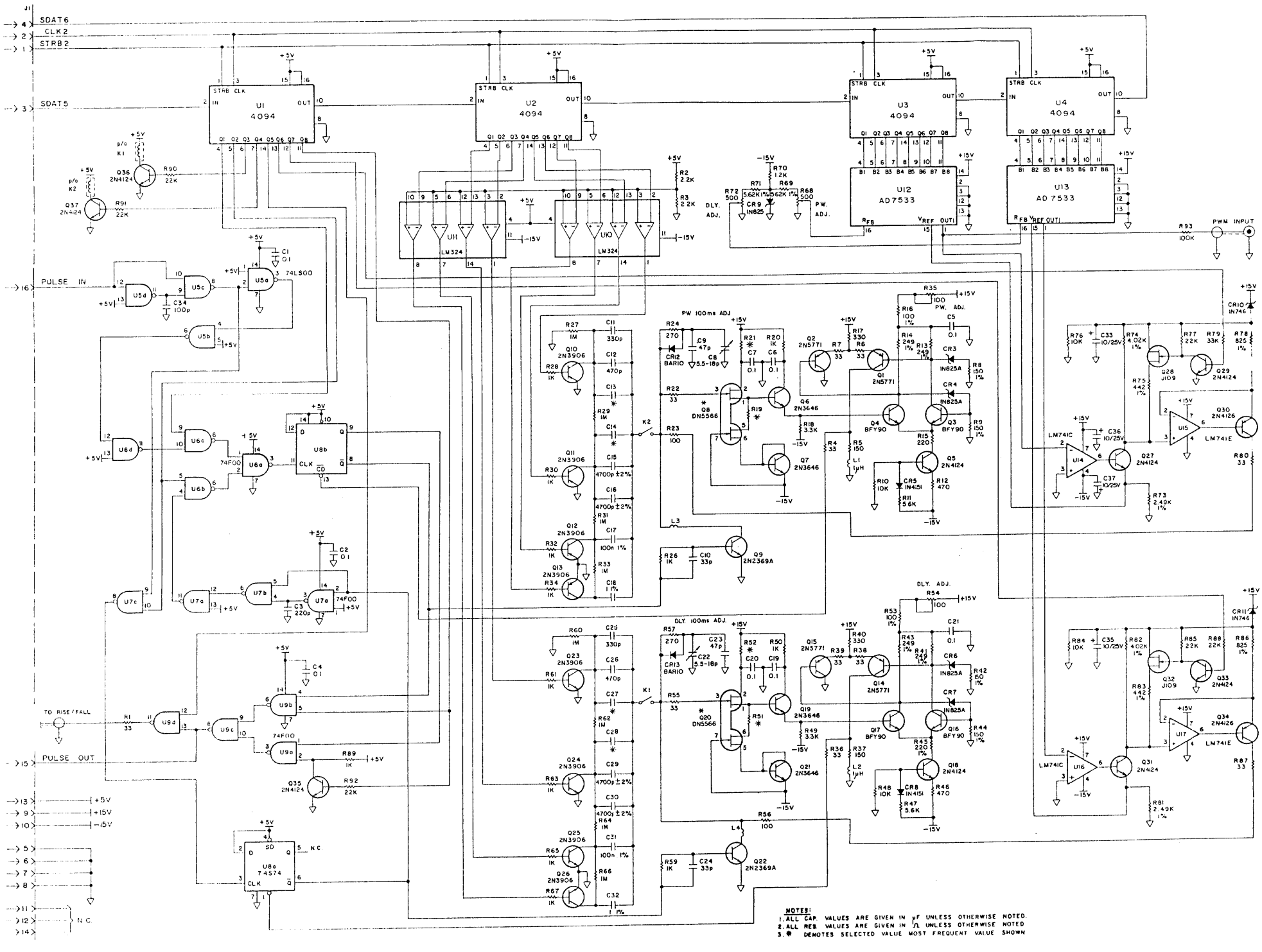


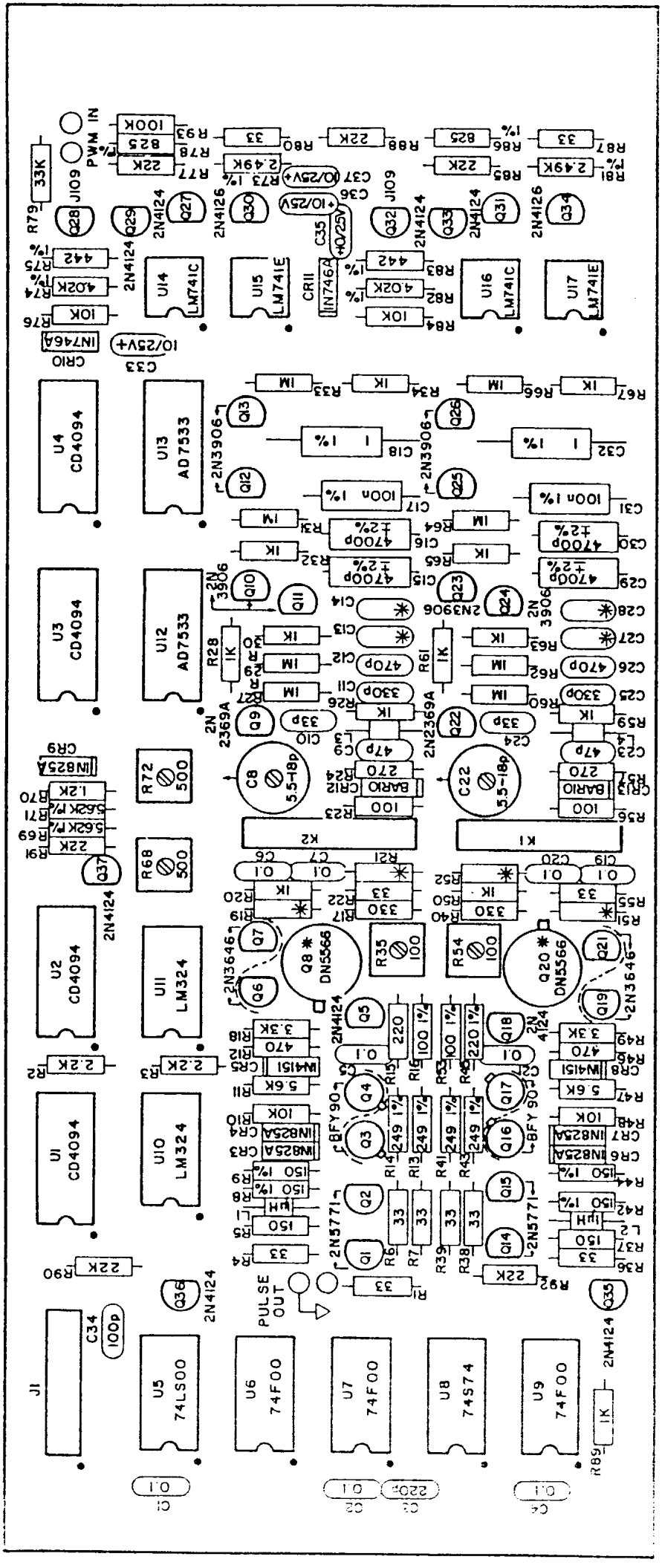
NOTES:
1. ALL CAP VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED
2. ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN



NOTES:
1. ALL CAP. VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED
2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.

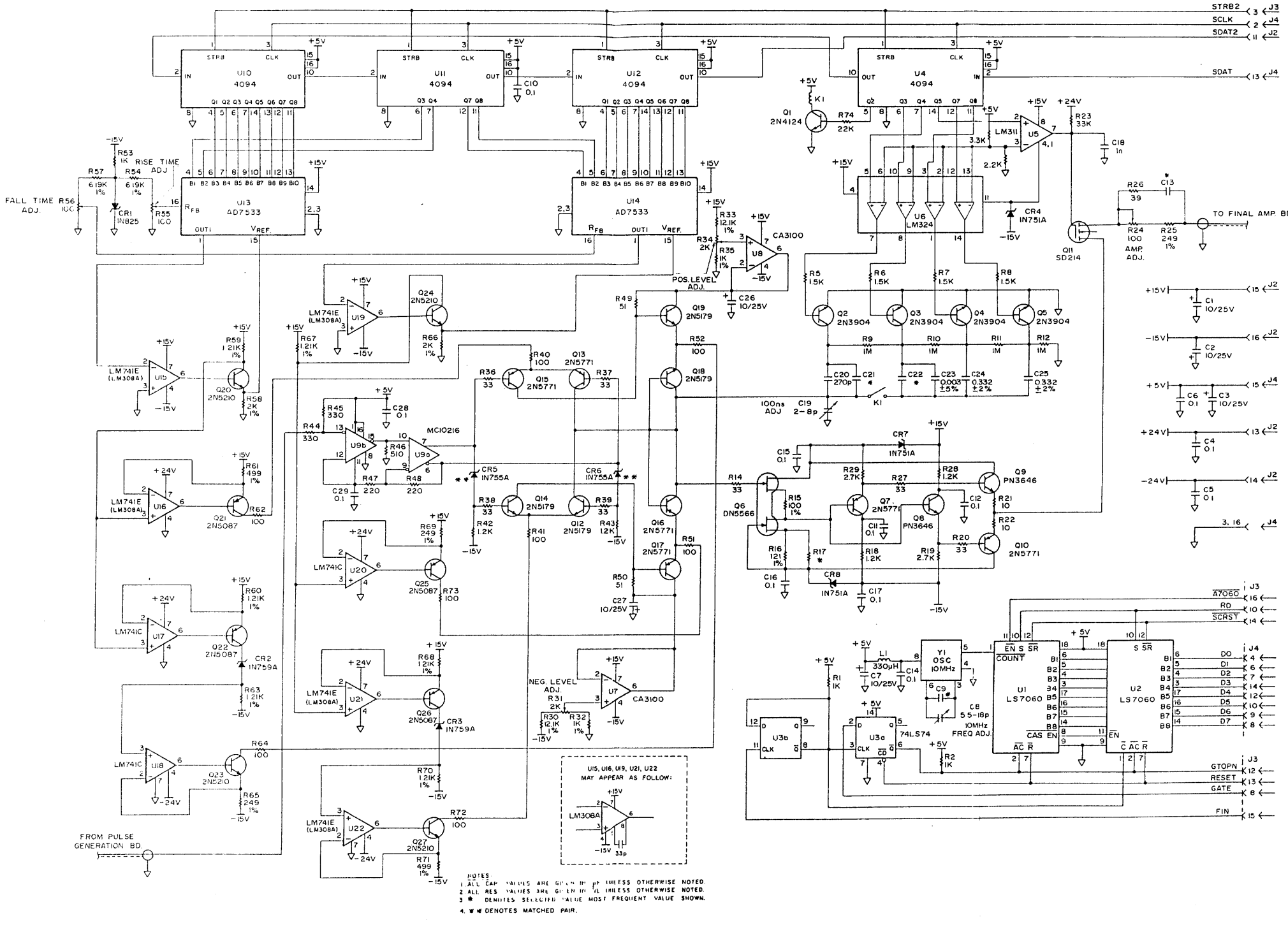
9-11 Final Amplifier Board - Components Layout


SDAT6
CLK2
STRB2
SDAT5
PULSE IN
PULSE OUT
TO RISE/FALL
PWM INPUT
U1 4094
U2 4094
U3 4094
U4 4094
U12 AD7533
U13 AD7533
U11 LM324
U10 LM324
74LS00
74F00
74574
LM741C
LM741E
PW 100ms ADJ
DLY. 100ms ADJ
DLY. ADJ.
PW. ADJ.
NC
NOTES:
1. ALL CAP. VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED.
2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN

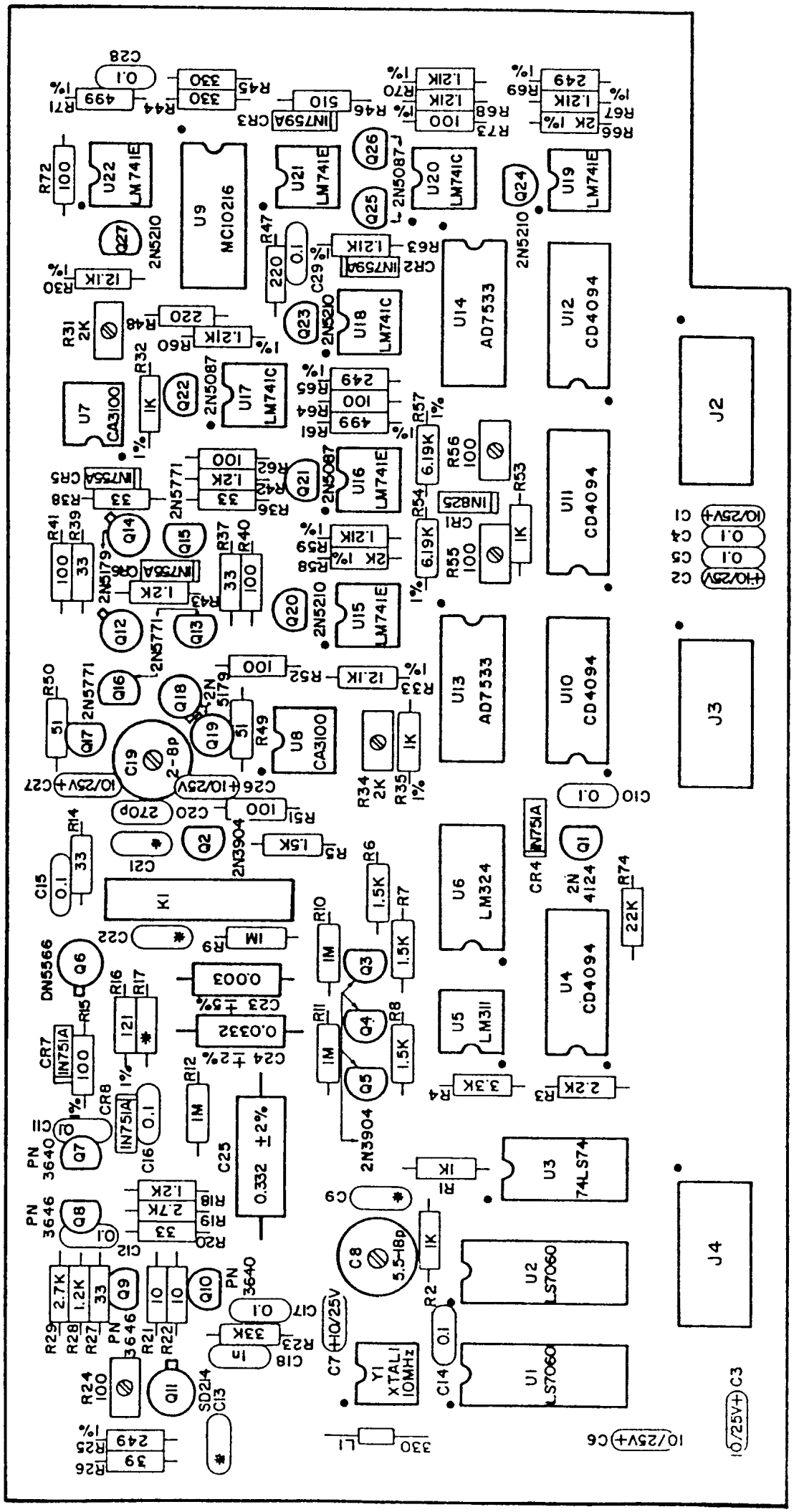


NOTES:
1. ALL CAP VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED.
2. ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.

9-13 Pulse Generation - Components Layout

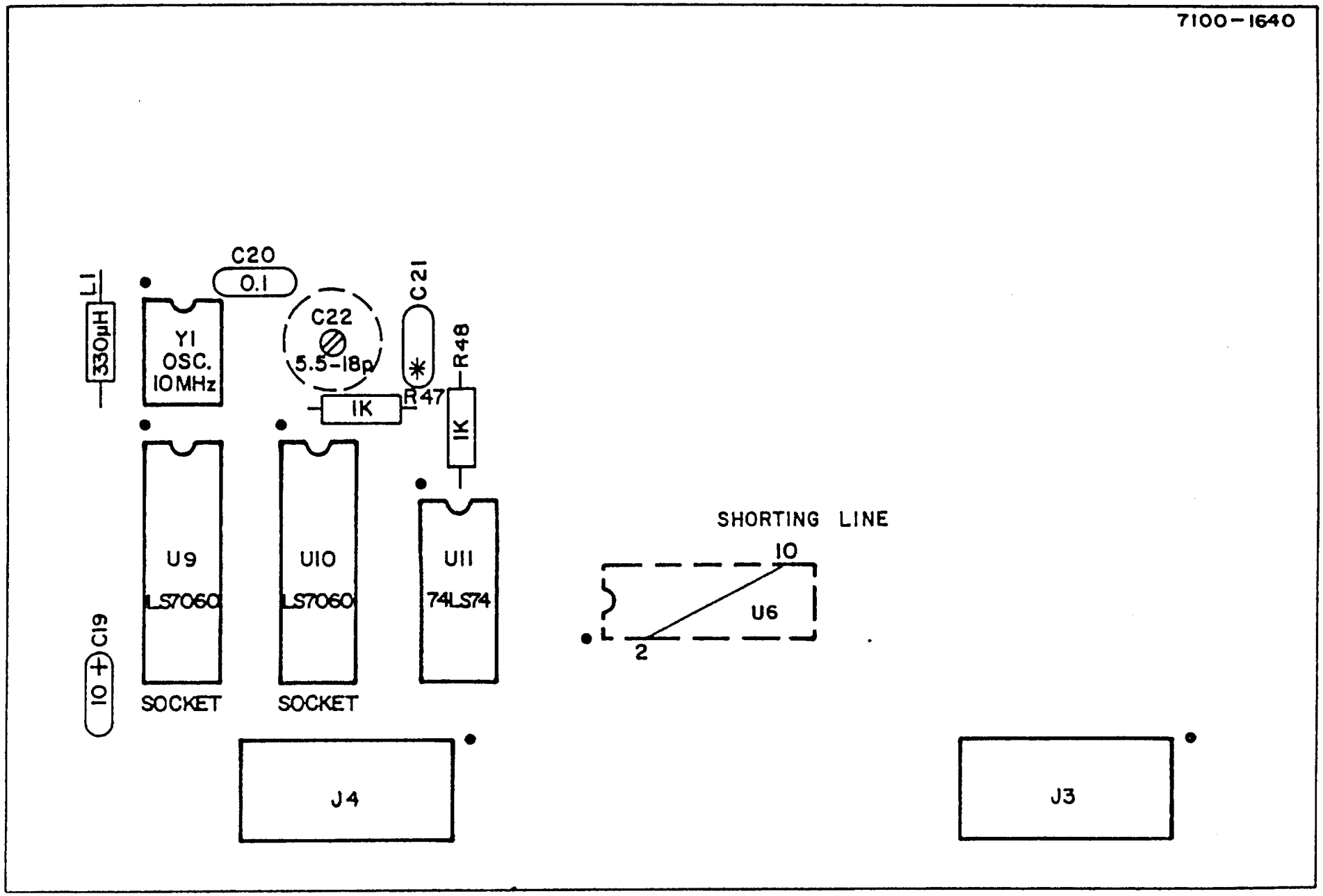


NOTES
1. ALL CAP VALUES ARE GIVEN IN µF UNLESS OTHERWISE NOTED.
2. ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.
4. ** DENOTES MATCHED PAIR.



NOTES:
1. ALL CAP. VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED.
2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.
4. * * DENOTES MATCHED PAIR.

9-15 Rise/Fall Time Control Circuit - Components Layout



9-17 Counter Board - Components Layout

SIDE SUPPORT LEFT
4500-5160
PULSE GENERATION BOARD
7100-1470
RISE/FALL TIME BOARD
7100-1740
SIDE SUPPORT RIGHT
4500-5170
FINAL AMPLIFIER BOARD
7100-1750
TO PCB
7100-1470
TO PCB
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Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY(continued)

Dwg Ref	Description		p/n
Q9	trans	2N4124	0400-0030
Q10	trans	2N5087	0400-0190
Q11	trans	2N5210	0400-0191
Q12	trans	2N5087	0400-0190
Q13	trans	2N5210	0400-0191
Q14	trans FET	J109	0400-0250
Q15	trans	2N5210	0400-0191
Q16	trans	2N4124	0400-0030
Q18	trans FET	DN5566	0400-4050
Q19	trans	2N3640	0400-0010
Q20	trans	2N3646	0400-0020
Q21	trans	2N3646	0400-0020
Q22	trans	2N3640	0400-0010
Q23	trans	2N5771	0400-0075
Q24	trans	2N5771	0400-0075
Q25	trans	2N3906	0400-0134
Q26	trans	2N4122	0400-0050
Q27	trans	MPS3827	0400-0282
Q28	trans	2N4124	0400-0030
Q29	trans FET	J109	0400-0250
Q3	trans FET	J109	0400-0250
Q31	trans	2N4126	0400-0040
Q32	trans	2N3904	0400-0120
Q33	trans	2N3904	0400-0120
Q34	trans	2N5771	0400-0075
Q35	trans	2N5771	0400-0075
Q36	trans	MPS3827	0400-0120
Q37	trans	PN4122	0400-0134
Q38	trans	2N3904	0400-0120
Q39	trans	2N3904	0400-0120
Q40	trans	2N3904	0400-0120
Q41	trans	2N3904	0400-0120
Q42	trans	2N4126	0400-0040
Q43	trans FET	J109	0400-0250
Q44	trans	2N4124	0400-0030
Q48	trans	2N4124	0400-0030
Q49	trans	2N5771	0400-0075
Q50	trans	2N5771	0400-0075
U1	ic	8031	0500-2141
U2	ic	MM74HC4040	0520-0700
U3	ic	74LS373	0510-0365
U4	ic	74LS138	0510-0270
U5	ic	27128	0500-2123
U7	ic	HM6116LP	0500-1115
U8	ic	74LS00	0510-0010
U9	ic	CD4049BE	0540-0063

Table 8-1. Model 8201 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

Dwg Ref	Description		p/n
U10	ic	LM311	0500-5330
U11	ic	8291A	0500-2130
U12	ic	75160A	0500-2151
U13	ic	75161A	0500-2152
U14	ic	LM308	0500-5340
U15	ic	LM317	0500-5360
U16	ic	LM7915	0500-5250
U17	ic	LM7824	0500-5260
U18	ic	LM7924	0500-5270
U19	ic	CA4094	0540-0110
U23	ic	CD4094	0540-0110
U24	ic	LF13741	0500-5600
U25	ic	CD4094	0540-0110
U26	ic	7541	0560-0080
U28	ic	LM308A	0500-5340
U29	ic	LF13741	0500-5600
U30	ic	CD4094	0540-0110
U31	ic	AO7533JN	0560-0070
U32	ic	LM308A	0500-5340
U33	ic	LM308A	0500-5340
U34	ic	741C	0500-5631
U35	ic	CD4094	0540-0110
U36	ic	AO7533JN	0560-0070
U37	ic	LM308A	0500-5340
U38	ic	LM308A	0500-5340
U39	ic	LM308A	0500-5340
U40	ic	CD4094	0540-0110
U44	ic	CD4094	0540-0110
U45	ic	74LS122	0510-0241
U46	ic	CA3102	0500-5770
U47	ic	CA3127	0500-6000
U48	ic	CA3127	0500-6000
U49	ic	CA3127	0500-6000
U50	ic	LM741C	0000-5631
U51	ic	CD 4094	0540-0110
U52	ic	LM324	0500-5321
U53	ic	LM741C	0500-5631
U54	ic	LF13741	0500-5600
U55	ic	DG211	0500-9090
U56	ic	CD4094	0500-0110